MÄLARDALENS HÖGSKOLA
ESKILSTUNA VÄSTERÅS

# Industrial Internet of Things and Opportunities in Manufacturing

*Mohammad Ashjaei*
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# About me

- I got my PhD degree from MDH in 2016
  - Resource reservation in networks
  - Schedulability analysis in real-time switched Ethernet networks
  - Reconfiguration and online adaptation in real-time switched Ethernet
- Currently
  - Senior lecturer in embedded systems at IDT – MDH
  - Research and teaching

# About me

- Research
  - Real-time communication
  - Resource reservation in networks
  - Communication in cloud and fog computing
  - IoT connectivity
  - Software defined networking and network virtualization
- Projects
  - Developing Predictable Vehicle Software Utilizing Time Sensitive Networking (DESTINE), co-applicant and co-supervising 2 PhD students, 2019-2021, VINNOVA.
  - Federated Choreography of an Integrated Embedded Systems Software Architecture (FIESTA), co-applicant and co-supervising 1 PhD student, 2020-2024, KK-Stiftelsen.
  - Predictable Software Development in Connected Vehicles Utilising Blended TSN-5G Networks (PROVIDENT), co-applicant and co-supervising 1 PhD student, 2020-2024, VINNOVA.
  - Future Factory in Cloud (FiC), co-supervising 1 PhD student, 2016-2020, SSF.
  - Excellence in Production Research (XPRES), 2010-ongoing, governmental project.
  - Process Automation for Discrete Manufacturing Excellence (PADME), MDH representative for the project, 2017-2019, national project Production 2030.

# About me

- Teaching
  - Computer networks I and II (distance), course responsible
  - Introduction to IoT infrastructures (distance), course responsible
  - Data communication in embedded systems, giving lectures
  - Embedded systems I and II, giving lectures
  - Master and bachelor thesis projects supervising and examining
  - IoT and cloud computing for production students

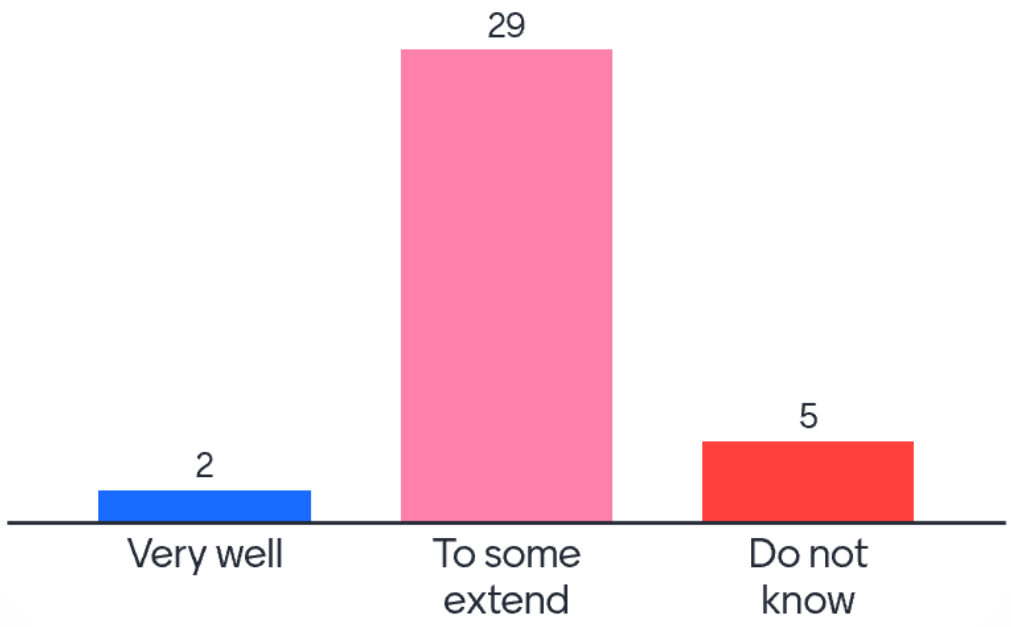
# Plan for this seminar

- Introduction on Industry 4.0
- What is connectivity?
- Concrete examples of benefits with connectivity
- Basics of automation pyramid
- Cyber physical system (CPS)
- CPS-based automation
- IoT basics and Industrial IoT
- Modern Industrial IoT architectures
- Concrete example (PADME project)

