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ICT-TEX

ICT-TEX course on Digital skills

Topic 6: Internet of things and embedded software systems

The course is developed under Erasmus+ Program Key Action 2:
Cooperation for innovation and the exchange of good practices Knowledge Alliance

ICT IN TEXTILE AND CLOTHING HIGHER EDUCATION AND BUSINESS

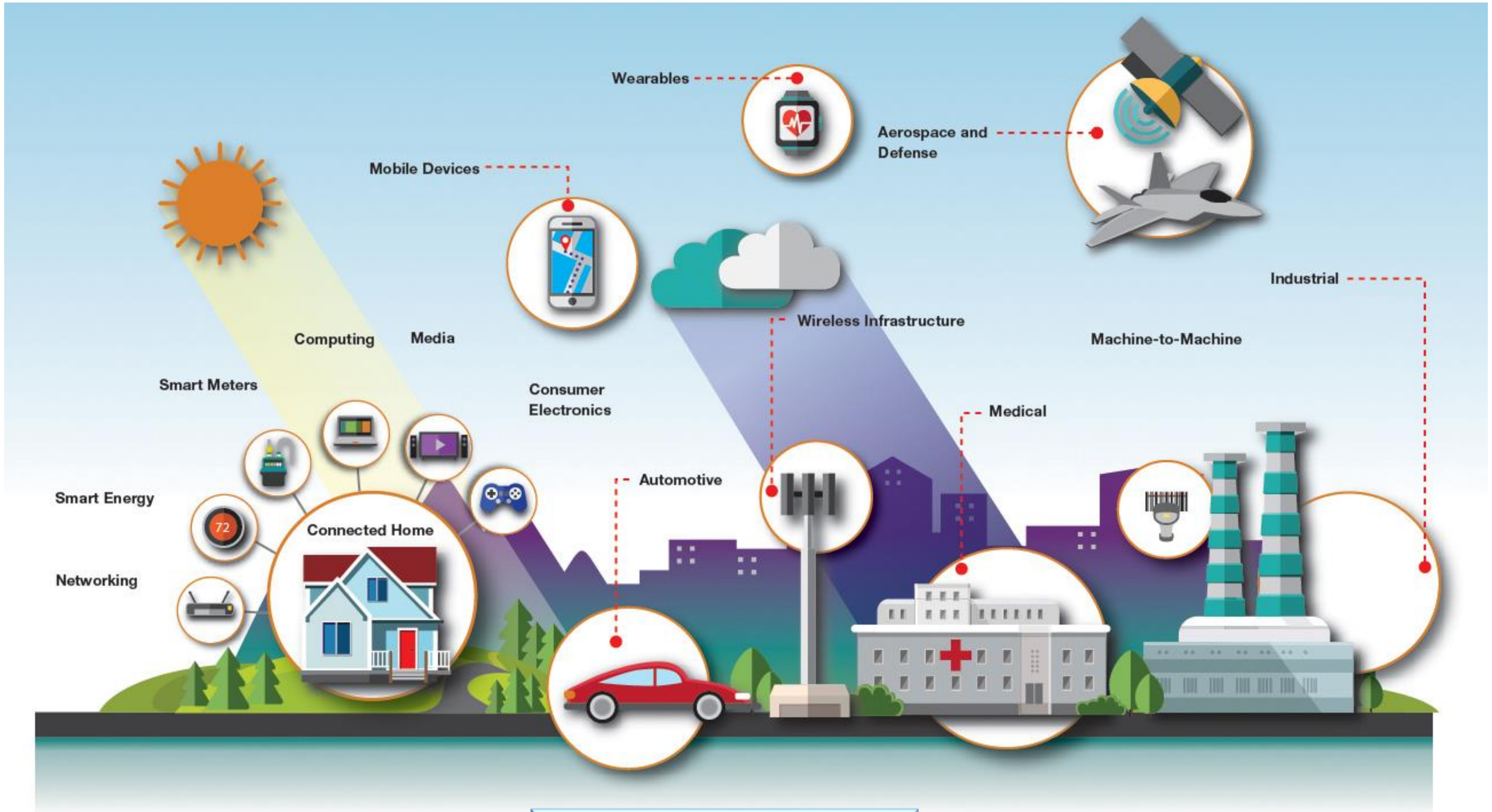
Project Nr. 612248-EPP-1-2019-1-BG-EPPKA2-KA

Contents

Introduction

- The Internet of Things (IoT) is a network of computing-enabled objects
- This comprise various devices like vehicles, buildings, wearable devices, home appliances, sensors etc.
- Network connectivity provides these objects with opportunity exchange data, which may be stored and analyzed

Where may IoT take place?

