

# 9. SMART TECHNOLOGY. DATA ANALYSIS



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## 9.1. IoT (Internet of Things)

9.1. IoT

9.2. Smart Home

9.3. Smart Grid

9.4. Data Analysis



# IoT Learning Objectives

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- Define IoT
- Understand history of IoT
- Describe IoT characteristics

# Internet of Things (IoT)

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- The Internet of Things (IoT) is the network of physical objects—devices, vehicles, buildings and other items embedded with electronics, software, sensors, and network connectivity—that enables these objects to collect and exchange data.



# History

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- As of 2016, the vision of the Internet of things has evolved due to a convergence of multiple technologies, including ubiquitous wireless communication, real-time analytics, machine learning, commodity sensors, and embedded systems.
- 1982 - a modified Coke machine at Carnegie Mellon University becoming the first Internet-connected appliance, able to report its inventory and whether newly loaded drinks were cold.
- Mark Weiser's seminal 1991 paper on ubiquitous computing, "The Computer of the 21st Century", as well as academic venues such as UbiComp and PerCom produced the contemporary vision of IoT.

# History (2)

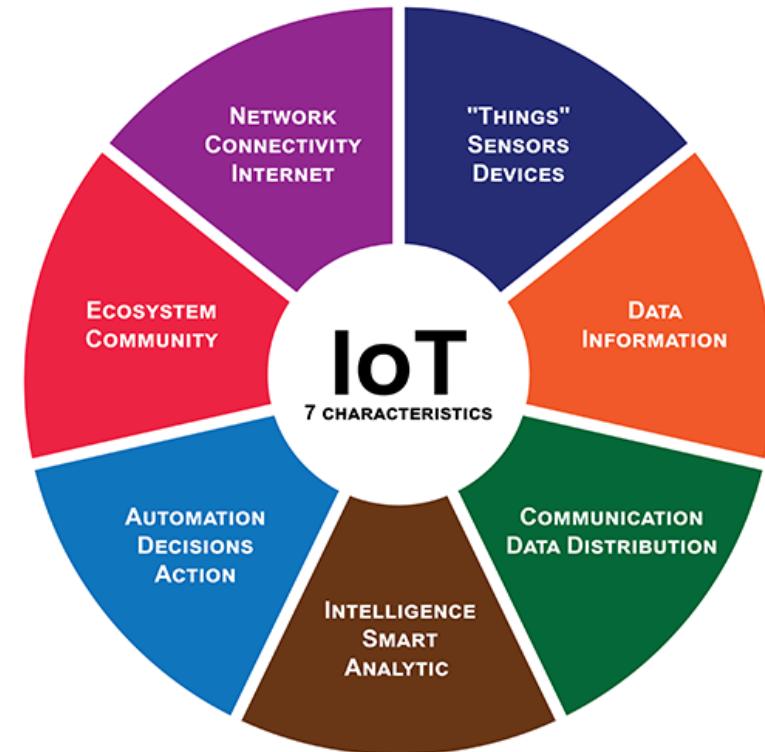
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- 1994 - Reza Raji described the concept in IEEE Spectrum as "[moving] small packets of data to a large set of nodes, so as to integrate and automate everything from home appliances to entire factories".
- 1993 - 1996 - several companies proposed solutions like Microsoft's at Work or Novell's NEST. However, only in 1999 did the field start gathering momentum. Bill Joy envisioned Device to Device (D2D) communication as part of his "Six Webs" framework, presented at the World Economic Forum at Davos in 1999.
- The concept of the Internet of things became popular in 1999, through the Auto-ID Center at MIT and related market-analysis publications.

# Internet of Things Characteristics

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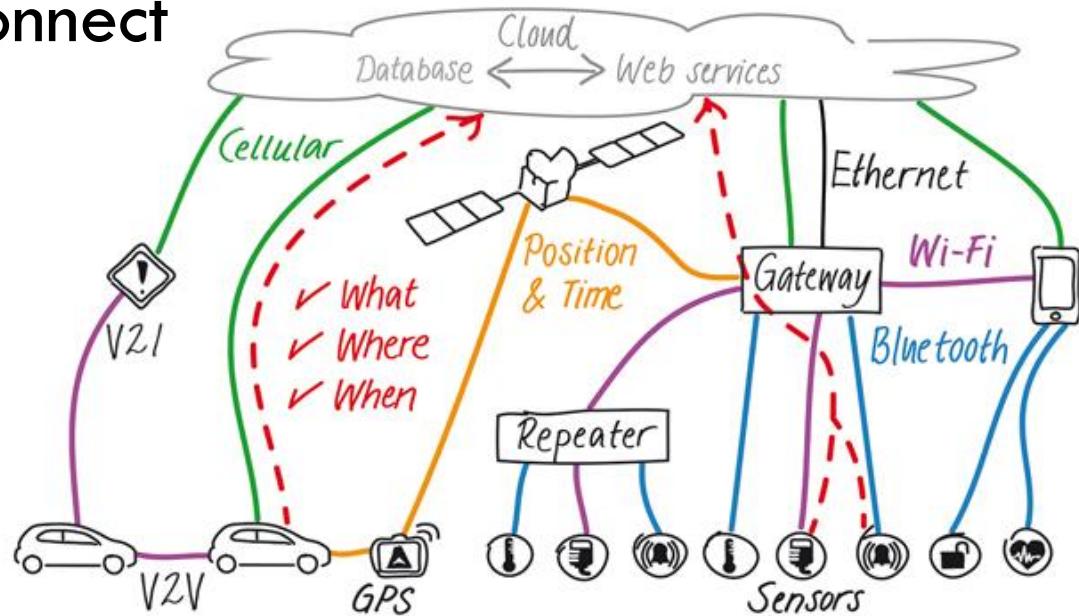
- Connectivity
- Things
- Data
- Communication
- Intelligence
- Action
- Ecosystem



# Characteristics (1): Connectivity

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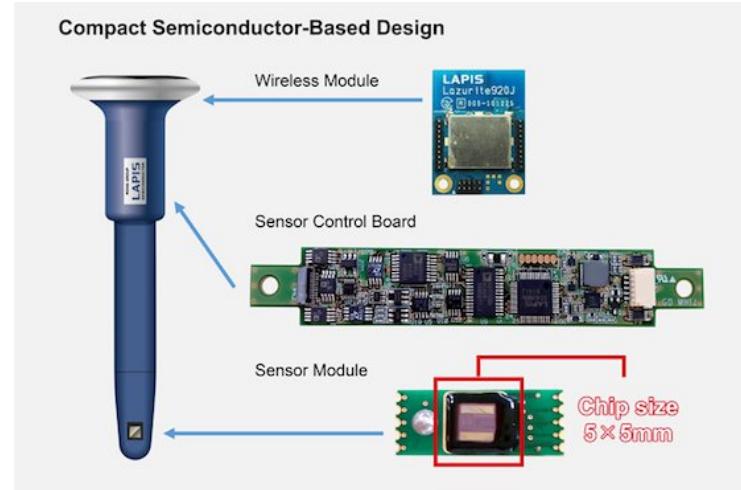
- Devices need to connect to each other, to a network, or to the internet
- Many use cloud computing



# Characteristics (2): Things

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- Anything that is designed to be connected
  - ▣ Complex devices that contain sensors
  - ▣ Simple sensors that communicate
  - ▣ Sensing materials can be attached to devices, items, humans, or animals



