LECTURER: Nghia Duong-Trung

DATA UTILIZATION

TOPIC OUTLINE

TOPIC OUTLINE

UNIT 5

DETECTION AND SENSING

STUDY GOALS

On completion of this unit, you will have learned …

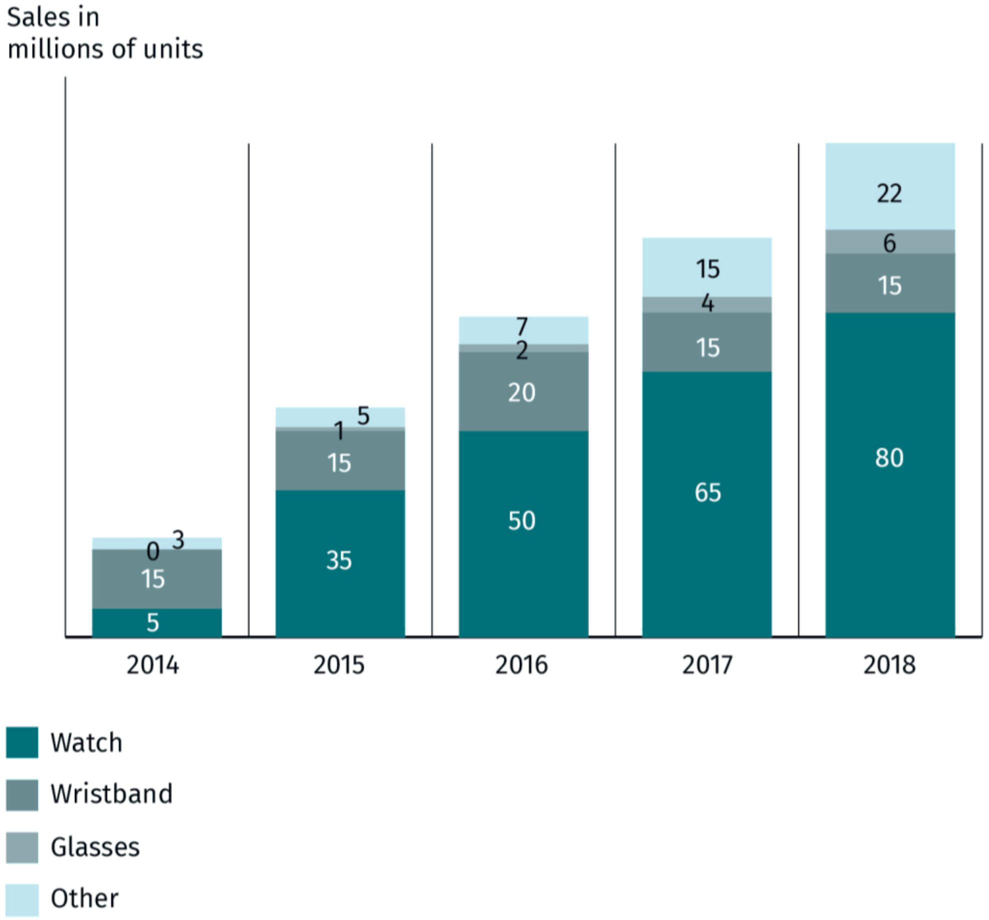
- … different types of sensors in daily life and industry.
- … the typical anatomy of a simple network-connected sensor.
- … underlying concepts and architecture of wireless sensor networks and Internet of Things (IoT) and their applications.
- … real case studies of sensor and IoT applications in farming, industry, and healthcare.
- … a case study of how to use sensors for intelligent surveillance.
- … the application of sensor networks in intelligent information systems.

EXPLAIN SIMPLY

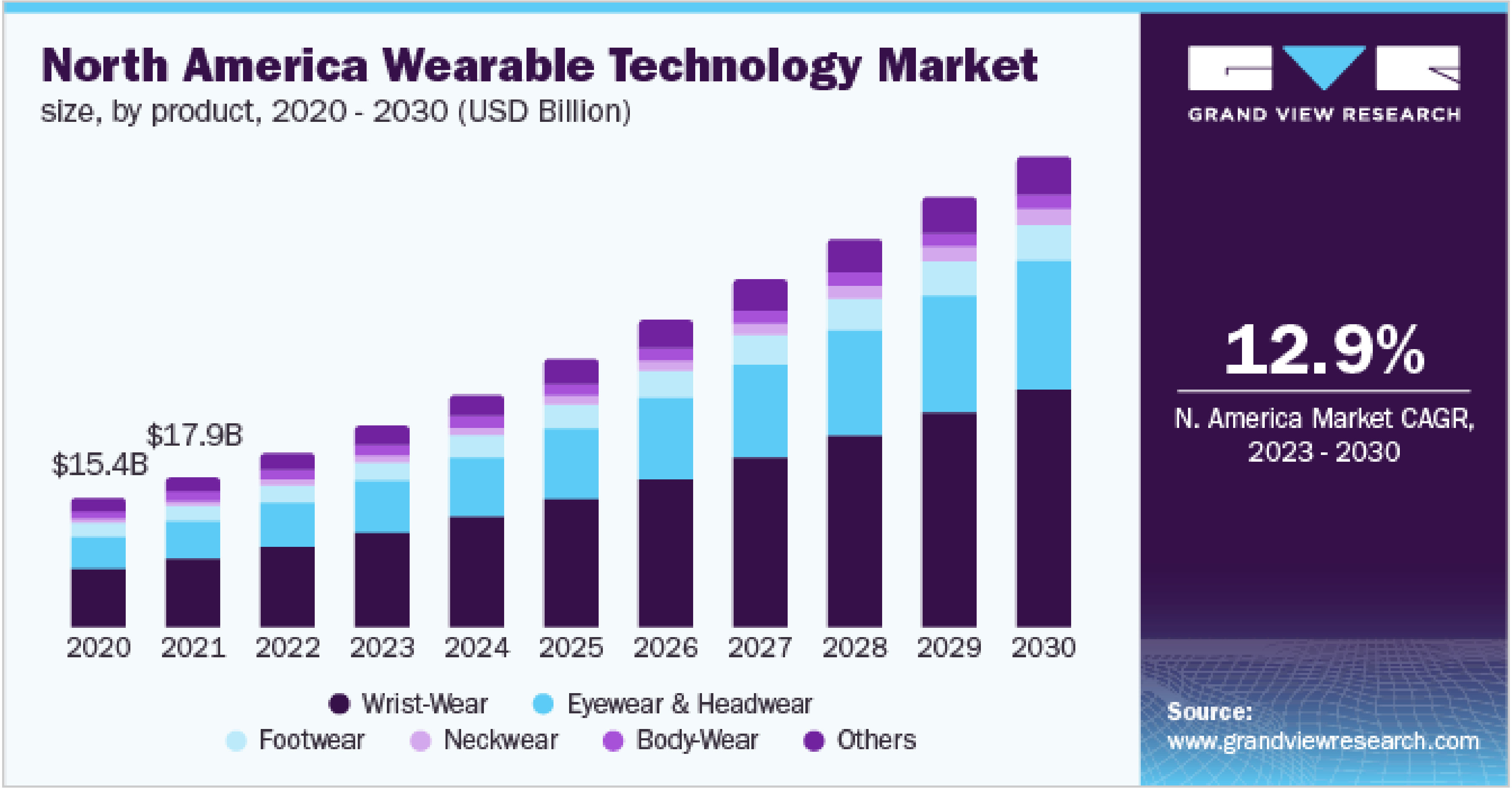
1. What is a sensor and what are its constituent modules?
2. Describe the usage of sensors in intelligent transportation.
3. What is the definition of Internet of Things (IoT)?