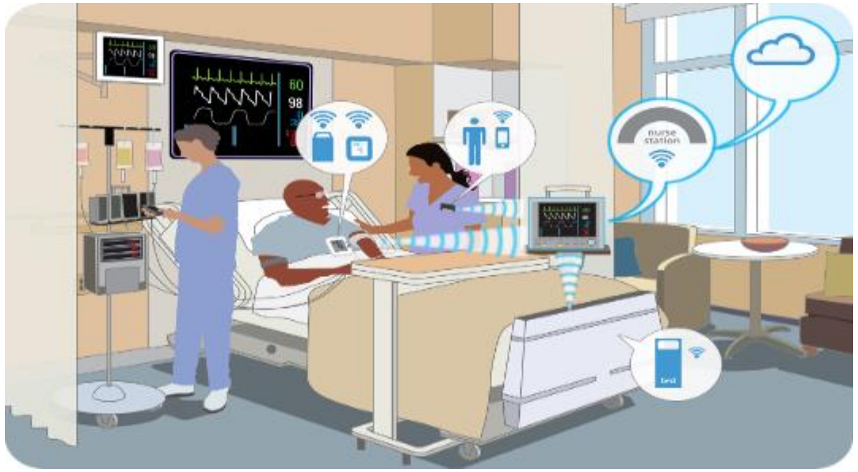


Smart Appliances

Wearable Tech

Automotive industry

Healthcare



Examples of IoT

The notion of *Thing*

- Things may be either physical or virtual
  - Physical things are objects of the environment like robots, home appliances, industrial processes, reservoir water level, etc.
  - Virtual things are software objects that also may affect our behaviour, like various content (video, audio, text), application software, database, Artificial intelligence software agents, etc.
- IoT concerns more the interconnection of physical things into a network, where they may send and/or share data
  - However, some application may also include virtual things in IoT

History and evolution

- Term IoT was first used at the end of 20th century
- There exist even earlier applications of interconnection of computing devices, embedded and controlling a larger physical system
- Actually, IoT is an extension of another ICT domain, named *Embedded Software Systems*, which dates back to the sixth decade of the 20th century

Characteristics of IoT

- Reliability
- Security
- Safety
- Data management
- Connectivity

Reliability

- **Strict definition:** The probability (i.e. a mathematical value) of failure-free (as per specification) operation over a specified time, in a given environment, for a specific purpose.
- Reliability is important attribute as it answers the question to what extent a user could be sure that the IoT software will behave as per their expectations

Safety

- Safety shows ability of IoT software to function, without danger of causing any kind of harm to its surrounding environment (humans, nature or equipment).
  - Note that this also consider malfunctioned software that could not be reliable but results of its malfunctioning could not be unsafe.
- In this respect it is very important to consider and reason about safety in terms of IoT software

Security

- Software security deals with design methods, infrastructure, and technology to prevent unauthorized or malicious access, modification, removal or usage of information.
- It is critical for IoT software as the latter should ensure that no unauthorized access may be gained to the process that is controlled by the embedded software
  - Recently privacy also became a crucial factor to be taken in mind when designing IoT systems

Data management

- The large number of interconnected devices produce also large amounts of data
- These data amounts are usually diverse in many of their characteristics, sometimes really large or other factors exist that hinders their processing