# Characteristics (3): Data

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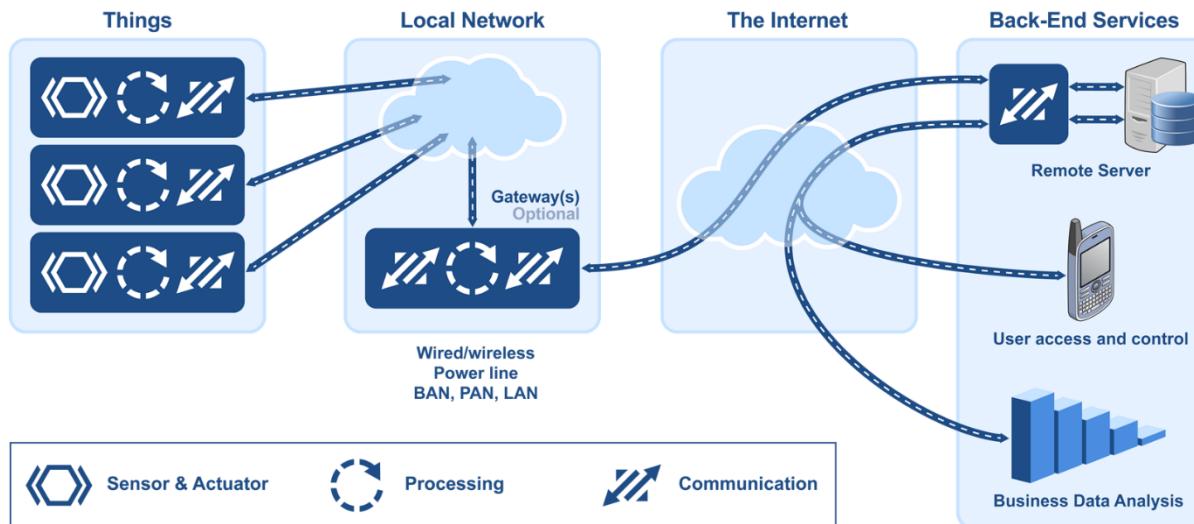
- Data is the glue of the Internet of Things, the first step towards action and intelligence.



# Characteristics (4): Communication

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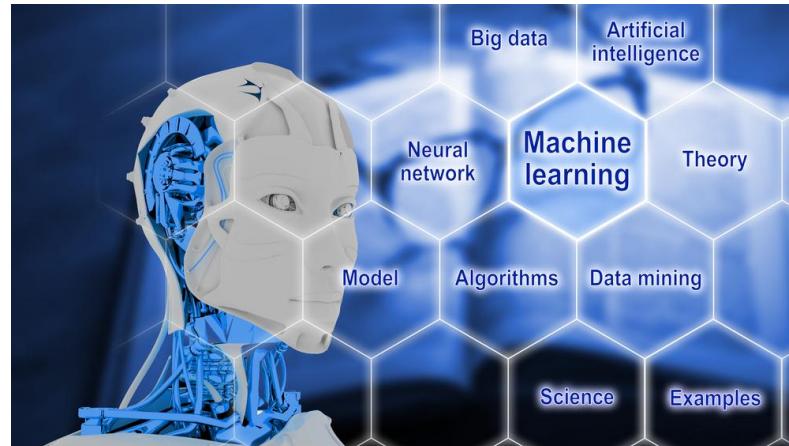
- Devices get connected so they can communicate data and this data can be analyzed.



# Characteristics (5): Intelligence

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- Two types of intelligence
  - Intelligence as in the sensing capabilities in IoT devices
  - Intelligence gathered from data analytics (also artificial intelligence)



# Characteristics (6): Action

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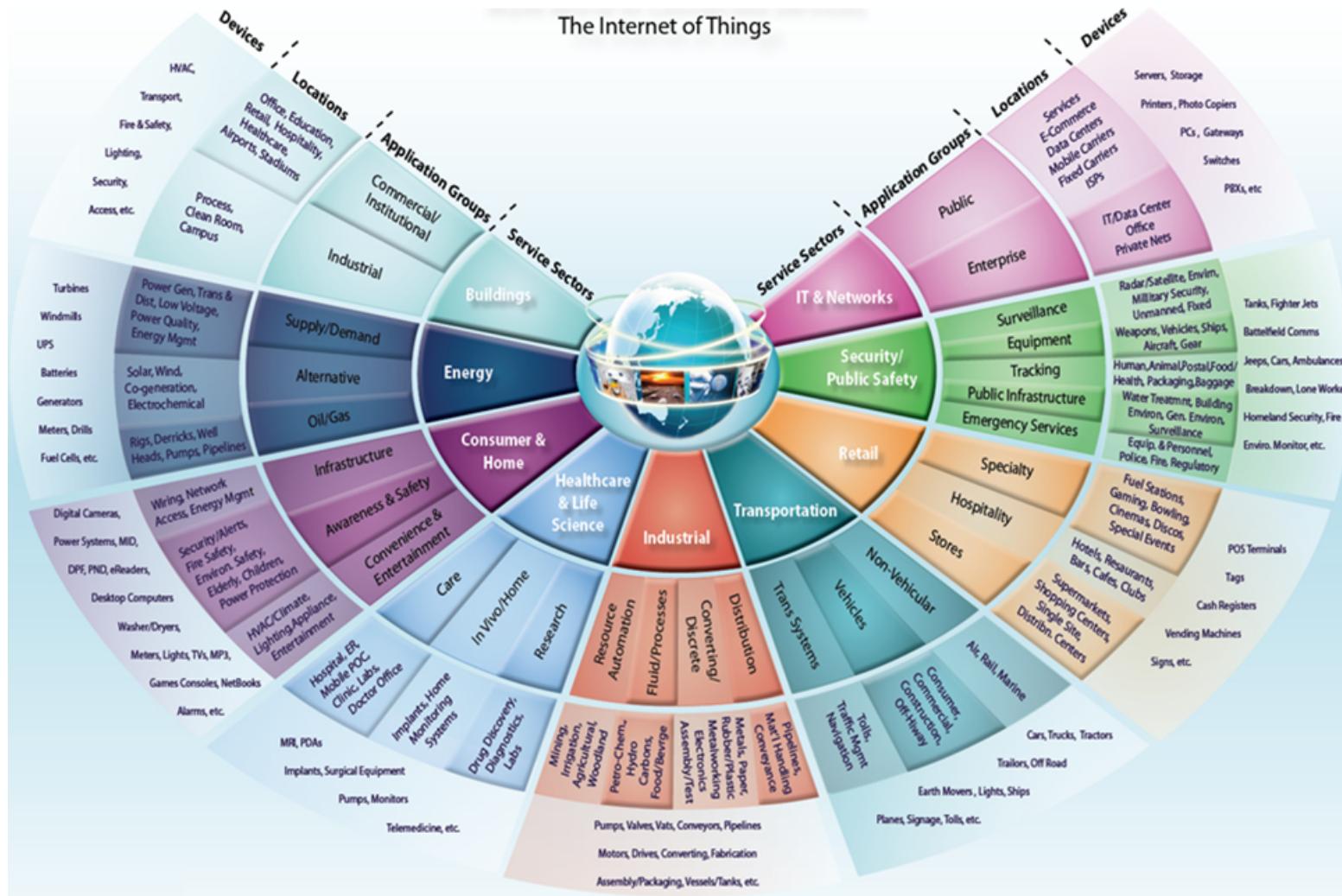
- The consequence of intelligence.
- This can be manual action, action based upon debates regarding phenomena (for instance in climate change decisions) and automation, often the most important piece.