Go to **www.menti.com** and use the code **53 20 97**

Mentimeter

# How much do you know about opportunities of using IoT in your Industry?

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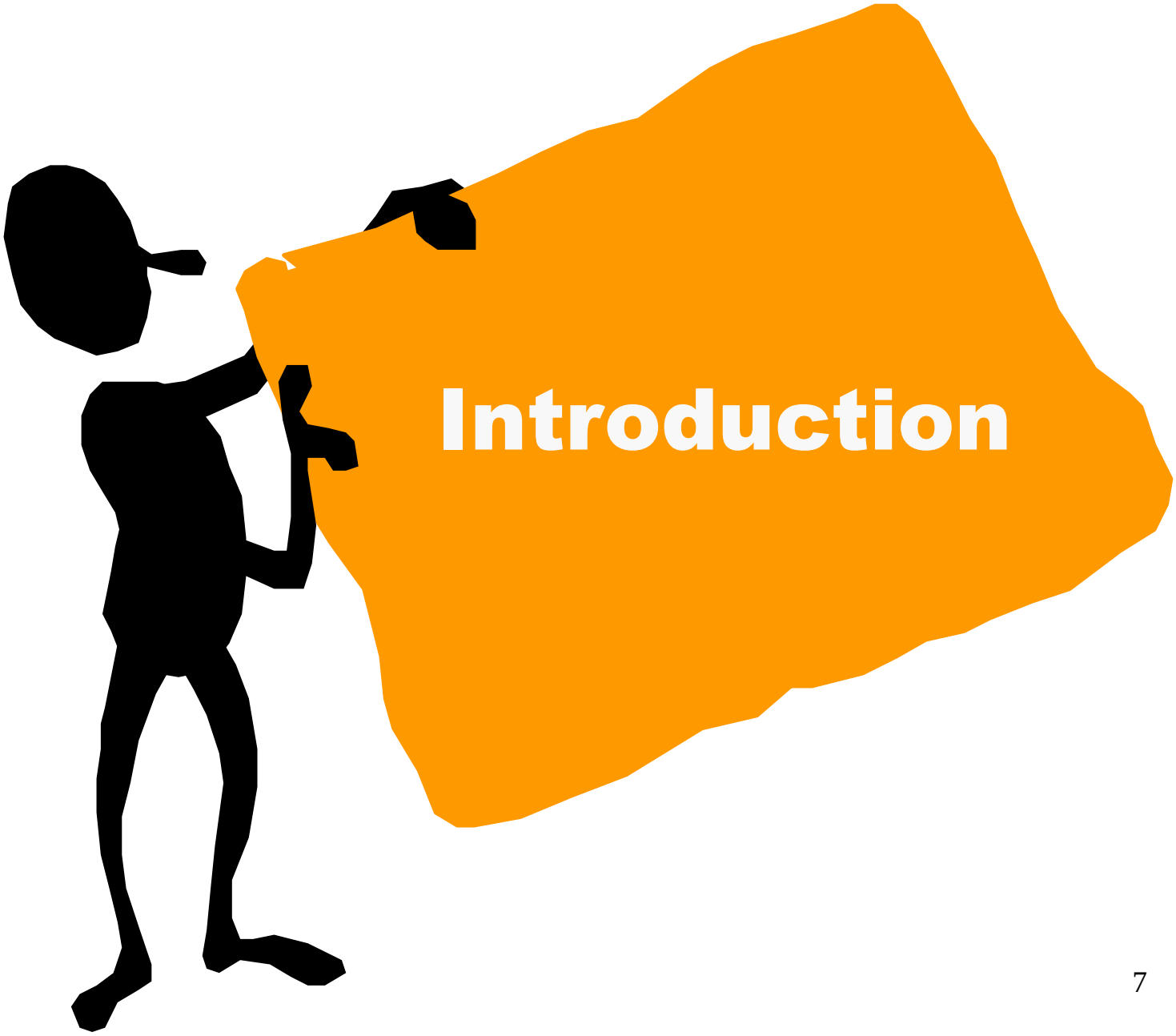