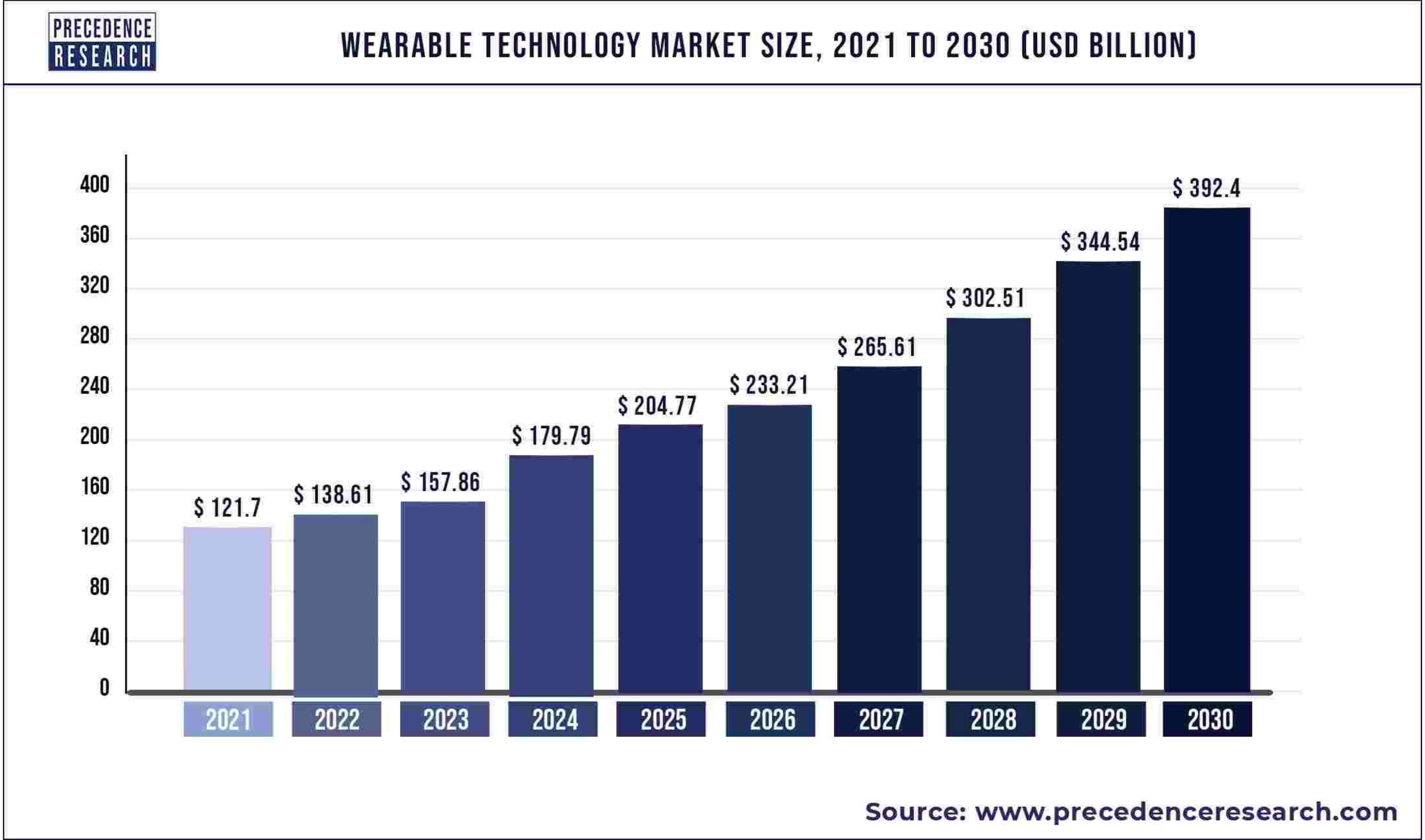
- Billions of sensors and smart instruments are widely used nowadays.
- Sensors, smartphones, tablets, wearable devices, and radio frequency identifications (RFIDs) are common technologies in our daily life that are embedded with sensing, computing, communication and most of them are increasingly connected to the internet.
- This results in the next technological revolution known as the Internet of Things (IoT).

Statistics on Annual Sales of Wearable Technologies



Source of the graphic: Course Book DLMBBD01, p. 122


North America Wearable Technology Market
size, by product, 2020 - 2030 (USD Billion)
$15.4B
$17.9B
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Wrist-Wear
Eyewear & Headwear
Footwear
Neckwear
Body-Wear
Others
GRAND VIEW RESEARCH
12.9%
N. America Market CAGR, 2023 - 2030
Source:
www.grandviewresearch.com


PRECEDENCE RESEARCH
WEARABLE TECHNOLOGY MARKET SIZE, 2021 TO 2030 (USD BILLION)
400
360
320
280
240
200
160
120
80
40
0
$ 121.7
$ 138.61
$ 157.86
$ 179.79
$ 204.77
$ 233.21
$ 265.61
$ 302.51
$ 344.54
$ 392.4
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Source: www.precedenceresearch.com

Sensors are devices that can…

– … detect **stimuli**, **events**, or **changes** in the environment and **send** this information to **other electronic devices**.

– … be used in **conjunction** with other devices, such as computers or smartphones, to **help make decisions** or **trigger actions** in our daily lives.