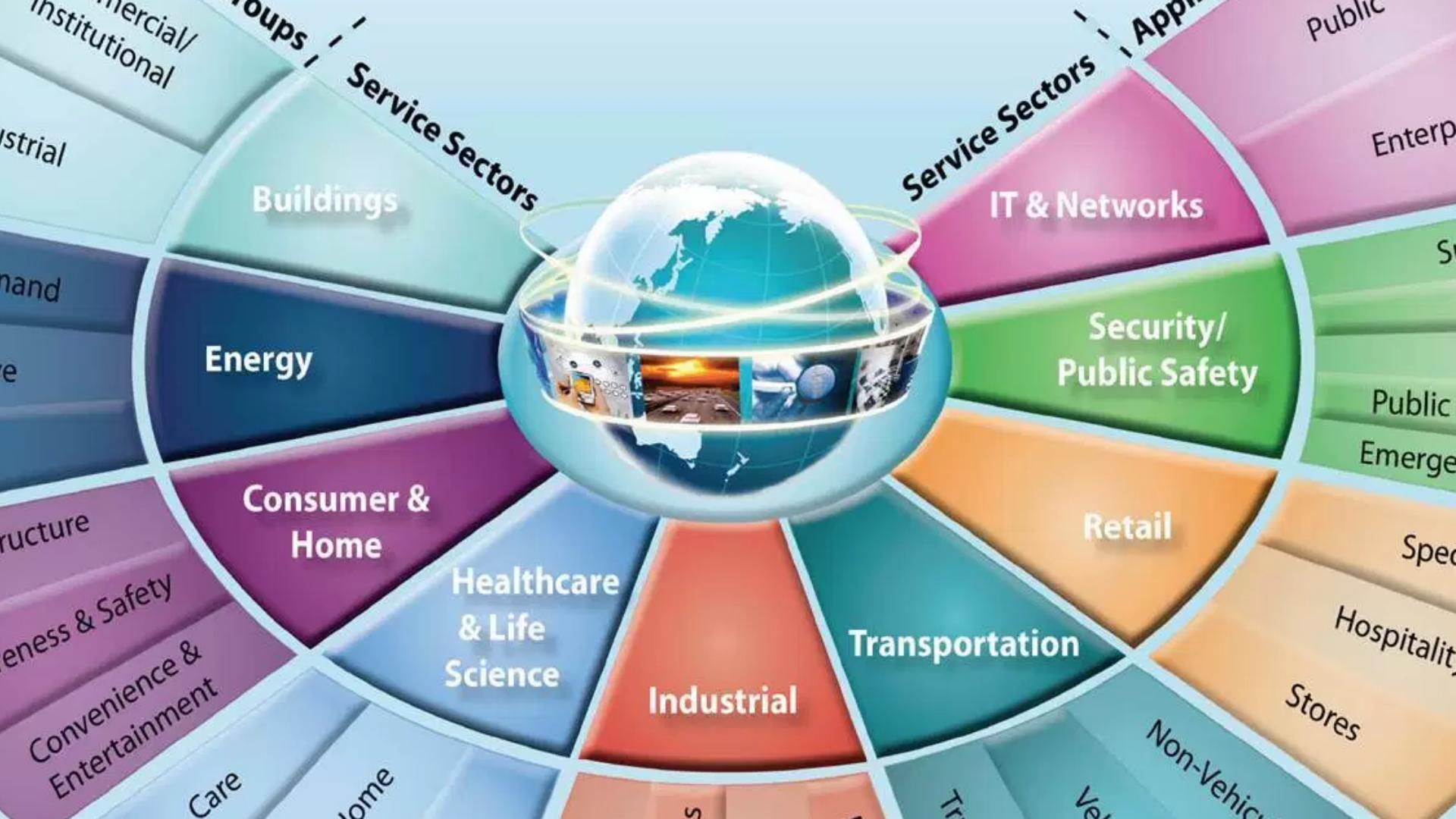


# Characteristics (7): Ecosystem

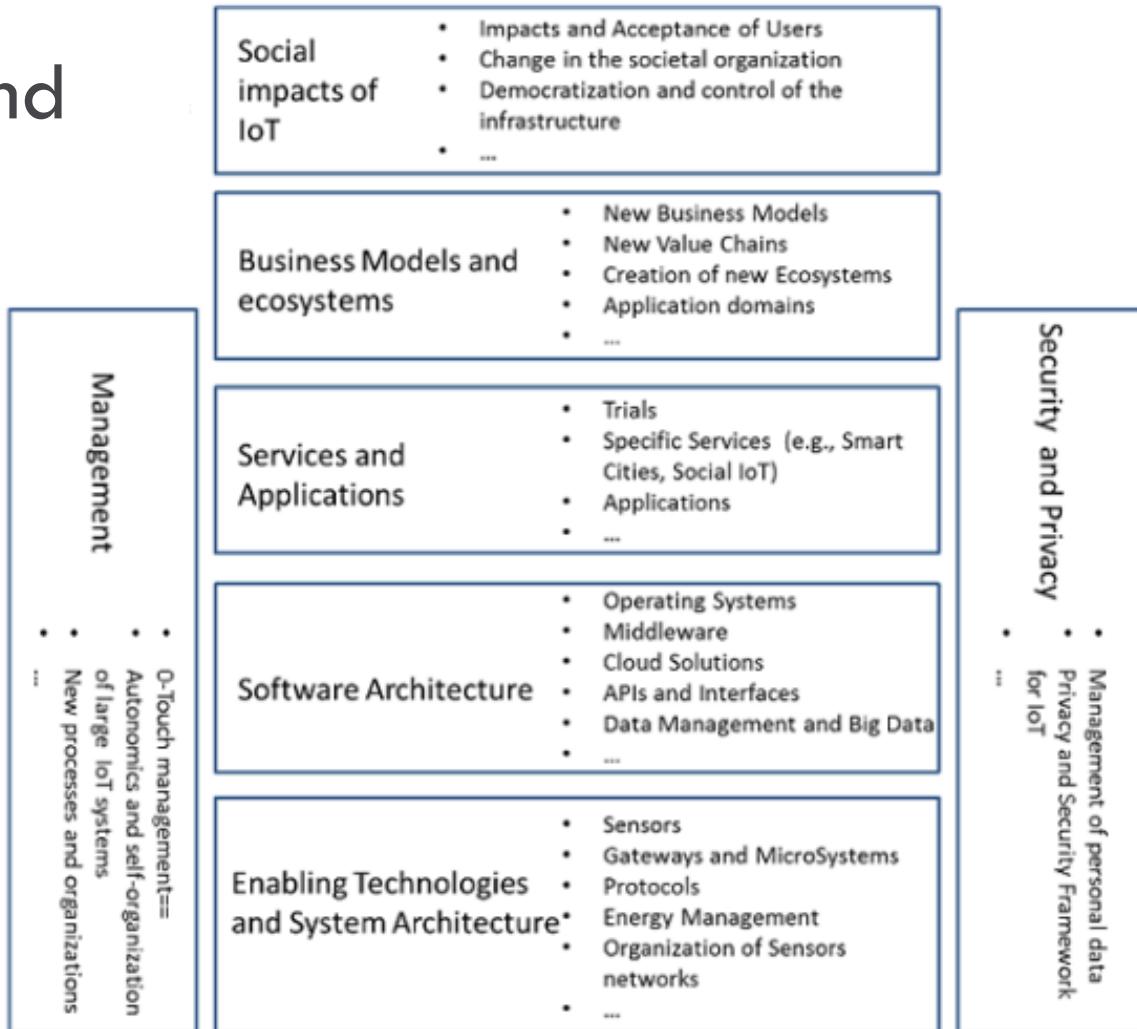
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- The place of the Internet of Things from a perspective of other technologies, communities, goals and the picture in which the Internet of Things fits.
- The Internet of Everything dimension, the platform dimension and the need for solid partnerships.





# Technological and social aspects related to IoT



# IoT Summary

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- The **Internet of Things** (IoT) is the network of physical objects that enables these objects to collect and exchange data. These objects are everyday items embedded with sensors to collect, analyze, and transmit data.
- The Internet of Things generally has these characteristics:
  - The device has connectivity, it is something physical, it collects data, it communicates, it is intelligent, it performs actions, and it is part of an ecosystem.

## 9.2. Smart Home

9.1. IoT

**9.2. Smart Home**

9.3. Smart Grid

9.4. Data Analysis



# Smart Home Learning Objectives

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- Explain smart technology
- Define smart home
- List generations of home automation
- Determine key aspects of smart home

# Smart technology – Definition 1

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- Smart technology (includes physical and logical applications in all formats) that is capable of adapting automatically to modify its behavior to fit the environment.
- It senses things using sensors to collect and analyze data to perform some action.
- It is also capable of learning, which is using its experience to improve performance, anticipating, thinking and reasoning about what to do next.