Introduction

# Industry 4.0

## The Fourth Industrial Revolution

| First Industrial Revolution | Second Industrial Revolution | Third Industrial Revolution | Fourth Industrial Revolution |
|---|---|---|---|
| • Introduction of mechanical production tools | • Labor organization, mass production, use of electricity | • First step regarding automation, with electronics and computer science entering companies | • Interconnected products and services thanks to the new digital technologies |

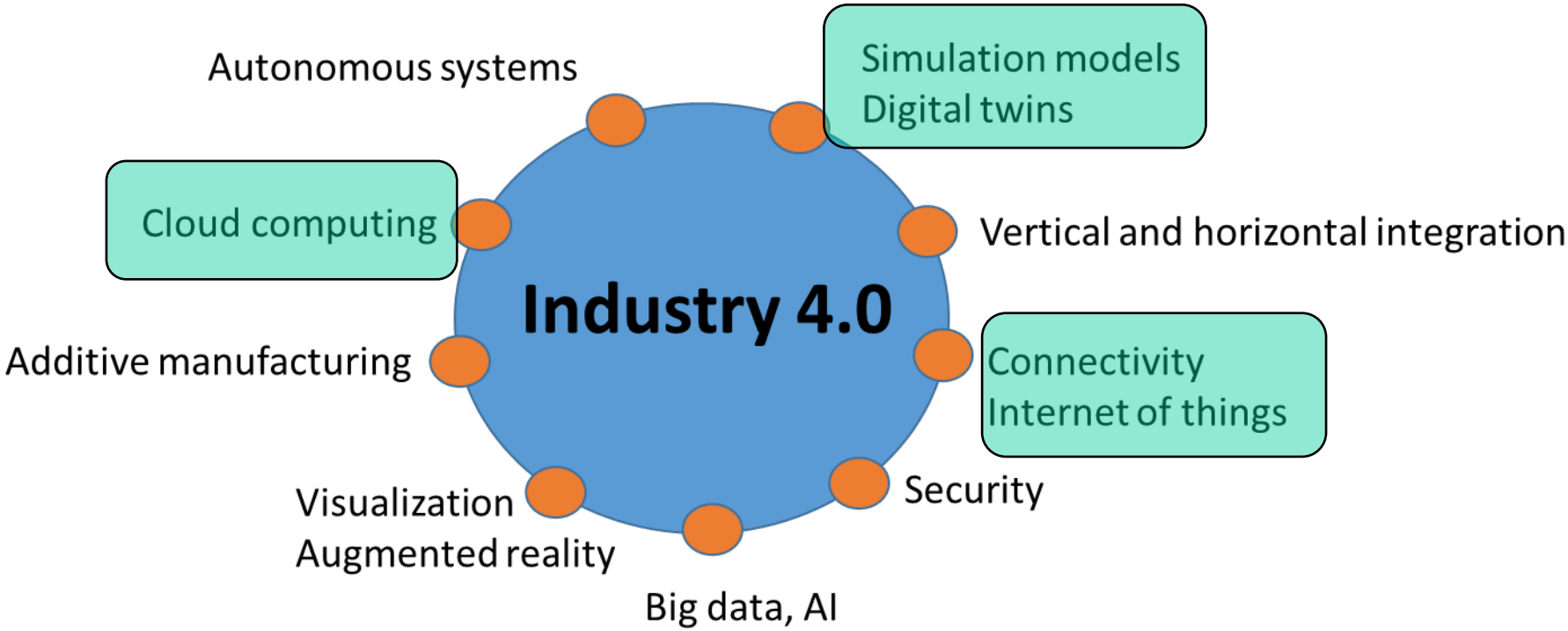
1780: First loom powered by steam

1870: First assembly line

1970: First PLCs

2011: First appearence of "Industry 4.0"