– … be used as convenient tools in **industrial IoT** and **cyber-physical systems (CPS).**

Common sensor applications:

smart cars, smart houses, manufacturing and machinery, airplanes and aero- space, healthcare and medicine, robotics

Common Sensors Integrated into Smartphones and Tablets:

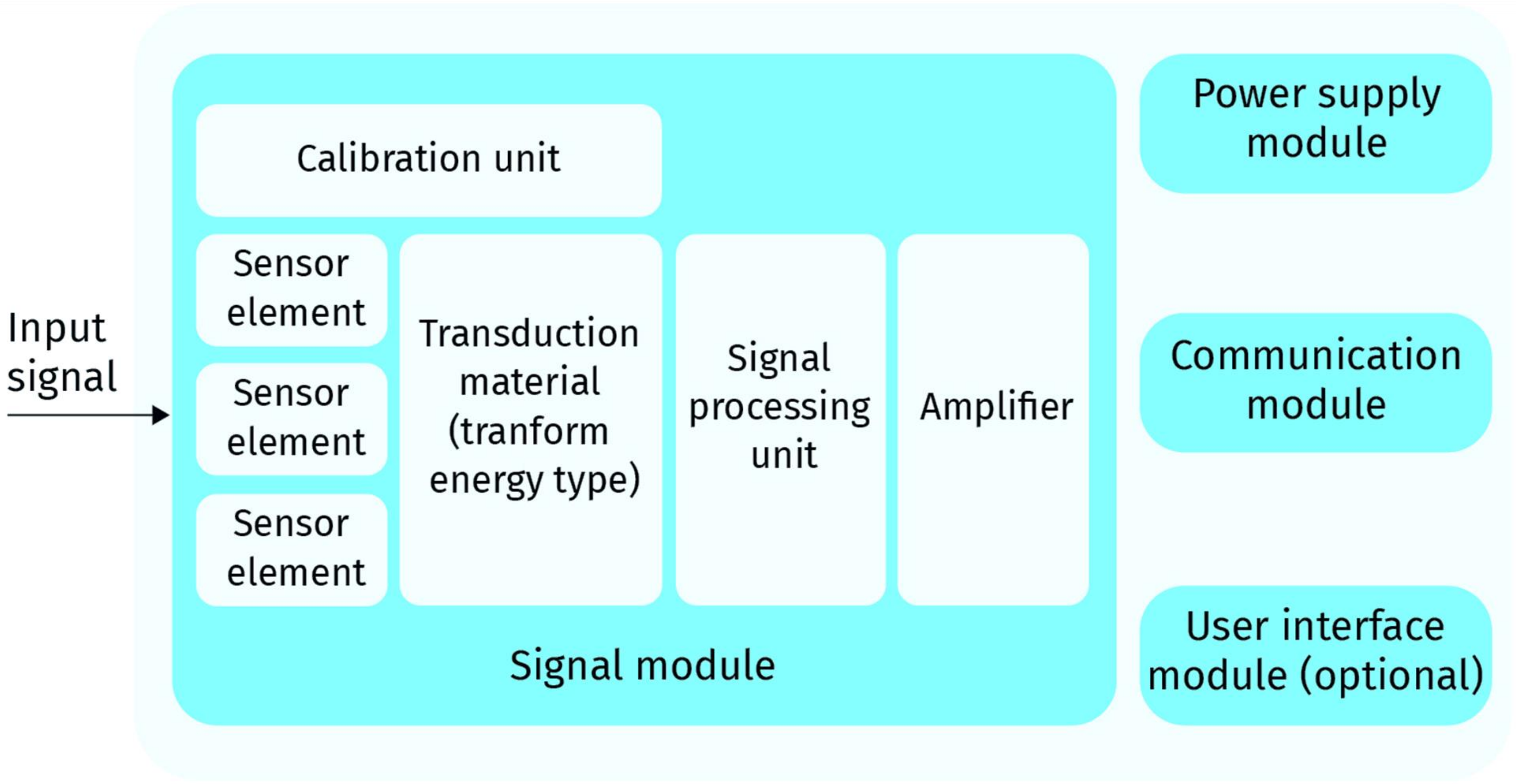
Microphone	Converts real-world sound and vibration into digital audio.
Camera	Senses visible light or electromagnetic radiation and converts it into digital images or video.
Gyroscope	Provides orientation information.
Accelerometer	Measures linear acceleration.
Compass or magneto-meter	Works as a traditional compass, providing orientation in relation to earth's magnetic field.
Proximity sensor	Finds the proximity of a phone from its user.
Ambient light sensor	Optimizes the brightness of the display.
Global positioning system (GPS)	Tracks a target or "navigates" to a target location using a map with the help of satellites.
Barometer	Measures atmospheric pressure.
Fingerprint sensor	Captures the digital image of a fingerprint pattern.

Smart network sensors consist of three main modules:

- **sensing:** receives energy in one and transforms it into another form
- **communication:** can be wired or wireless
- **power supply:** may be implemented internally (e.g., solar energy, internal rechargeable batteries) or externally

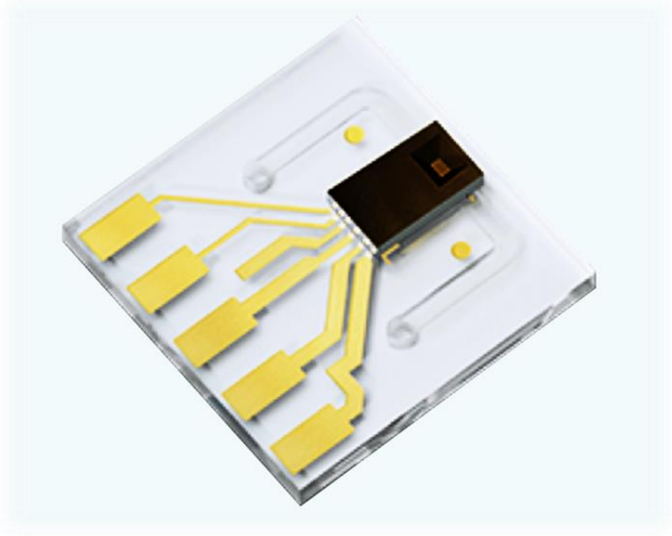
(**A user interface:** can be equipped with a user interface, such as small touch screens, to display useful data or take commands from the user for configuration purposes.)

TYPICAL ANATOMY OF A SIMPLE NETWORK-CONNECTED SENSOR



Source of the graphic: Course Book DLMBBD01, p. 126

Smart sensors can **process** a digital signal **before transmission**. The signal output is data that is **more reliable** and **robust** and with **less noise**.