# Smart technology – Definition 2

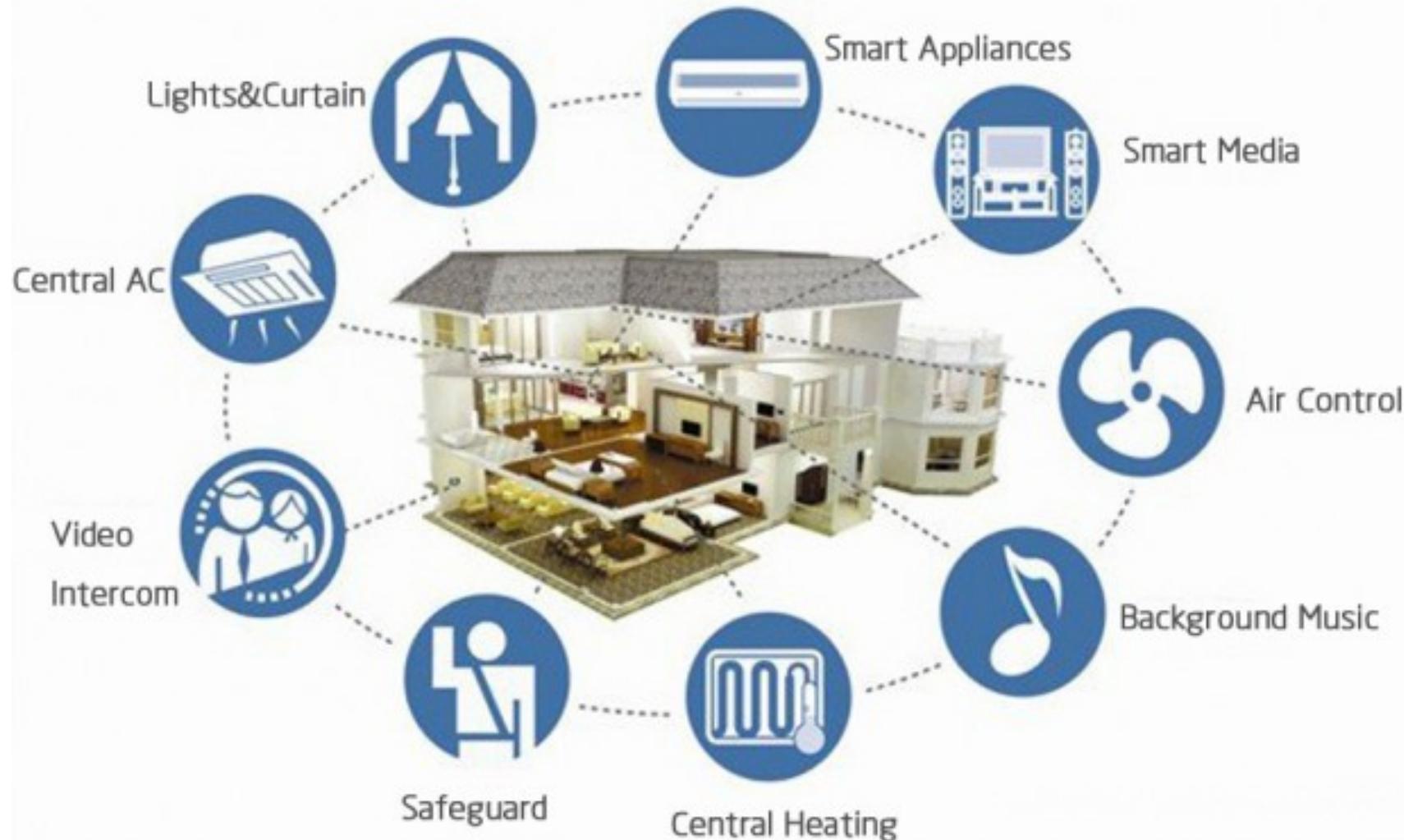
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- Technology that has sensors, data storage, and wireless access to collect and transmit data about the environment
- These smart devices provide data to the user
- More data collection and less automation



# Smart Home

- A smart home involves the control and automation of lighting, heating, ventilation, air conditioning, appliances, and security.
- Modern systems generally consist of switches and sensors connected to a central hub sometimes called a "gateway" from which the system is controlled with a user interface.
  - A wall-mounted terminal, mobile phone software, tablet computer, or a web interface.



# History

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- Early home automation began with labor-saving machines. Self-contained electric or gas powered home appliances became viable in the 1900s with the introduction of electric power distribution and led to the introduction of washing machines (1904), water heaters (1889), refrigerators, sewing machines, dishwashers, and clothes dryers.
- In 1975, the first general purpose home automation network technology, X10, was developed.
- By 1978, X10 products included a 16 channel command console, a lamp module, and an appliance module. Soon after came the wall switch module and the first X10 timer.
- By 2020, in the United States, according to ABI Research, 1.5 million home automation systems were installed.

# Generations of home automation

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- First generation
  - wireless technology with proxy server, e.g., Zigbee automation
- Second generation
  - artificial intelligence controls electrical devices, e.g., Amazon Echo;
- Third generation
  - robot buddy who interacts with humans, e.g., Robot Rovio, Roomba.

# Applications and Technologies

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- Heating, ventilation and air conditioning (HVAC)
- Lighting control system
- Occupancy-aware control system
- Smart grid integration
- Security
- Leak detection
- Indoor positioning systems
- Home automation for the elderly and disabled
- Pet Care

# Occupancy Sensor

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- A key aspect to smart homes is occupancy sensors
- An **occupancy sensor** is an indoor motion detecting devices used to detect the presence of a person to automatically control lights or temperature or ventilation systems.
- Infrared sensors
  - ▣ Heat difference detection, measuring infrared radiation
- Environmental sensors
  - ▣ Temperature, humidity and CO<sub>2</sub> sensors

# Heating, ventilation and air conditioning (HVAC)

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- Simple and friendly user interface to monitor and control home HVAC systems over the internet
  - Temperature reporting
  - Humidity control



# Lighting Control System

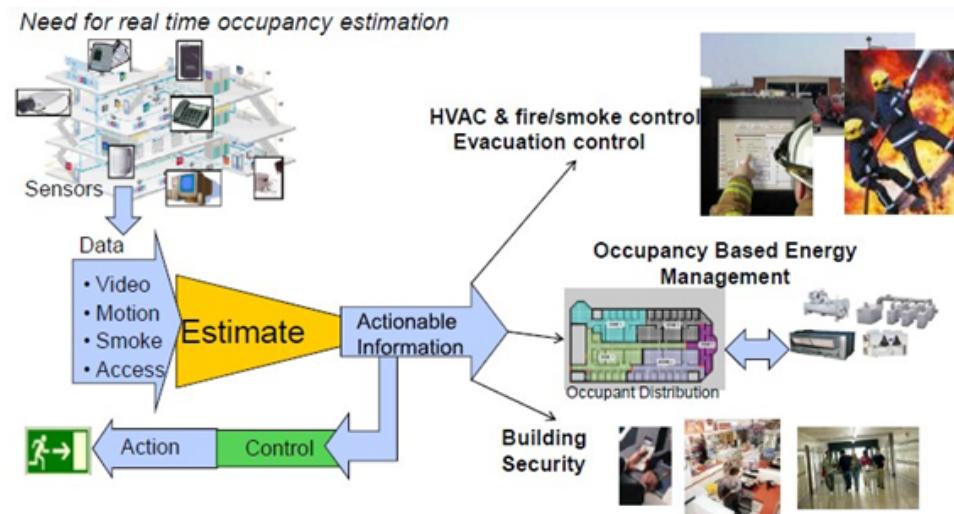
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- A system for controlling all of the home's lighting from a single panel or user interface
  - Voice commands
  - Motion sensors



# Occupancy-Aware Control System

- A system that monitors and controls the environment based on changes
  - Motion and sound
  - Temperature, humidity
  - Air quality
    - (CO<sub>2</sub>, gas leaks, mold spores, smoke)



# Smart Grid Integration

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- **Appliance control and integration with the smart grid**
  - For example, using power from the solar panel output in the middle of the day to run washing machines.



# Security

- A household security system integrated with a home automation system can provide additional services
  - Remote surveillance of security cameras over the Internet
  - Central locking of all perimeter doors and windows



# Leak Detection System

- Real-time alerts to harmful gasses in the home to a device
  - Smoke
  - CO<sub>2</sub> gas
  - Natural gas



# Indoor positioning systems

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- Locate objects or people inside a building using radio waves, magnetic fields, acoustic signals, or other sensory information collected by mobile devices
- Precisely determine someone's position based on their mobile device



# Home Automation for the Elderly and Disabled

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- Remote Monitoring
- Medication reminders
- Daily medical testing
- Remote medical consultation
- Security



# Pet Care

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- Tracking the pets movements and controlling access rights



# Smart Home Summary

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- **Smart technology** (includes physical and logical applications in all formats) that is capable of adapting automatically to modify its behavior to fit the environment.
- **Smart home** is a home that involves the control and automation of lighting, heating, ventilation, air conditioning, appliances, security, and other features.
- A smart house has automated features or IoTs to assist the occupants. Examples are occupancy sensors, lighting control systems, and security systems.