# Industry 4.0

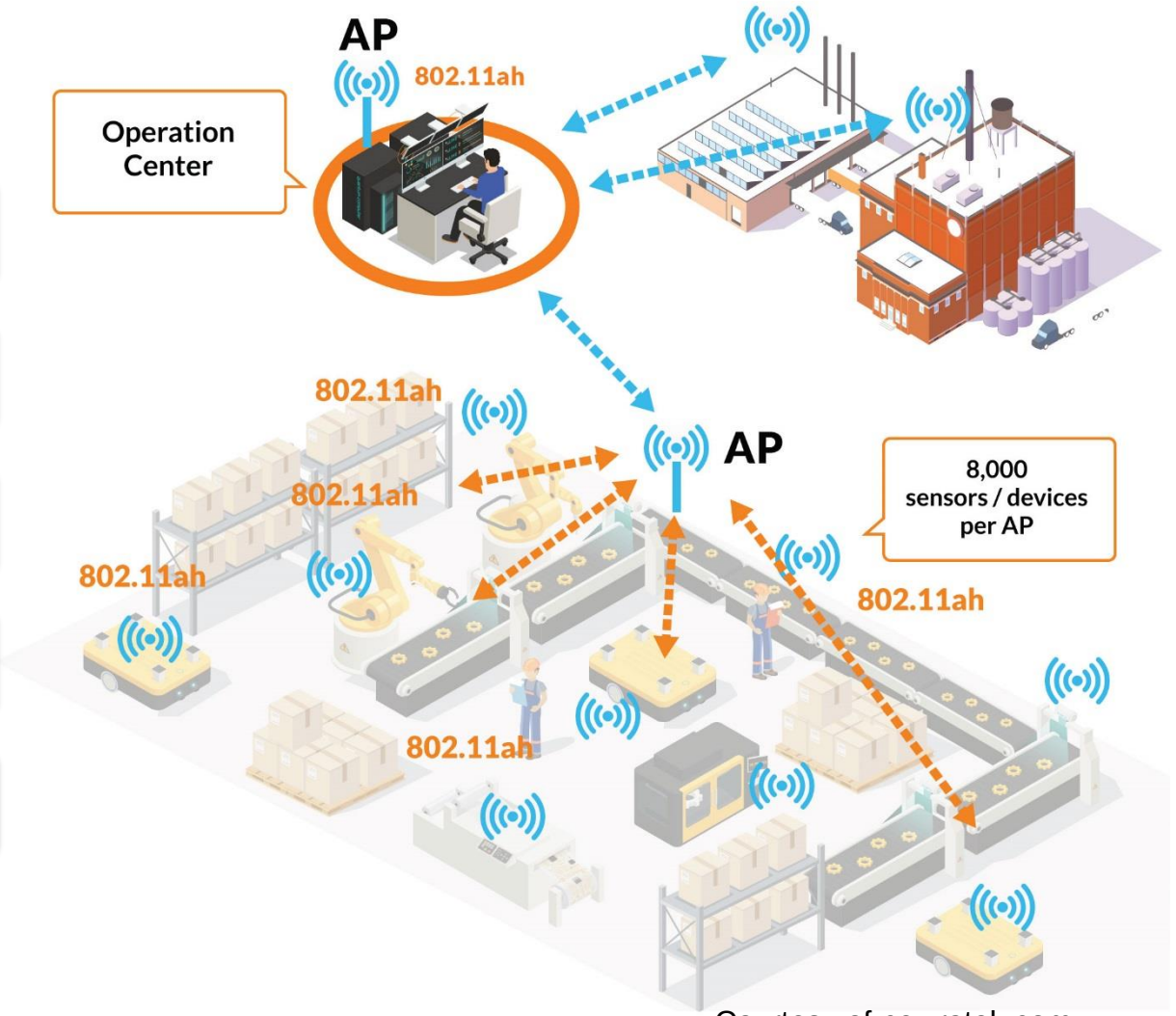

Autonomous systems
Simulation models
Digital twins
Cloud computing
Vertical and horizontal integration
Industry 4.0
Additive manufacturing
Connectivity
Internet of things
Visualization
Augmented reality
Security
Big data, AI