Advantages of smart sensors:

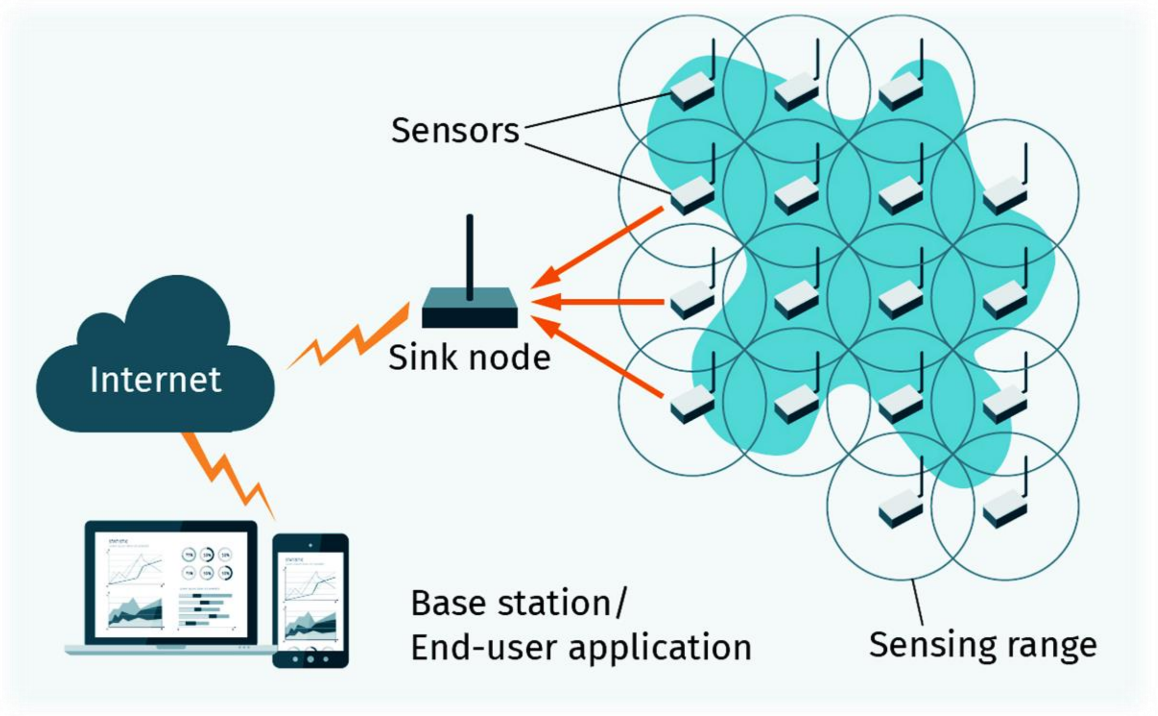
- Avoid sending unnecessary data.
- Reduce the communication load.
- Extend the battery life of the sensor.

Challenges:

- passing messages and networking activities in distant sensors
- privacy and security

Source of the graphic: Sensirion, n.d.

- **Wireless Sensor Network (WSN):** group of spatially distributed autonomous devices that use sensors to monitor and record physical or environmental conditions like temperature, sound, air pollution, humidity, and wind speed.
- A WSM system consists of several sensors. Each cluster of sensors is connected to a gateway (sink node), and each sink node is in turn connected to a wired or wireless network.



Source of the graphic: El Khamlichi et al., 2017

WIRELESS SENSOR NETWORKS

Primary applications of wireless sensor networks in remote monitoring:

- Asset tracking
- Environmental monitoring(air, water…)
- Structural monitoring (Building, Bridge…)
- Industrial machine monitoring
- Process monitoring

Definition:

– a network of physical devices, vehicles, home appliances, and other items equipped with electronics, software, sensors, and actuators, which enable them to connect, collect, and exchange data interactively.

Applications of IoT:

– smart vehicles, home automation, wearable technology, connected health, appliances with remote monitoring capabilities

Industries that highly benefit from IoT:

– health, manufacturing, farming, ...

IOT examples:

Health:
A smart health-monitoring system uses several smart devices, sensors, and medical instruments to monitor, track, and record a patient's vital medical and health data.

Manufacturing:
IoT-based systems can shorten the design and production cycle of new products, improve management of the supply chain, and reduce costs. IoT also creates new business and marketing opportunities.

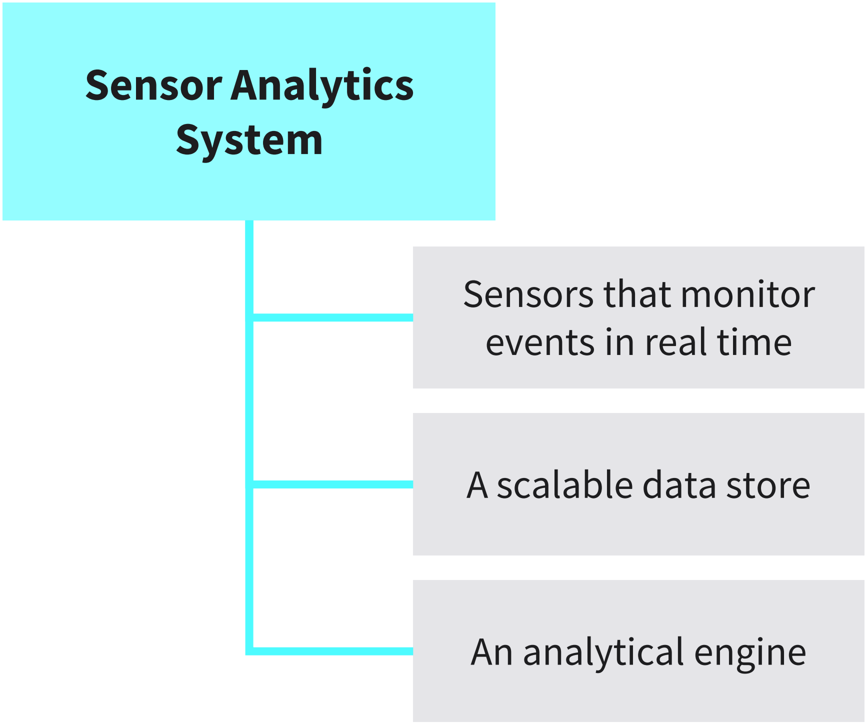
Farming:
Weather conditions, soil quality, temperature, rainfall intensity, humidity, wind speed, and pest infestation are a few examples of data which are of great importance to agriculture. Using smart farming apparatuses to gather such data has numerous benefits and advantages compared to traditional methods (waste reduction, cost management, increased performance, improved quality, mitigation of risks).

https://www.dfki.de/web/forschung/kompetenzzentren/smart-agriculture-technologies
https://www.lzh.de/en/innovation-fields/smart-agricultural-technology
https://www.iks.fraunhofer.de/en/topics/smart-farming.html
https://www.bmwk.de/Redaktion/DE/Artikel/Digitale-Welt/GAIA-X-Use-Cases/smart-health-connect.html
https://www.rethink-smart-manufacturing.de/
https://www.i-scoop.eu/industry-4-0/manufacturing-industry/

- Sensor analytics is the statistical analysis of data generated by sensors. Its primary goal is to detect anomalies in the data.