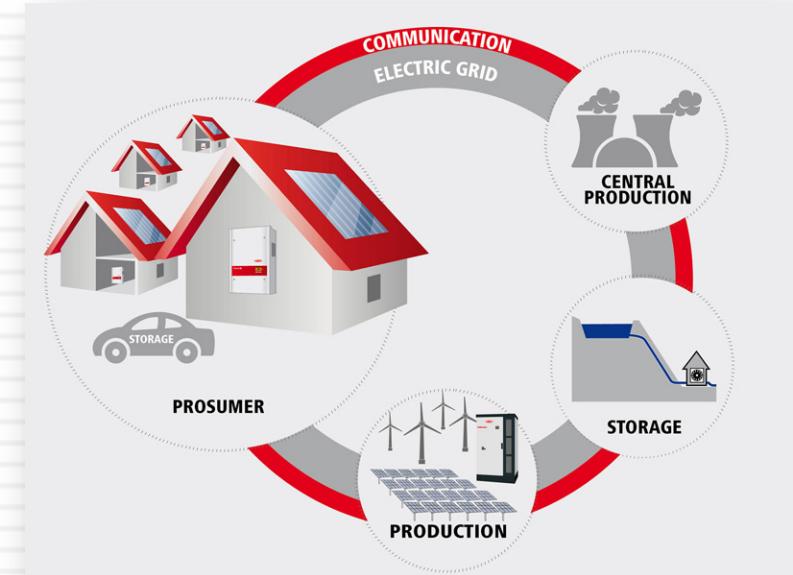
## 9.3. Smart Grid

9.1. IoT

9.2. Smart Home

**9.3. Smart Grid**

9.4. Data Analysis



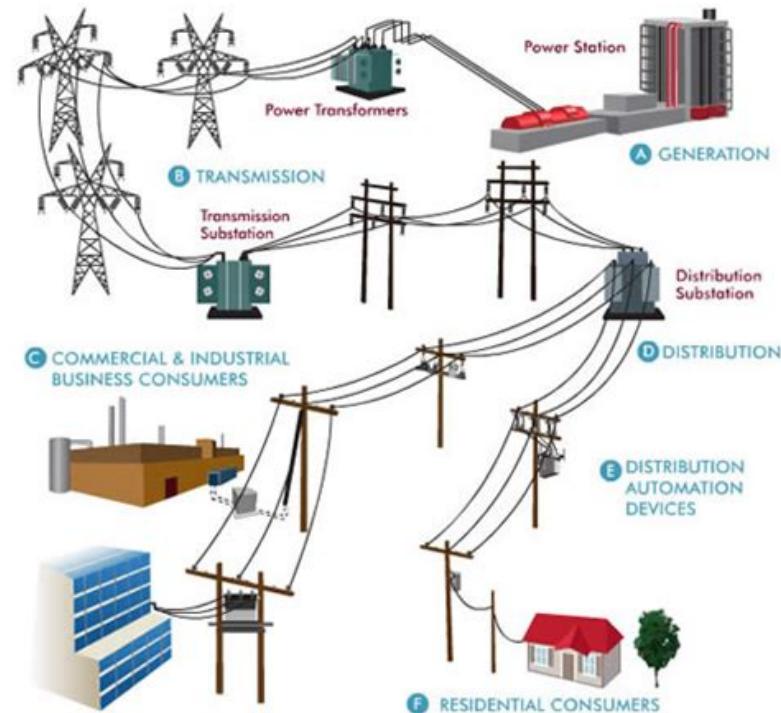
# Smart Grid Learning Objectives

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- Explain power grid
- Define smart grid
- Understand smart grid benefits

# The Power Grid (1)

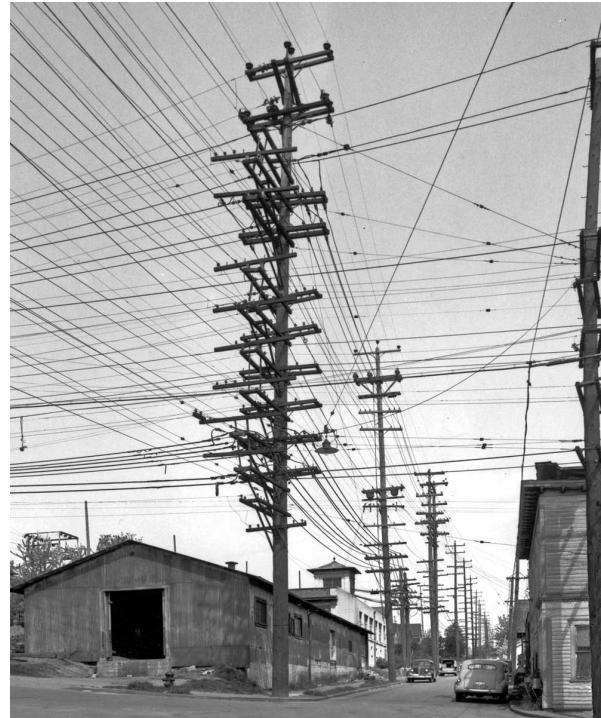
- The grid refers to the electric grid, a network of transmission lines, substations, transformers and more that deliver electricity from the power plant to your home or business.



# The Power Grid (2)

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- Our current electric grid was built in the 1890s
- Improvements were made with new technology
- However, it is based on the distribution model using centralized power generation



# A New Type of Grid (1)

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- To move forward, we need a new kind of electric grid to address growing needs
  - Fossil fuels are limited
  - Much energy is wasted
  - Large scale power generation stations are not sustainable



# A New Type of Grid (2)

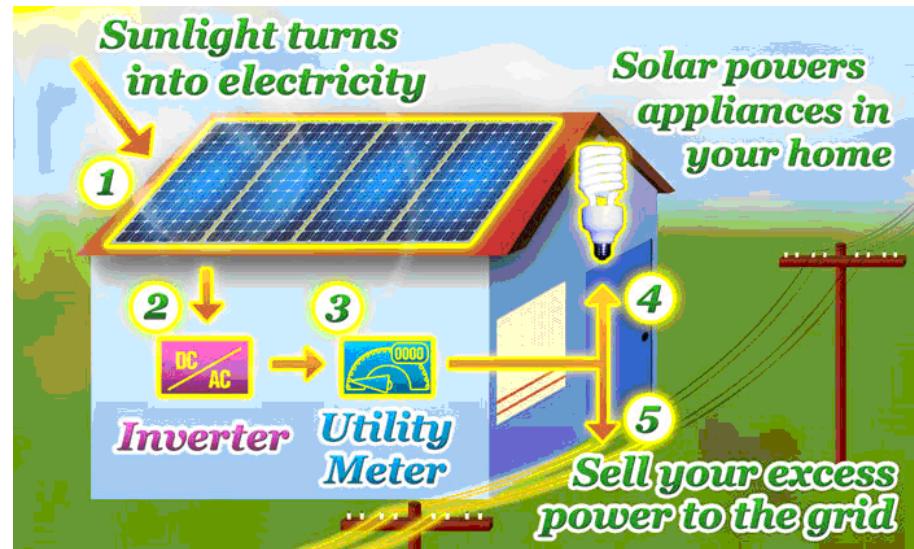
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- The smart grid allows someone to buy (use) or sell (contribute) electricity to the grid
- Customer use micro-power generation
  - Solar panels
  - Windmills
  - Waterwheels