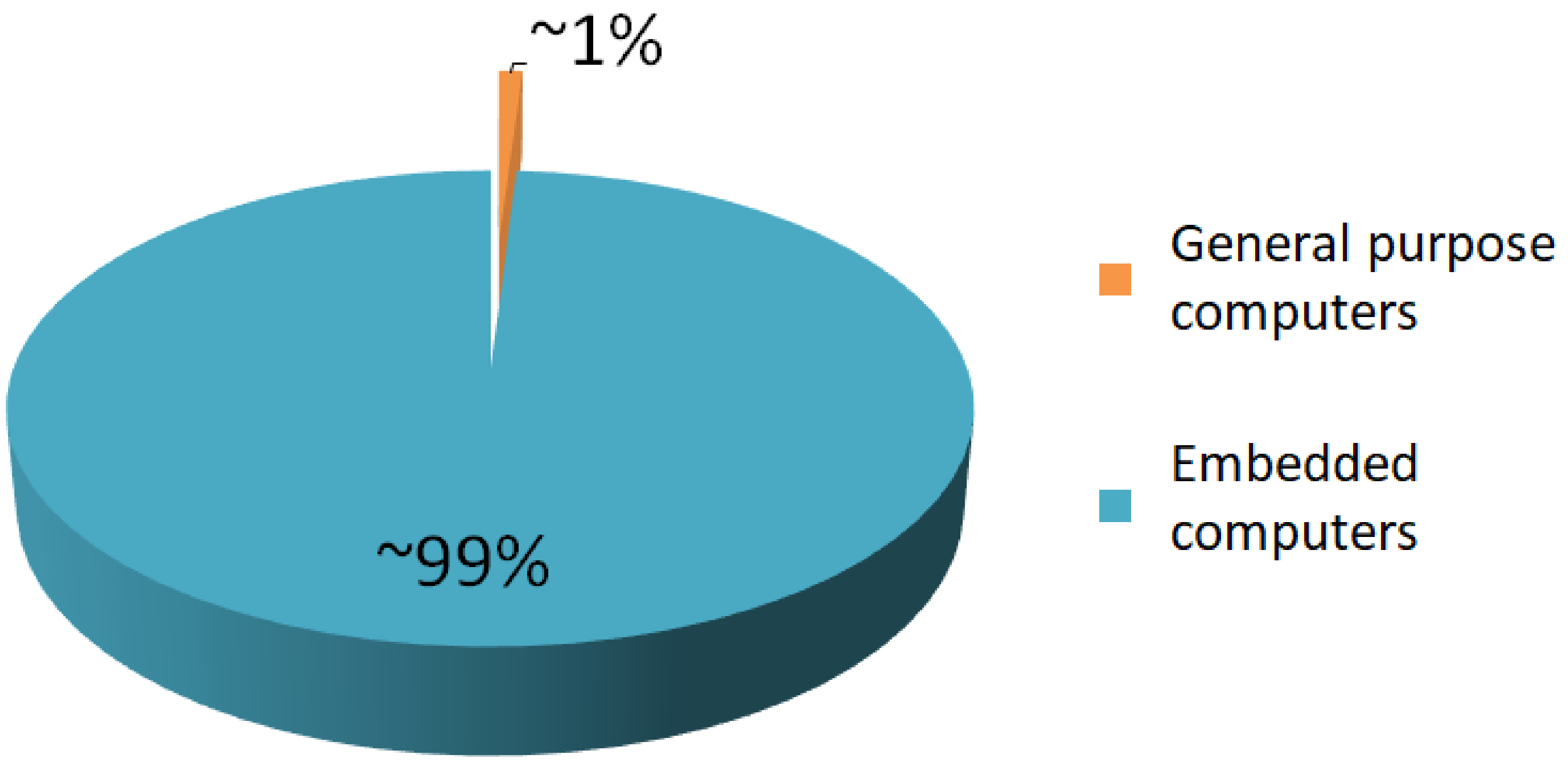
Connectivity

- General purpose network protocols used for Internet and WWW for example are not always suitable for IoT
- Sometimes embedded devices should operate under specific requirements like *real-time, low resource consumption, or typical industrial environment*
- For such reasons, networks and protocols specifically for IoT have been developed.