- A sensor analytics system has three parts.

- Analysis can be carried out either inside each sensor, in a sensor hub, or in the cloud.



APPLICATION OF SENSORS IN SURVEILLANCE - DEVICES FOR INTELLIGENT SURVEILLANCE

Cameras:

Surveillance cameras can reduce the staff needed to monitor vast areas like factories, stadiums, and refineries. Typically, surveillance cameras are connected to special recording devices which store videos for a specific period in case they need to be reviewed. To reduce the volume of recorded data, cameras often only record when a movement is detected.

Aerial:

Aerial surveillance captures images and videos by means of flying objects such as quadcopters or aircrafts. Due to modern aerospace and information technologies, undertaking aerial surveillance is now accessible.

Biometric:

Smart surveillance is not only limited to imagery. It is very common to use other human physical or behavioral biometric characteristics for identification, authentication, and screening tasks.

Satellite imagery:

Imaging satellites operated by governments or private companies collect images of earth.

IOT devices:

IoT devices are considered a new source of data for intelligent surveillance.

INTELLIGENT SURVEILLANCE SYSTEM ARCHITECTURE

Sensor layer:

Different sensors gather data from the environment and transmit data to the integration layer.

Integration layer:

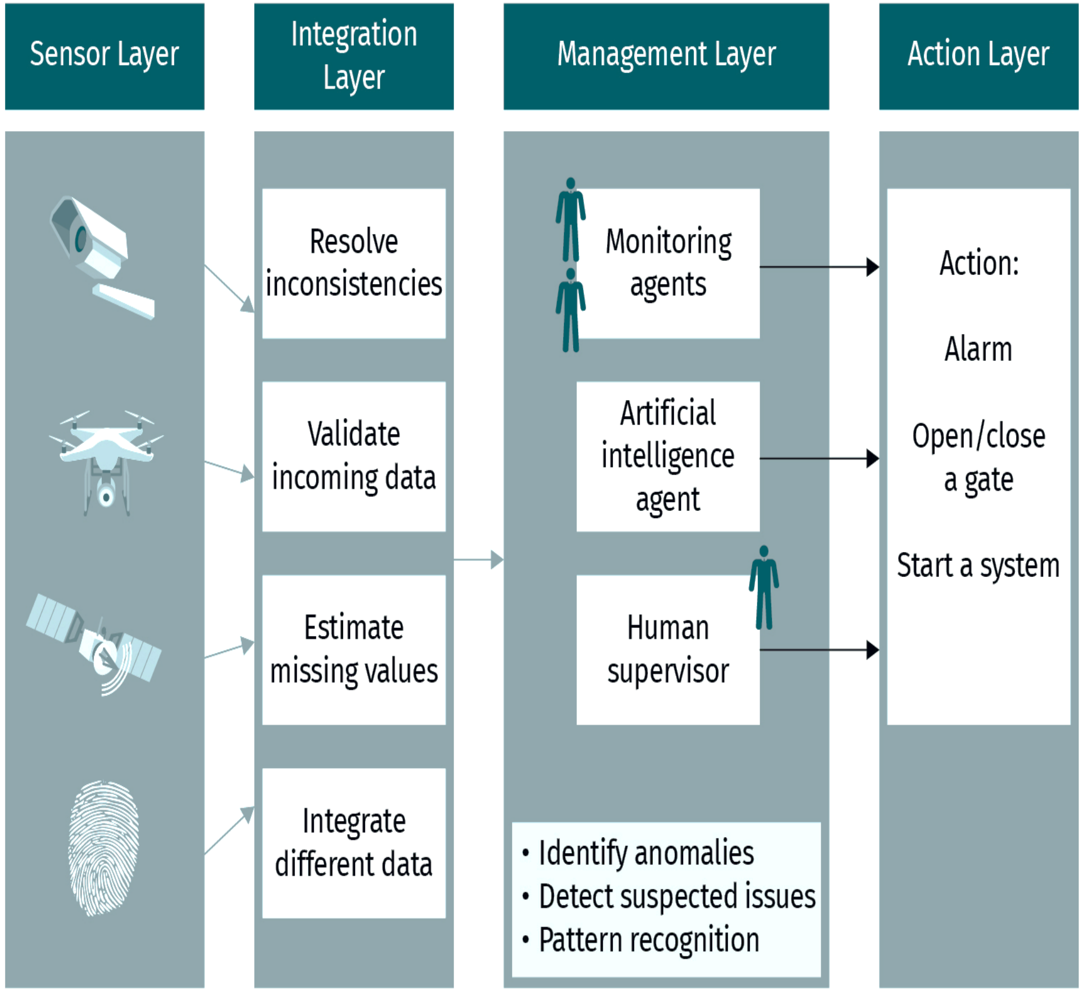
Gathers data, evaluates and validates incoming data, and resolves missing values and corrupted and inconsistent data.

Management layer:

Monitors the environment via screens installed in a centralized control room. Some parts of this task can be done automatically using artificial intelligence or machine learning methods.

Action layer:

Choosing the appropriate action in each case.