# A New Type of Grid (2)

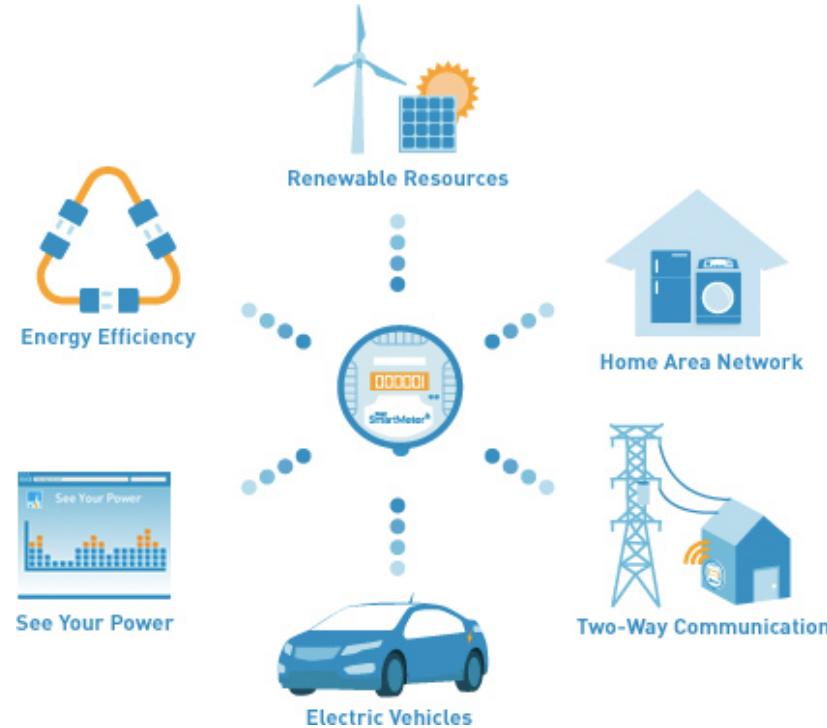
- A home owner uses their own generated electricity first, then electricity from the grid
- They sell excess electricity back to the grid

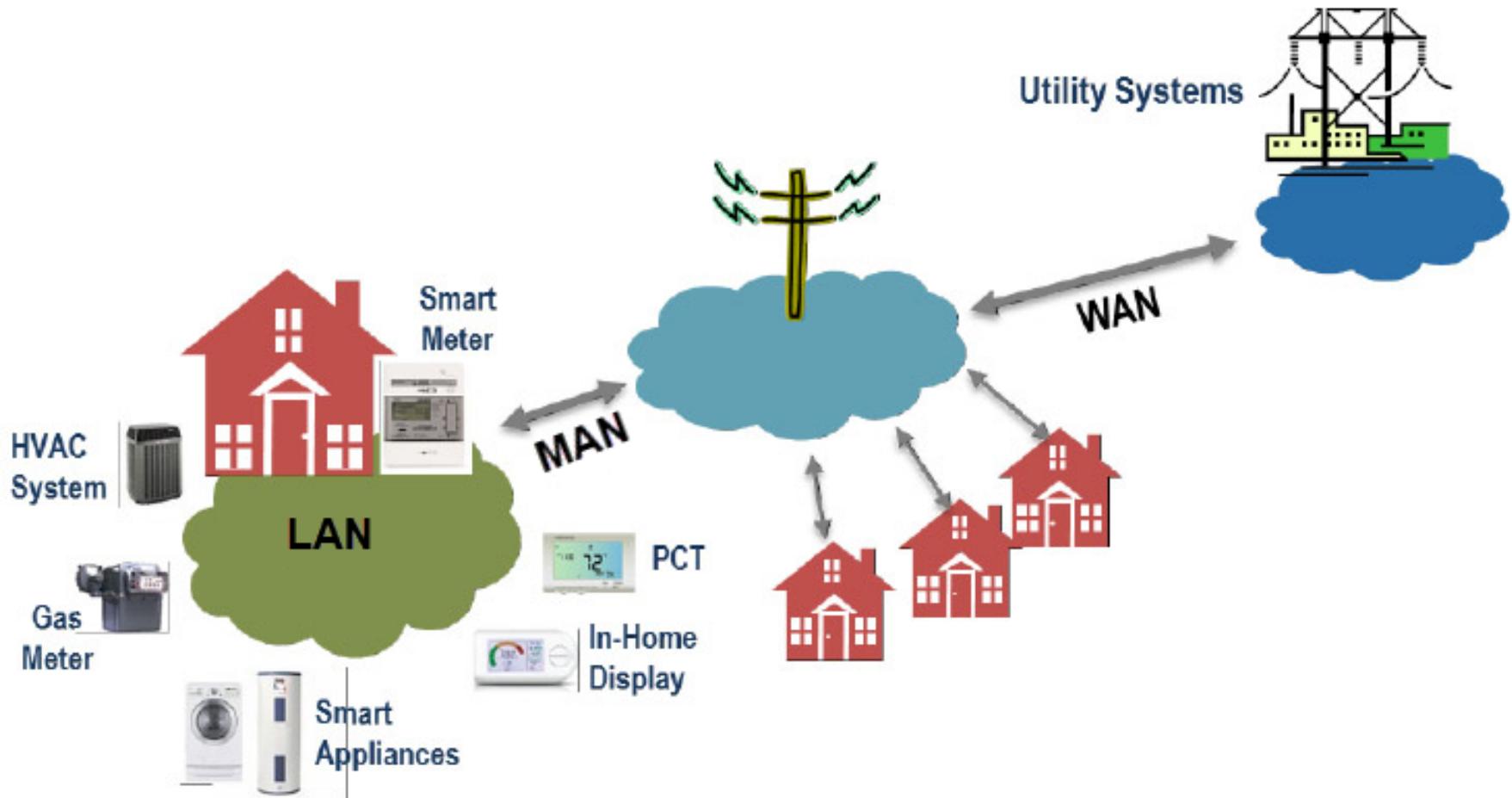


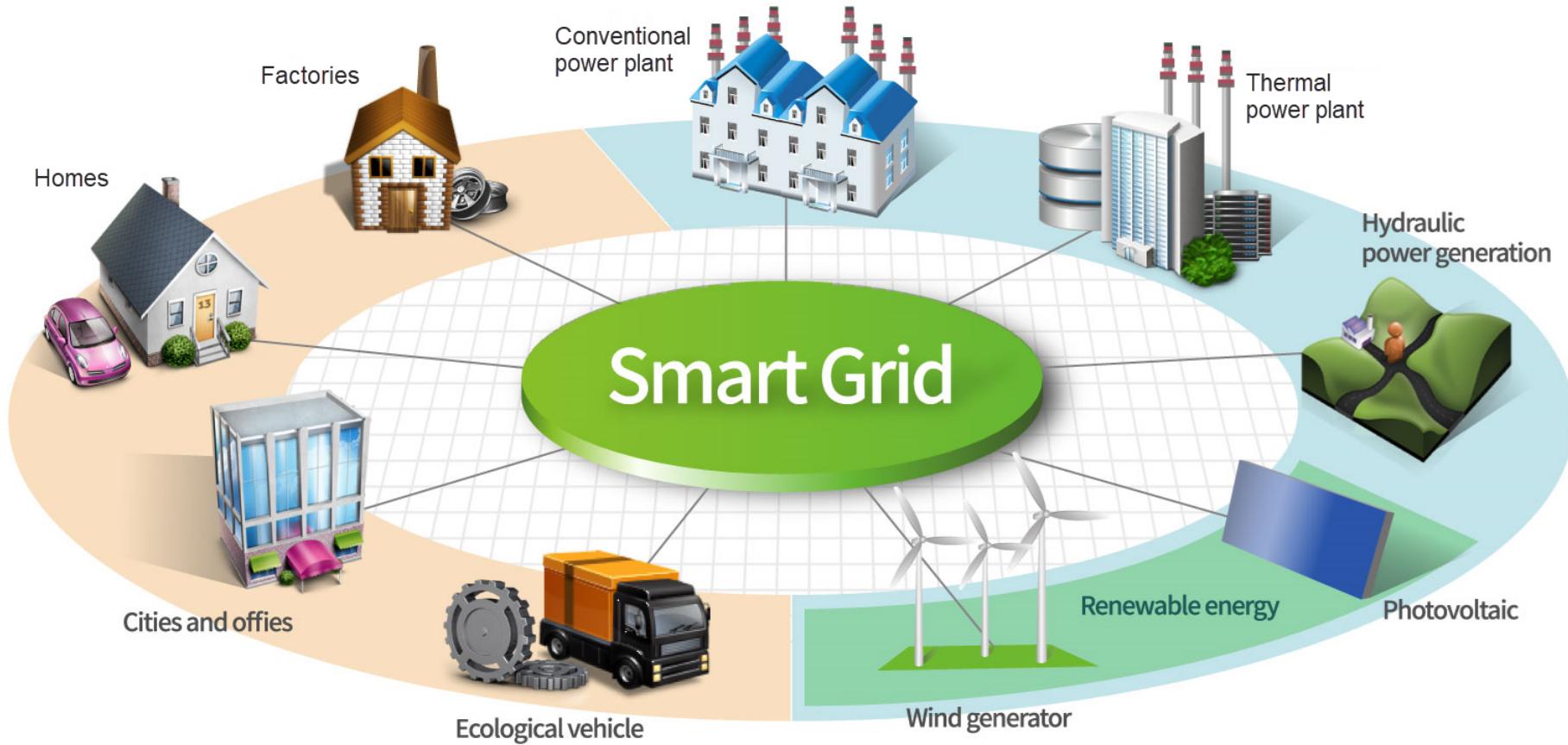
# Smart Grids (1)