Embedded Software System (ESS)

- ESS is a software system deployed onto a microprocessor that is part of a larger system and performs control and monitoring of that system
- That larger system could be a technical process, the human body, or an industrial automation system

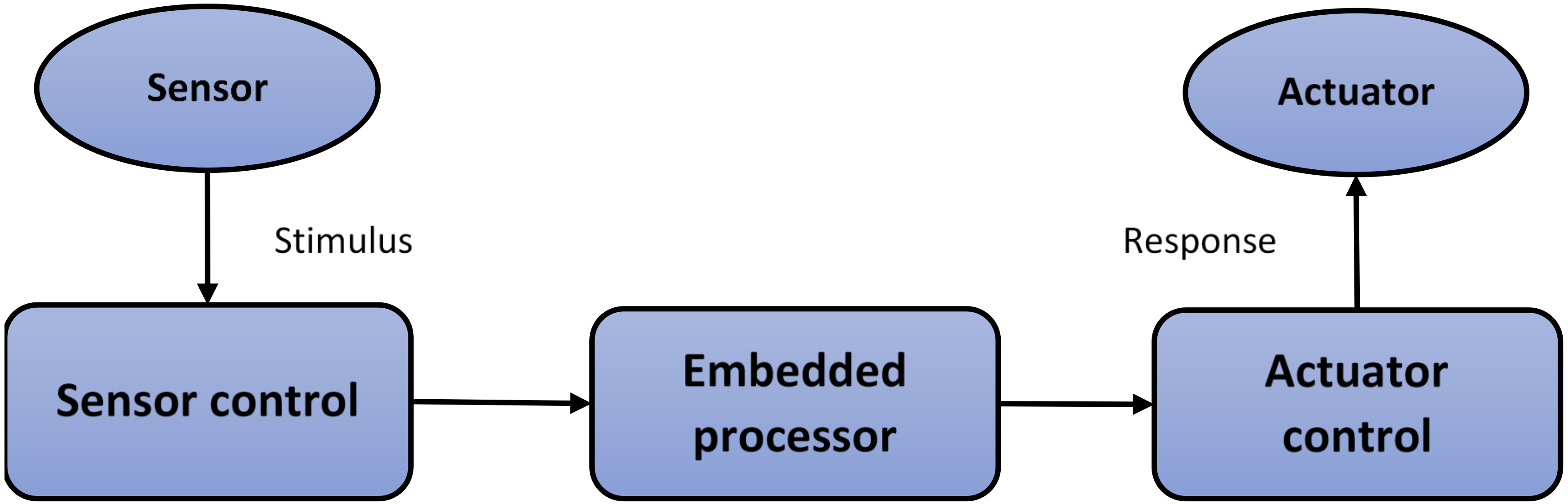
Distribution of embedded systems



Specific facts for embedded systems

- Low hardware resources (memory, processor speed, etc.)
- Real time performance
- *Safety-critical and high dependability*
- Long time of system use
- Difficulties to undertake changes or maintenance
- May work uninterruptedly (no shutdown)
- Hardware and software design is done simultaneously