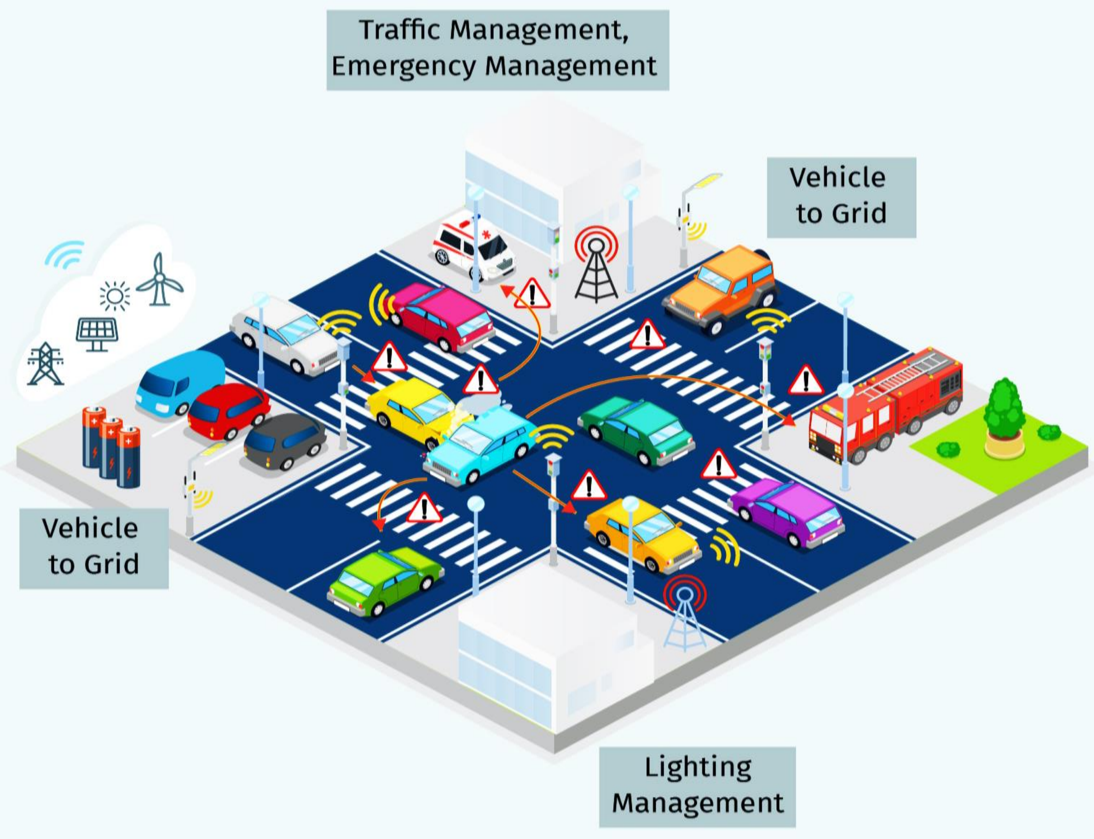


Source of the graphic: Course Book DLMBBD01, p. 136

Smart systems are used in almost all aspects of transportation, such as roads, railways, marine and aerial transport.

In-Car Sensors:	On-Road Sensors:
Tire pressure sensors, RADAR sensors, GPS sensors, video cameras, microphones, inertial sensors, exhaust gas sensors, infrared sensors, A/C sensors, fuel sensors, and rear-view visibility system sensors.	Traffic detectors, automatic vehicle identification (AVI), weight in motion sensors, speed detection, journey time monitoring, environmental sensors

Data gathered from in-car and on-road sensors can be transferred between cars, cars and local management systems, or transferred to a central monitoring center.



Applications:

- Traffic management, emergency management, lighting management etc.

Goals:

- optimizing transportation for shorter, faster, and more fuel-efficient routes
- improving the safety of transportation systems by imposing more controls on vehicles and pedestrians

Source of the graphic: Course Book DLMBBD01, p. 139

On completion of this unit, you will have learned …

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UNIT 6

PROBLEM-SOLVING

STUDY GOALS

On completion of this unit, you will have learned …

- … the process of knowledge management.
- … different approaches to knowledge representation.
- … different approaches for acquiring and using a knowledge management system.
- … the underlying concepts and architecture of a rule-based system.
- … the architecture and building blocks of an expert system.
- … some real-world applications of expert systems in problem solving.

EXPLAIN SIMPLY

1. Describe knowledge and a knowledge management system.
2. What are the principal building blocks of knowledge management?
3. What are rule-based systems?

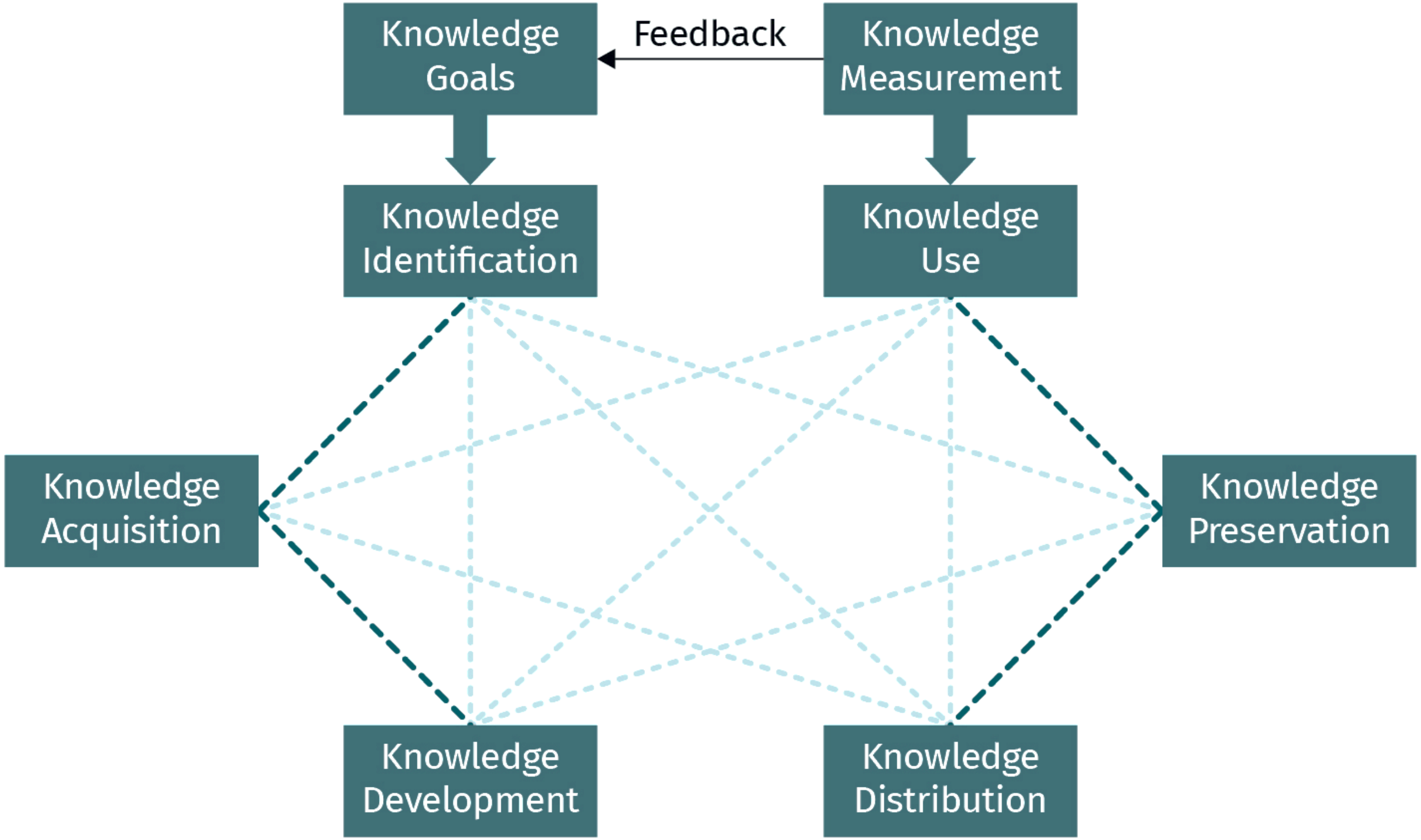
Knowledge

– a company's most valuable asset. The performance of a company depends heavily on how it manages knowledge and to what extent it utilizes this knowledge in an intelligent way.

