B2. Smart machines and Connected machines

What is a smart machine? Smart machines are capable of operating independently to some extent and can adapt to changing conditions. They are mostly used for tasks that are not repeated regularly. Smart machines must also avoid process errors and be able to correct them, while learning from such situations in order to avoid similar problems in the future. Smart machines also typically provide information to higher-level control systems that generally facilitate smart operations.

Traditional computer-controlled machines used machine control together with a human-machine interface. In contrast, smart machines have a more *modular architecture* that uses robots to speed up the development phase. At the same time, smart machines for decentralized data processing use additional built-in controllers and *monitoring systems*.

This property of smart machine results in a new software-based solutions and programming tools that allow to use a single software design tool for multiple tasks.

What parts are smart machines usually made of?

Smart machines use a vast network of *sensors* that collect information about the state of the machine and the status of ongoing processes. The measurements are used to enable the control unit to monitor the current situation and performance of the machine.

Robotic dog opening doors

The *sensor network* is large enough for the control unit to gather enough information to decide whether to initiate maintenance or even automatically apply various control value entries to the system.

Smart machines also need a high-performance network of embedded systems to implement control strategies and complex control algorithms. The current trend is to integrate monitoring and control functions into a single hardware system.

Remark: This approach offers many economic advantages and can also increase the performance of automation elements. Manufacturers also rely on an additional system that is added to the machine control and performs monitoring independently of the control system. These two systems usually communicate via a standard Input/Output link.

Decentralized control for example abandons the model of one central motor and instead drives individual axes using gears, camshafts, or other lever mechanisms. Separate motors usually drive specific axes and work in synchronization with the software.

This approach reduces the cost and weight of the machine itself and makes the mechanical system more flexible. Such machines can also be modular, and it is easier to expand them further in the future.

Example: Field Programmable Gate Array (FPGA) is a type of logic integrated circuit in electronics that is manufactured so that it can be programmed at the customer's location. It contains an array of programmable logic circuits, logic blocks, and allows you to connect them to each other and thus create almost any digital device (for example, a microprocessor, network card control circuit, etc.). This distinguishes it from customer integrated circuits, whose function is already given during production.

Communicated machines – "Machine-to-machine Communication" (M2M) communication is where machines can transfer data to other devices over a network without much human intervention. The transferred data can be used to improve the processes and for better control. *M2M communication* can be over a wired network or a wireless network, and they have been named accordingly.

The M2M represents any technology that allows two devices to exchange information with each other, e.g., communicate and send data. The communication that occurs between the machines is autonomous, there is no need for human intervention for this data exchange to take place.

M2M connectivity is related to the *Internet of Things* (IoT). Both are part of the same concept and complement each other. Thanks to IoT, a system of machines or interrelated devices can be connected wirelessly, and exchange and analyse data automatically in the cloud. IoT is enabled by integrating many M2M devices and using cloud web platforms to process all that data. M2M communications means the largely automated exchange of information between technical devices themselves, for example, machines, vending machines, vehicles, or measuring equipment, or between the devices and a central data processing unit. Although M2M usually does not involve human assistance, the cited definition does not rule out limited human intervention.

Wired and Wireless M2M Communication.

In ***wired M2M communication***, the data transfer between the devices occurs over a wired transfer medium. It can be fiber optic cables, EtherCAT, or even coaxial cables. Wired communication networks are becoming rarer now.

Wireless M2M communication that majorly uses the wireless network for communication is termed as *Internet of Things* (IoT). The wireless communication methodologies used have a wide range from radio waves to the latest 5G[1] technology.

Examples of wireless communication technologies:

RFID – RFID or Radio Frequency Identification is quite an old technology that has stood the test of time.
NFC – Near-Field Communication is similar to RFID but can only be used for short-range transfer of data. It is widely used for access control and payment systems.
WiFi – WiFi or wireless fidelity is widely used in homes and offices to access the internet wirelessly. There have been many newer iterations of WiFi technology that increased the bandwidth and reduced communication latency.