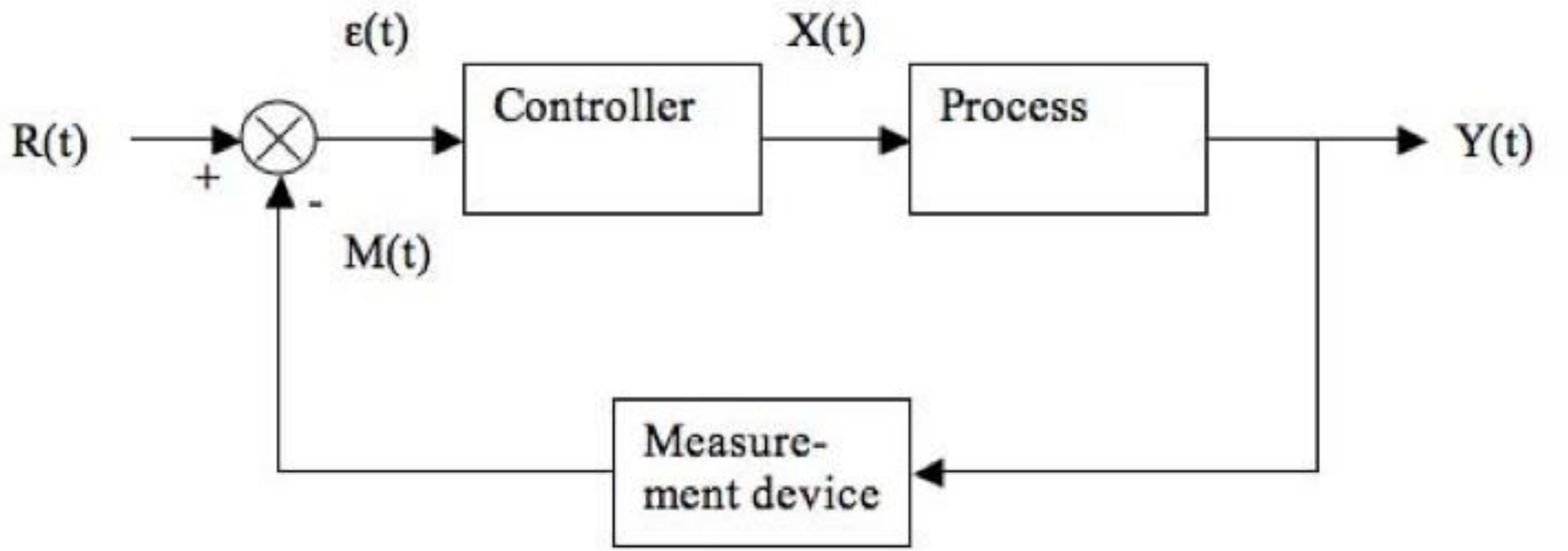
Basic architecture of embedded system



Adapted from: Sommerville, I. (2016). Software Engineering. 10th edition. Pearson Education.

- The picture in the previous slide represent the classical loopback principle
- Sensors gather data about the environment
- Sensor control is used to compare gathered data with the requirements (desired value)
- Actuator should manipulate the environment so that the controlled value is close to the desired value