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- A smart grid is an electrical grid which includes a variety of operational and energy measures including smart meters, smart appliances, renewable energy resources, and energy efficient resources



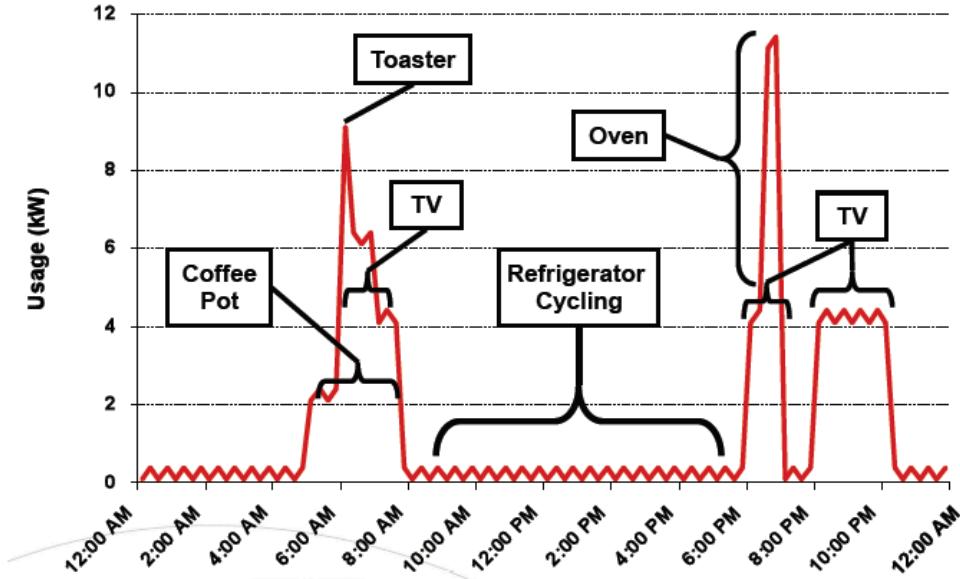




# Smart Grids (2)

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- Electronic power conditioning and control of the production and distribution of electricity are important aspects of the smart grid.



# Smart Grids (3)

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- Rolling out smart grid technology requires a fundamental re-engineering of the electricity services industry
- Resource intensive (time and finance)



# Smart Grids (4)

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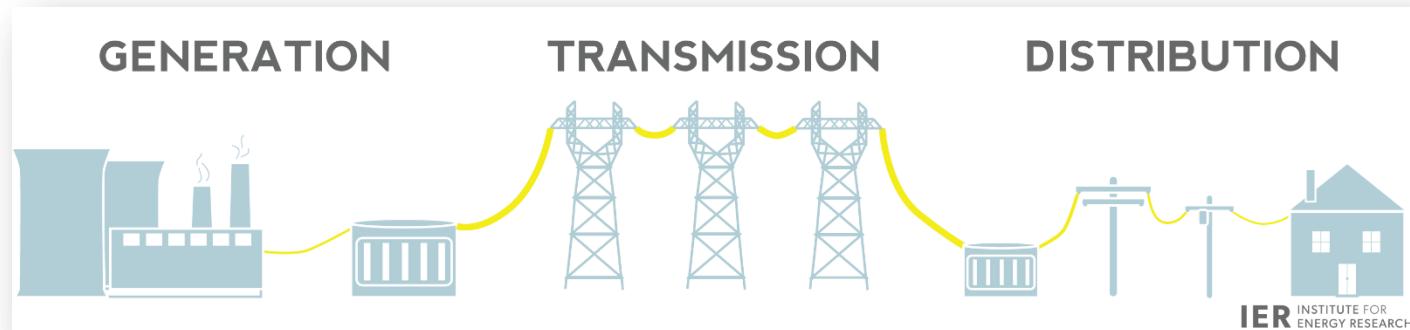
- The Smart grid represents an unprecedented opportunity to move the energy industry into a new era of reliability, availability, and efficiency that will contribute to our economic and environmental health.



# Smart Grid Benefits (1)

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- More efficient transmission of electricity
- Quicker restoration of electricity after power outages
- Reduced operations and management costs for utilities, which will lower power costs for consumers



# Smart Grid Benefits (2)

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- Reduced peak demand, which will also help lower electricity rates
- Increased integration of large-scale renewable energy systems
- Better integration of customer-owner power generation systems, including renewable energy systems



# Resiliency

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- Today, an electricity disruption such as a blackout can have a domino effect—a series of failures that can affect banking, communications, traffic, and security.
- A smarter grid will add resiliency to our electric power system and make it better prepared to address emergencies such as
  - Severe storms
  - Earthquakes
  - Large solar flares
  - Terrorist attacks
  - Human error



# Smart Grid Summary

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- A **smart grid** is an electrical grid which includes a variety of operational and energy measures including smart meters, smart appliances, renewable energy resources, and energy efficient resources.
- Smart grid benefits: more efficient transmission of electricity, quicker restoration of electricity after power outages, reduced operations and management costs for utilities, which will lower power costs for consumers and etc.
- A smarter grid will add resiliency to our electric power system and make it better prepared to address emergencies.

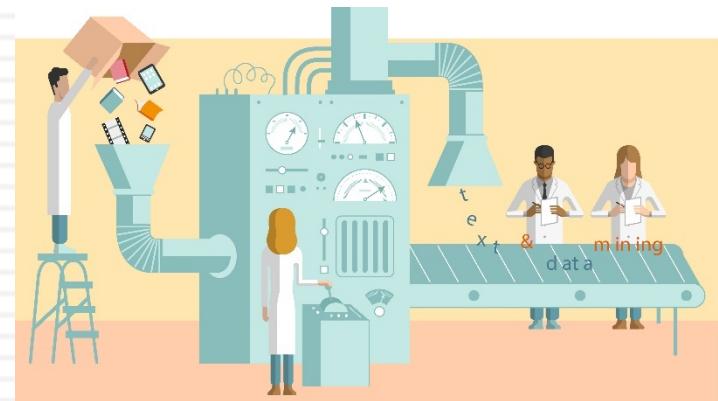
## 9.4. Data Analysis

9.1. IoT

9.2. Smart Home

9.3. Smart Grid

**9.4. Data Analysis**



# Data Analysis Learning Objectives

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- Define data analysis
- Explain the difference between data analysis and data science
- Understand benefits and challenges of data analysis
- List steps in data analysis
- Describe applications of data analysis

# Trends leading to Data Analysis

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- Companies around the world are generating vast volumes of data every year.
- Data has been generated at a rapid rate from social media websites and applications.
- Companies want to use it to make business decisions.

# Definition of Data Analysis

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- Data analysis is the process of **inspecting, cleansing, transforming, and modelling** data with the goal of discovering useful information, informing conclusions, and supporting decision-making.
- Companies use a lot of modern tools and technologies to perform data analysis.



# Data Analysis vs. Data Science

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- Data analysis is a component of data science, used to understand what an organization's data looks like.
- **Data analysis** describes the **current** or historical state of reality, whereas **data science** uses that data to **predict** and/or understand the **future**.