Smart machine technologies learn on their own and can produce unanticipated results. They must:

- Adapt their behaviour based on experience (learning).
- Not be totally dependent on instructions from people (learn on their own).
- Be able to come up with unanticipated results.

Now communication is already at the limit of its possibilities. Thousands of devices would be able to "talk to each other" very fast and with very minimal lag over a *5G network*. Implementation of 5G in the industrial setting is said to be akin to a new industrial revolution in the works.

[1] 5G is the fifth generation of wireless technology. It can provide higher speed, lower latency and greater capacity than 4G LTE networks. It is one of the fastest technologies the world has ever seen. That means quicker downloads, much lower lag and a significant impact on how we live, work and play. 5G speed connectivity benefits are expected to make businesses more efficient and give consumers access to more information faster than ever before. Connected cars, smart stadiums, and advanced gaming – they all will rely on 5G networks.

Advantages of connected machines: Connected machines are changing the processes and business models of manufacturing companies. *Machine-to-machine technology* is used for a wide range of applications. Intelligent machines can exchange information without human assistance and even coordinate and perform actions.

Example: Some interesting applications of M2M

- For example, the connected vending machines allow the distributor to know their replacement status and to notify in cases which some product runs out.
- It is also very useful in the health area. Telemedicine is a concept already implemented in some places and has meant great improvements in this area. In hospitals, processes are automated to improve efficiency and safety, for example, using devices capable of reacting faster than humans. If a patient has a drop in vital signs and is connected to an M2M device, the machine can automatically administer extra oxygen before the hospital staff reaches it.
- Likewise, it is also used in the industry , allowing machines to be connected to each other and sending data each other. With this data, they can optimize processes automatically, notify when a machine has a breakdown or even self-repair.

In general, we can establish the following industrial applications:

- Automated maintenance
- Procedure for requesting spare parts
- End of process notice
- Data collection for processing by other equipment
- Intelligent stock control
- Implementation of just-in-time systems

There are many reasons why manufacturers should be focusing on connected machines, for example: *remote maintenance* at short notice can increase customer satisfaction, *predictive maintenance* can help in achieving cost savings. Companies which don't seize these opportunities, run the risk of being left behind by the competition.

Ecosystem setup: The ecosystem can be created by upgrading existing machines and systems or by setting up completely new facilities. Another option is partnerships and strategic alliances with service providers specialising in the field of *Green Economy*. The most suitable method will depend on the individual situation of each specific company.

Summary:

Smart machines for decentralized data processing use built-in controllers and monitoring systems. These machines use a network of sensors collecting information about the state of the machine and ongoing processes. The sensor network gathers information and controls actions of a machine. The communication that occurs between the machines is autonomous, there is no need for human intervention for this data exchange to take place. Machine to machine (M2M) connectivity is related to the Internet of Things (IoT), both are part of the same concept and complement each other. A system of machines can be connected wirelessly, and exchange and analyse data automatically in the cloud. They adapt their behaviour based on experience (learning), not be totally dependent on instructions from people (learn on their own), be able to come up with unanticipated results. Today, devices are able to “talk to each other”, fast and with very minimal lag over a 5G network. In wired M2M communication, the data transfer between the devices occurs over a wired transfer medium. It can be fibre optic cables, EtherCAT, or coaxial cables. Wireless M2M communication that majorly uses the wireless network for communication use a wide range from radio waves to the latest technology 5G.

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Links to relevant topics:

https://www.techtarget.com/searchcio/definition/smart-machines

https://en.wikipedia.org/wiki/Smart_device

https://toolsense.io/glossary/m2m/

https://computer.howstuffworks.com/m2m-communication.htm

Video:

https://www.seznamzpravy.cz/clanek/roboticky-pes-ktery-budi-hruzu-i-obdiv-miri-do-prodeje-73780

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