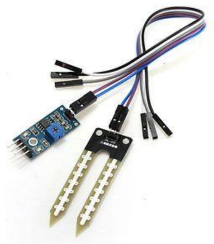
Loopback control principle



Sensor examples

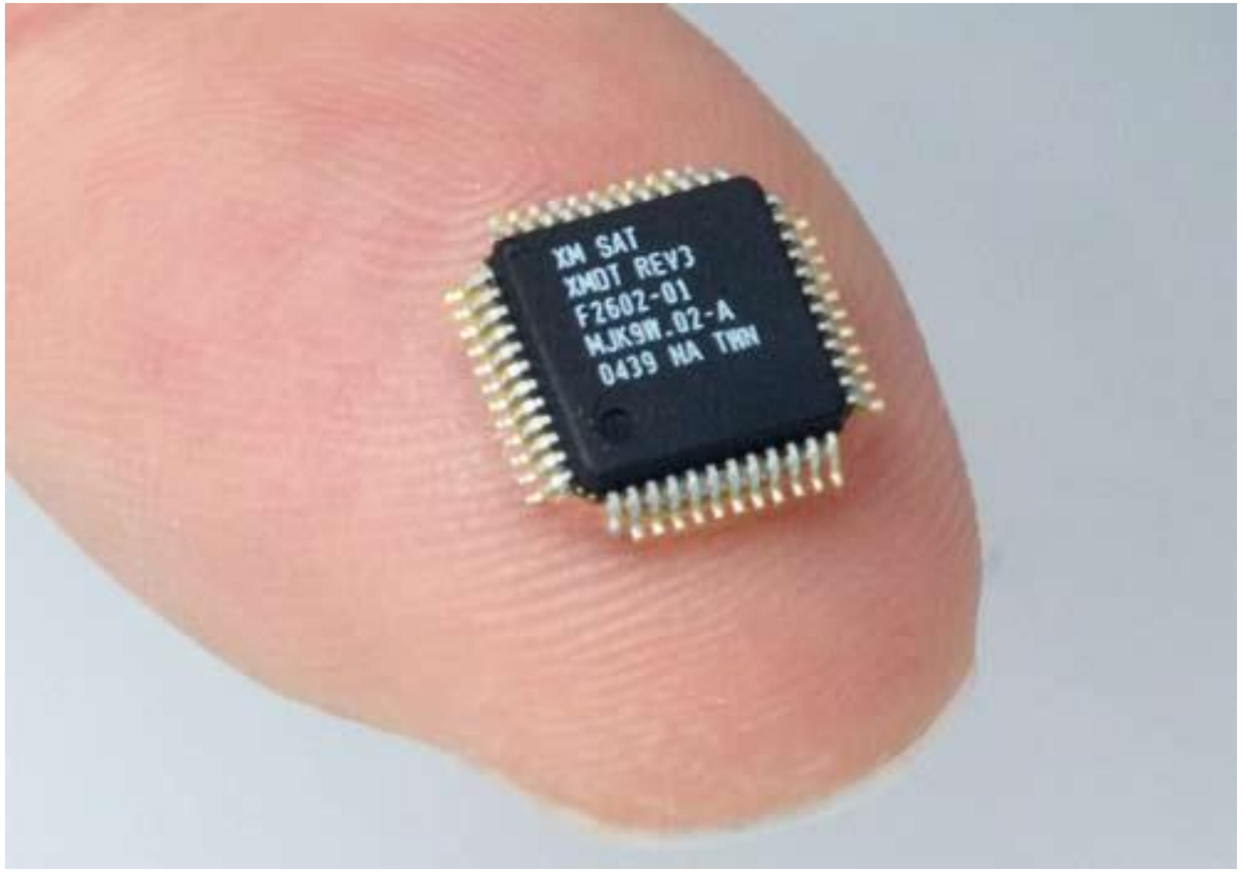
- Temperature

- Moisture



- Dust particles

Single-chip microcomputers



Single-chip microcomputers