Knowledge management

– is the process of capturing, storing, sharing (distributing), and using knowledge to execute various activities across a company in a productive and efficient manner.

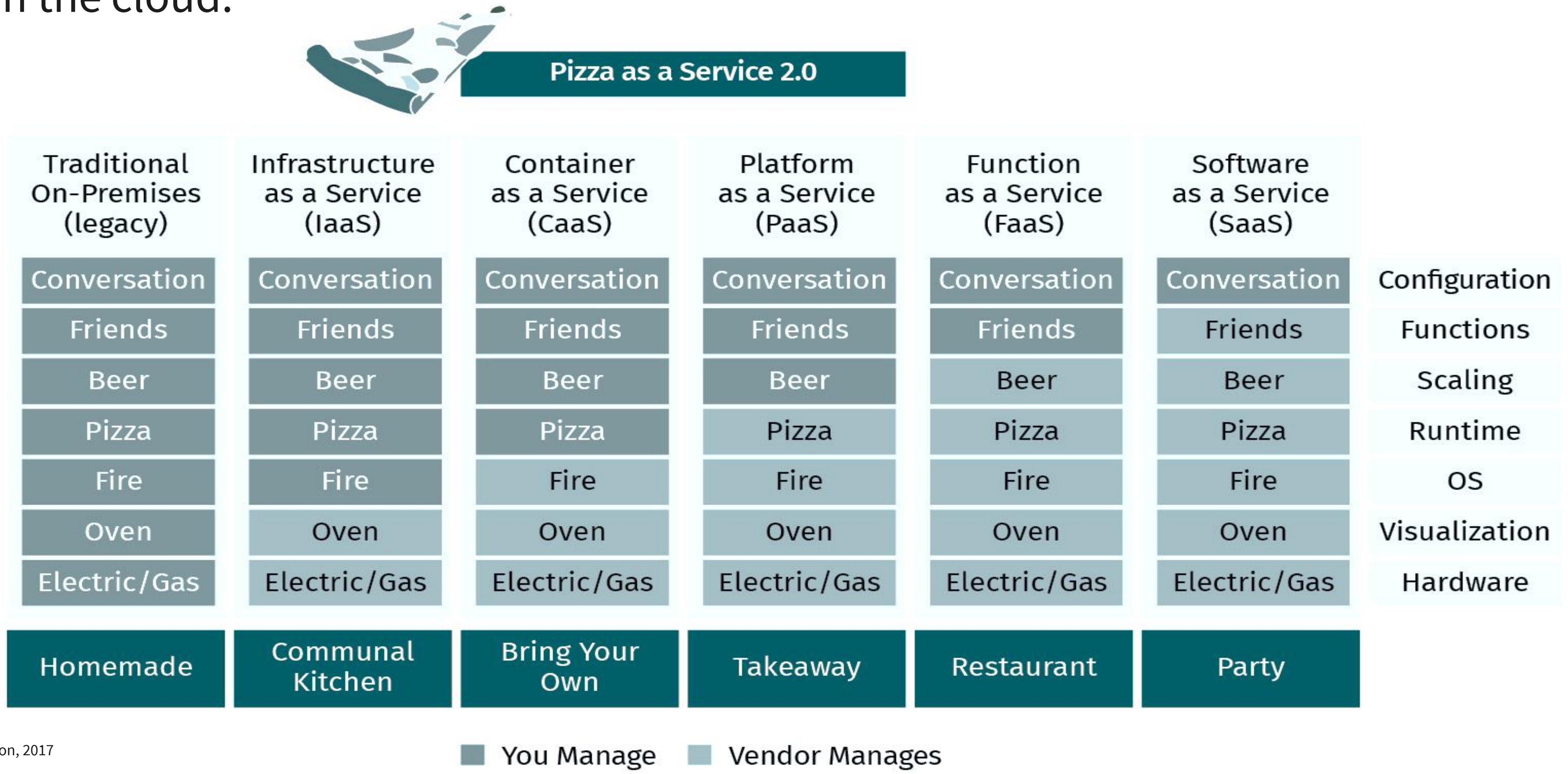
The common building blocks of a knowledge management system:



Source of the graphic: Course Book DLMBBD01, p. 147

- Cloud-based knowledge sharing brings new opportunities to both small and large companies wanting to manage their knowledge without dealing with the technical problems involved in the storage, distribution, and sharing of that knowledge.
- It allows organizations to focus on their business objectives, defining the process, guidelines, and policies of knowledge management.
- Tools: Microsoft SharePoint, Service Cloud, ProProfs, PALETTE

Pizza as a Service 2.0 framework shows various strategies that can be used in knowledge sharing on the cloud.