# Benefits of Data Analysis

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- Improved decision making
- Better customer service
- Efficient operations
- Effective marketing



# Improved Decision Making

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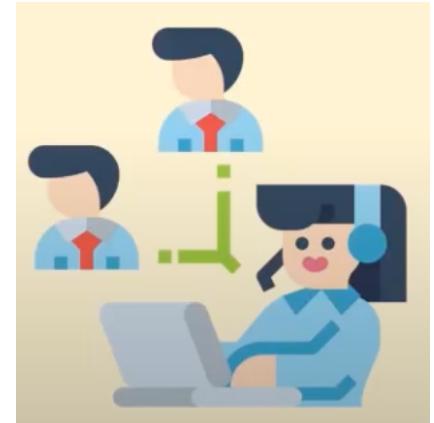
- ❑ Eliminate much of the guesswork
- ❑ Inform their decisions, leading to better outcomes and customer satisfaction
- ❑ Update your understanding as conditions change



# Better Customer Service

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- Tailor customer service to their needs, provide more personalization and build stronger relationships
- Reveal information about your customers' communications preferences, their interests, their concerns and more



# Efficient Operations

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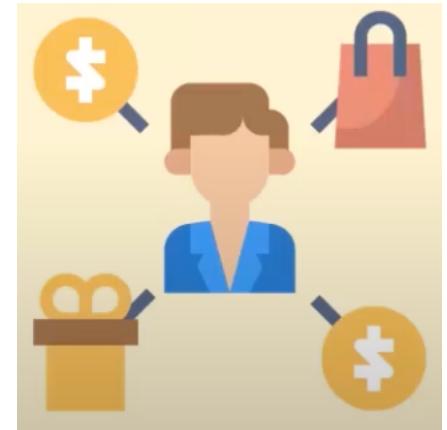
- ❑ Waste less time on creating ads and content that don't match your audience's interests
- ❑ Improved results from your campaigns and content strategies



# Effective Marketing

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- When you understand your audience better, you can market to them more effectively
- You can gain insights into which audience segments are most likely to interact with a campaign and convert



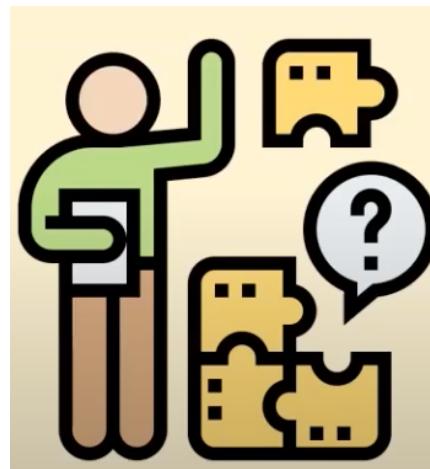
# Steps Involved in Data Analysis

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# 1. Understand the Problem

- Understand the business problem
- Define organizational goals
- Plan for a lucrative solution



## 2. Data Collection

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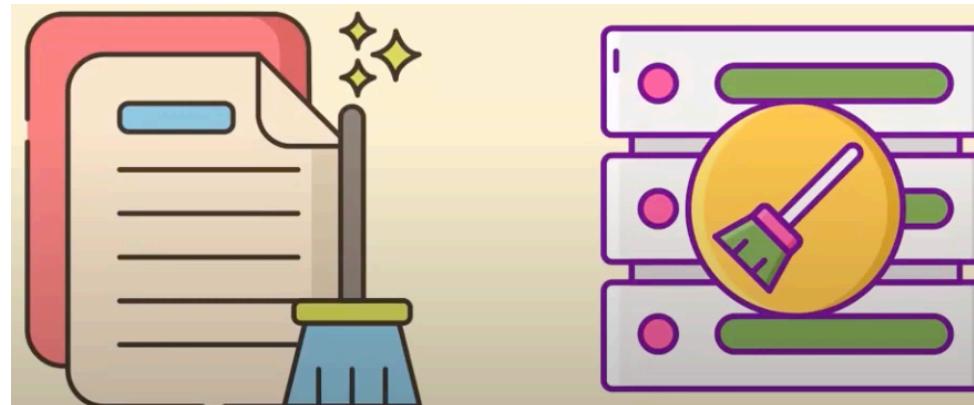
- Gather the right data from various sources and other information based on priorities



### 3. Data Cleaning

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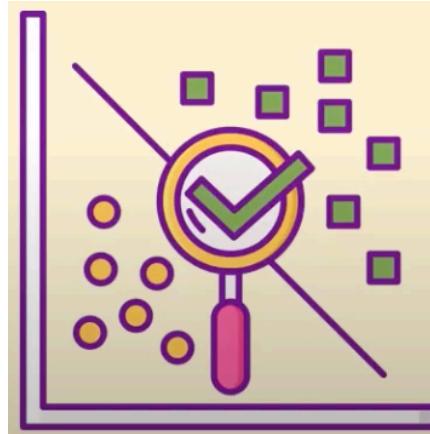
- Clean the data to remove unwanted, redundant and missing values and make it ready for analysis



# 4. Data Exploration and Analysis

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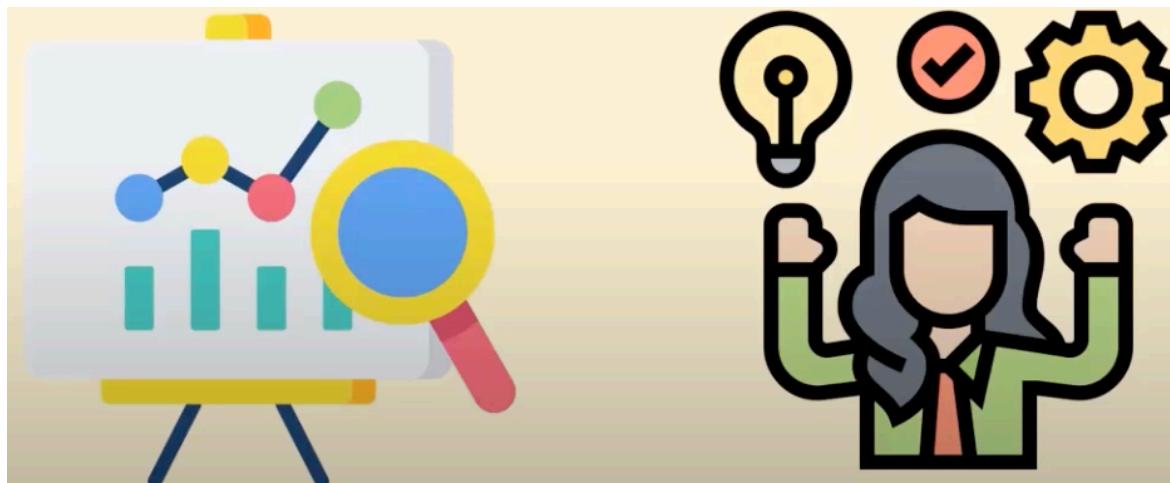
- Use data visualization and business intelligence tools, data mining techniques and predictive modelling to analyze data



## 5. Interpret Results

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- Interpret the results to find out hidden patterns, future trends and gain insights



# Data Analysis Applications

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- **Retail**
  - ▣ Understand customer needs and buying habits to predict trends, recommend new products
- **Health Care**
  - ▣ Provide lifesaving diagnoses and treatment options, better health profiles
- **Manufacturing**
  - ▣ Discover new cost saving and revenue opportunities, solve complex supply chain issues, labor constraints and equipment breakdowns
- **Banking**
  - ▣ Derive analytical insights and make financial decisions
- **Logistics**
  - ▣ Develop new business models, optimize routes, improve productivity

# Smart Data Analysis

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- Deals with the enormous amounts of data produced from sensor networks of smart technology projects (smart cities, smart homes and etc.)
- Analyzed for pollution control, security by preventing from thefts, energy conservation, traffic maintenance, disaster management and many more



# Challenges of Data Analysis

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- Collecting the data
- Storing the data
- Ensuring data quality
- Having the knowledge and tools necessary to make sense of the data



# Data Analysis Summary

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- **Data analysis** is the process of **inspecting, cleansing, transforming, and modelling** data with the goal of discovering useful information, informing conclusions, and supporting decision-making.
- **Benefits** of data analysis: improved decision-making, better customer service, efficient operations, effective marketing
- **Steps** involved in data analysis: understanding the problem, data collection, data cleaning, data exploration and analysis, interpretation of results.