- One chip contains the whole computer
  - Processor
  - Memory (ROM and RAM)
  - All input/output devices (Video, serial, etc.)

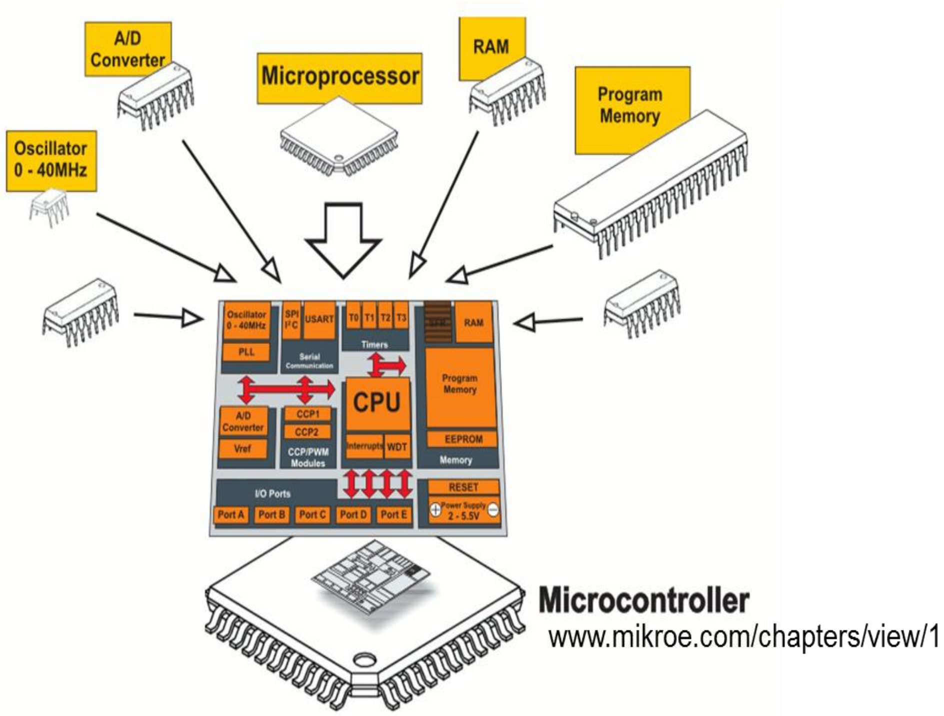
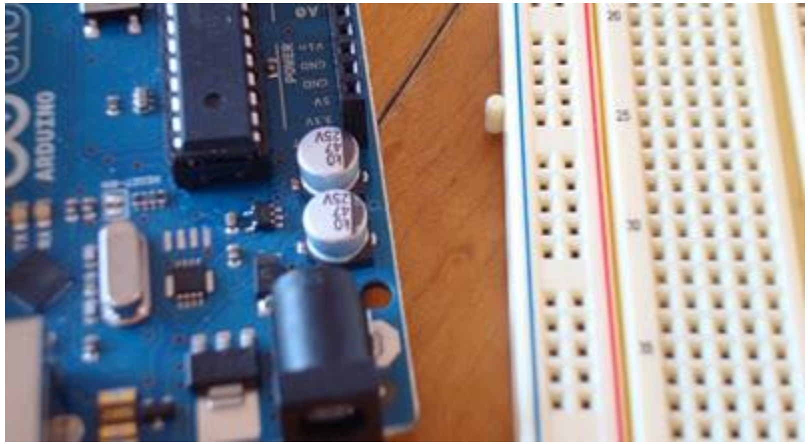