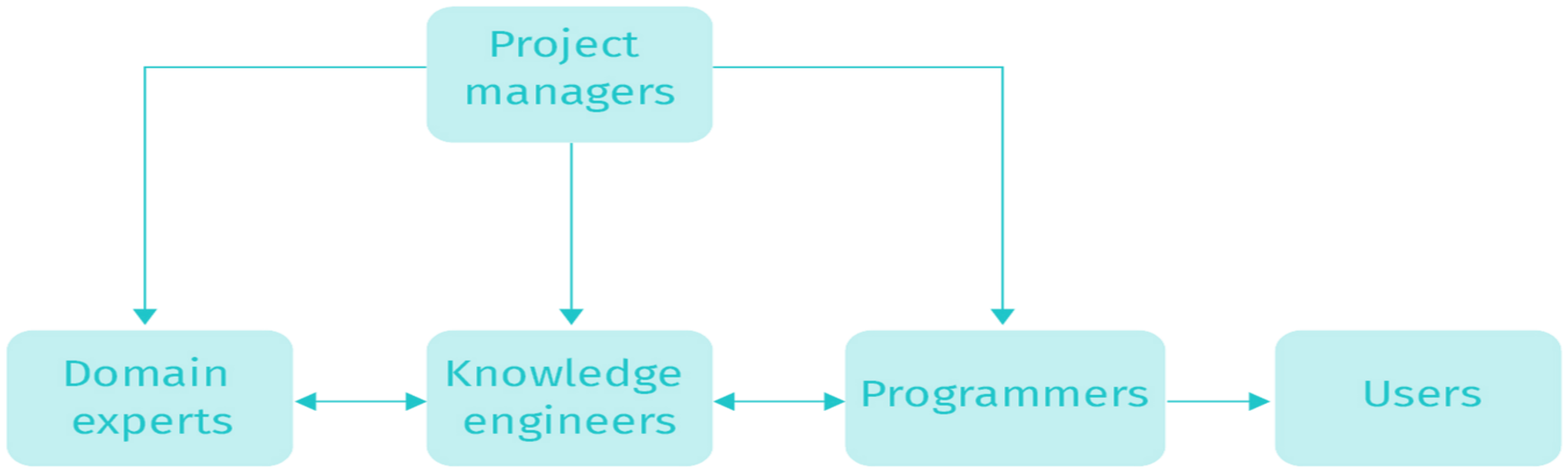
Source of the graphic: Kerrison, 2017

RULE-BASED SYSTEMS

- Rule-based systems are among the first attempts to make use of the powerful capabilities of artificial intelligence in problem-solving tasks.
- These systems are knowledge-based problem-solving applications which use methods of knowledge representation and inference.
- Knowledge can be represented and stored in different ways, such as semantic nets, frames, system architecture, ontologies, and rules.
- Ontology is an efficient way to represent concepts, their properties, and the relations between concepts.
- With rule-based representation, knowledge is represented in terms of a set of rules. Each rule has a common form of “IF P, THEN Q”, where P is a condition or property, and Q is the conclusion or consequent result.

1. Converting knowledge of the domain experts into IF–THEN structures to create rules.
2. Designing rules from the domain knowledge of the experts.
3. Converting the designed rules into actual computer programs.
4. Delivering the result to the users.

The whole process should be monitored and guided by a project manager.



Source of the graphic: Course Book DLMBBD01, p. 157

EXPERT SYSTEMS

- Expert system: intelligent model that tries to simulate the problem-solving process of human experts in a specific domain in the form of a software system.
- The knowledge base is the core of the system and contains the required knowledge to solve a specific problem. Typically, this knowledge is stored as a set of rules, as in rule-based systems.
- The inference engine has responsibility of receiving input data and parameters and then investigating the knowledge base and database if necessary, evaluating all existing alternatives corresponding to the present situation before choosing the best solution.
- The User Interface (UI) allows users to define their parameters and explain or report the situation to other authorized users.
- External sources can also provide data, apart from the user. These sources include information systems, Web services, and sensors.

APPLICATIONS OF EXPERT SYSTEMS

No.	Category	Application
1	Diagnosis	Recommend remedies/treatment for illness and trouble-shoot technical machine problems.
2	Repair	Suggest the planning schedule structure for repair of items and maintenance.
3	Instruction	Evaluate users’ abilities based on their current knowledge base and monitor their progress.
4	Interpretation	Analyze data input and determine its significance (compared to the knowledge base).
5	Prediction	Guess or make assumptions about the possible outcomes based on a data record.
6	Forecasting	Forecast gas prices.
7	Design and planning	Develop and decide on solutions within a short time, sometimes acting as a human expert.

APPLICATIONS OF EXPERT SYSTEMS

8	Monitoring	Compare observations to plan vulnerabilities
9	Control	Interpret, predict, repair, and monitor system behaviors.
10	Monitoring control	Monitor operations and control functions that are particularly important in decision-making.
11	Classification/identification	Classify or identify the objectives in the system based on different features or attributes.
12	Discovery	Aid a user in getting to, setting up, or otherwise exploring a system.
13	Debugging	Provide incremental solutions for complex problems.
14	Selection	Select the suitable machining tool.

REVIEW STUDY GOALS

On completion of this unit, you will have learned …

- … the process of knowledge management.
- … different approaches to knowledge representation.
- … different approaches for acquiring and using a knowledge management system.
- … the underlying concepts and architecture of a rule-based system.
- … the architecture and building blocks of an expert system.
- … some real-world applications of expert systems in problem solving.

Prompt Engineering for ChatGPT

https://www.coursera.org/learn/prompt-engineering?

SESSION 5

TRANSFER TASK

Select one of the following scenarios and explain how sensor networks in intelligent transportation systems can facilitate the condition.

Scenario 1: Unexpected Road Construction
Scenario 2: Intersections
Scenario 3: Abrupt Brake Accidents

Scenario 1: Unexpected Road Construction

Road maintenance activities become necessary from time to time. When a lane is under construction, traffic is directed to the remaining lanes. In order to undertake lane changes, drivers must have enough time to perform the necessary maneuvers. If traffic signs are not visible from a distance due to bad weather conditions, such as fog or a long truck blocking the driver’s view, it may become unsafe for drivers to change lanes in time. An intelligent transportation system may prevent this problem by directly communicating messages from the traffic signs to vehicles (roadside pole-to-vehicle communication). If a traffic sign on the roadside indicates construction work and is able to communicate this with a warning message to approaching vehicles, the probability of an accident due to late lane changes is considerably reduced.

TRANSFER TASK
PRESENTATION OF THE RESULTS

Please present your results.
The results will be discussed in plenary.

SESSION 5

TRANSFER TASK

TRANSFER TASK 2

1. Design a simple rule-based system based on your knowledge in a specific domain.
2. Select one of the applications of expert systems and describe how it works.

Please present your results.
The results will be discussed in plenary.

1. Which of the following is <u>not</u> an in-car sensor?
   a) noise sensor
   b) GPS
   c) radar sensor
   d) infrared sensor

2. Some sensor/signal parameters may need to use different values depending on the working conditions. Adjusting these parameters is the function of the…
    a) … monitoring and diagnostic module.
    b) … integration module.
    c) … automatic **calibration** module.
    d) … user interface module.

3. Using servers, storage, networking, and programming libraries is characteristic for…
   a) … container as a service.
   b) … **platform** as a service.
   c) … software as a service.
   d) … function as a service.

4. Conflict resolution in expert systems (or rule-based systems) is handled by…
   a) … the **inference** engine.
   b) … natural language processing.
   c) … the learning module.
   d) … the knowledge base.

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