Fig. 0-1 Microcontroller versus Microprocessor

What is a Development Board

- A printed circuit board designed to facilitate work with a particular microcontroller.
  - Typical components include:
    - power circuit
    - programming interface
    - basic input; usually buttons and LEDs
    - I/O pins



- Examples: Arduino, Raspberry Pi, etc.

Programming of embedded systems

- In general, this is a tedious task
- Most of the embedded processor do not have the computational power to have a software development environment installed in order to do the programming
  - Additional development computer is needed
  - The program is then deployed to the embedded processor
- Development boards simplify this process to great extent

Programmable logic controllers (PLC)

Programmable logic controllers (PLC)

- PLCs are specialized industrial computers, designated to operate as embedded systems
  - They are capable to operate in harsh surrounding conditions, like temperature, dust, etc.
- Domain specific languages are used to program PLCs
  - They are defined in standard IEC 61131
    - Instruction lists
    - Structured text
    - Ladder diagrams
    - Function block diagrams (FBD)
    - Sequential Function Chart

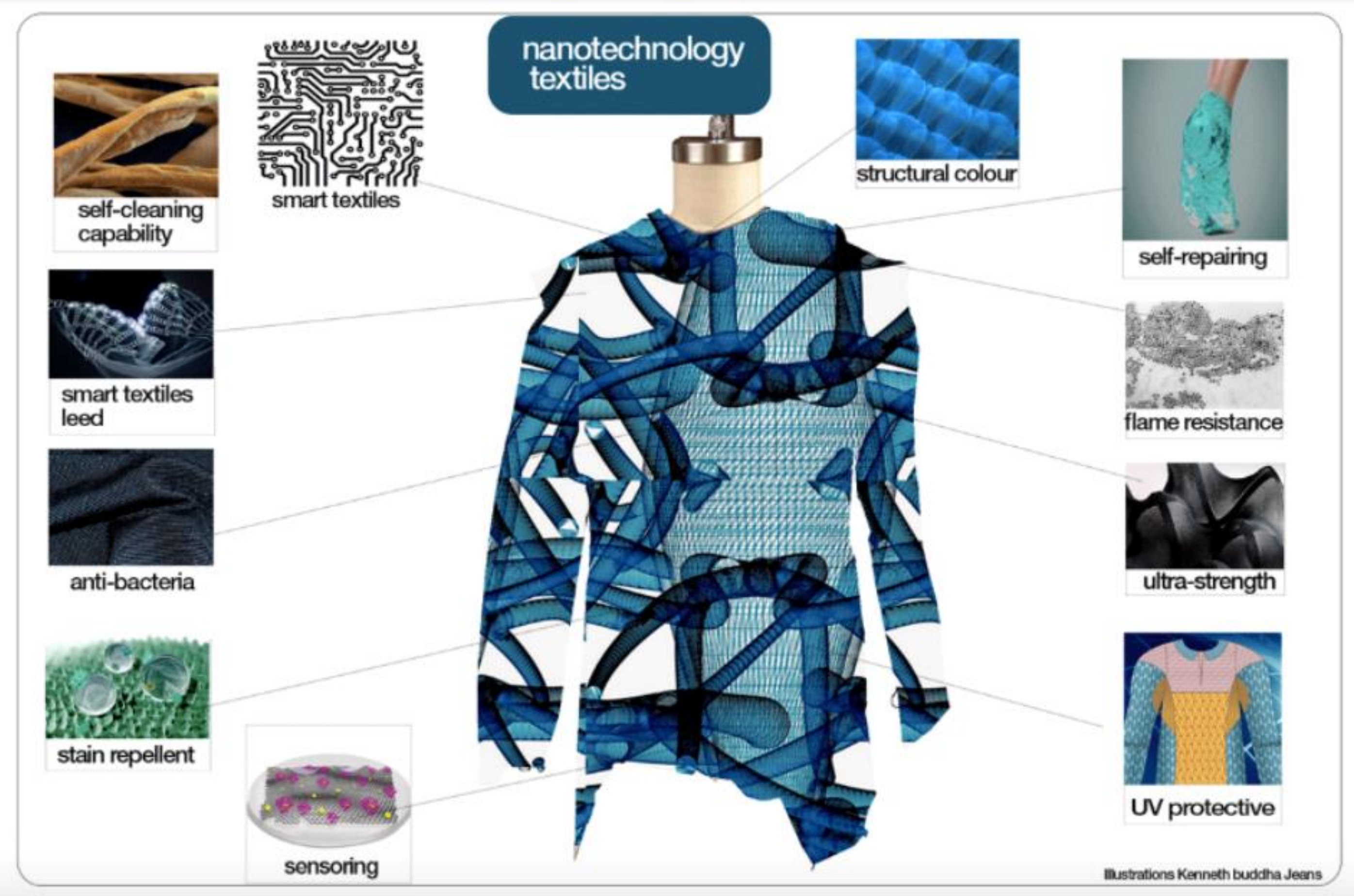
IEC 61131

- **Instruction List (IL)** - A low level 'assembler like' language that is based on similar instruction list languages found in a wide range of today's PLCs.
- **Structured Text (ST)** - A high level textual language that encourages structured programming. It has a language structure (syntax) that supports a wide range of standard functions and operators. The standard includes a formal syntax definition of ST
- **Function Block Diagram (FBD)** - A graphical language for depicting signal and data flows through function blocks - re-usable software elements. FBD is very useful for expressing the interconnection of control system algorithms and logic.
- **Ladder Diagram (LD)** - A graphical language that is based on the relay ladder logic - a technique commonly used to program current generation PLCs. However, the IEC Ladder Diagram language also allows the connection of user defined function blocks and functions and so can be used in a hierarchical design.
- **Sequential Function Chart (SFC)** - A graphical language for depicting sequential behaviour of a control system. It is used for defining control sequences that are time- and event-driven. This is an extremely effective graphical language for expressing both the high level sequential parts of a control program as well as programming low-level sequences, e.g. to program an interface to a device.

Applications of IoT (Smart clothing & textiles)

- Clothing becomes not only a stuff that we wear
- Smart clothes may be used for various purpose
  - Check weather forecast and alert what kind of wearing a person should use
  - Monitor health condition (blood pressure, heart rate and others) via embedded sensors
  - Medical notifications with dietary instructions
  - Sleeves that direct disabled people
  - Etc.

Applications of IoT (Smart clothing & textiles)



source: https://www.kaleidoinsights.com/impact-analysis-smart-textiles/

IoT in textile and fashion industry

- IoT in textile industry also has application in
  - Wearables
  - Optimization in the textile manufacturing sector
  - Marketing
  - Fashion design

IoT in textile and fashion industry

- Internet of Fashion (IoF)
  - We start speaking of IoF when clothes and wearable devices start sharing data and talk to each other
  - Digital fibres and garment
  - Fabric-based machine learning inference*

*Loke, G., Khudiyev, T., Wang, B. et al. Digital electronics in fibres enable fabric-based machine-learning inference. Nat Commun 12, 3317 (2021).

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