# Information is the key

- An intense pressure is on manufacturing industries to stay competitive
- Shifting the traditional industries into smart factory setups using technologies:
  - Industrial networks
  - Cloud and Fog computing
  - Industrial IoT
- Information is the key parameter

# Connectivity

- Predict
- Allocate
- Trace
- Dynamic
- Statistics




Courtesy of newratek.com

# Connectivity

- In order to enhance a traditional factory:
  - Data should be available from the shop floor devices
  - (useful) Information should be extracted from the collected data
  - The information should be shared
  - The information should be visualized
  - Techniques to utilize the information

# Example of connectivity

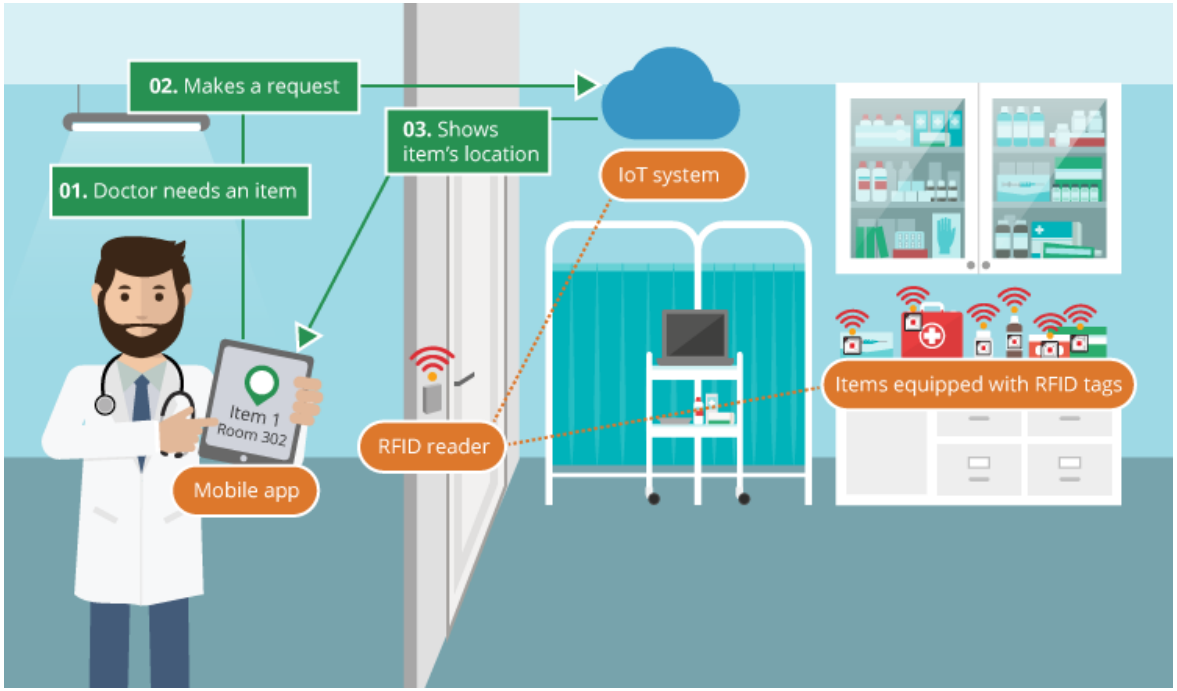
- BJC is the healthcare service provider, which operates 15 hospitals in Missouri and Illinois
- The company started to use RFID to track and manage medical supplies
- RFID (Radio Frequency Identification) is a technology that identifies objects by means of electromagnetic waves.

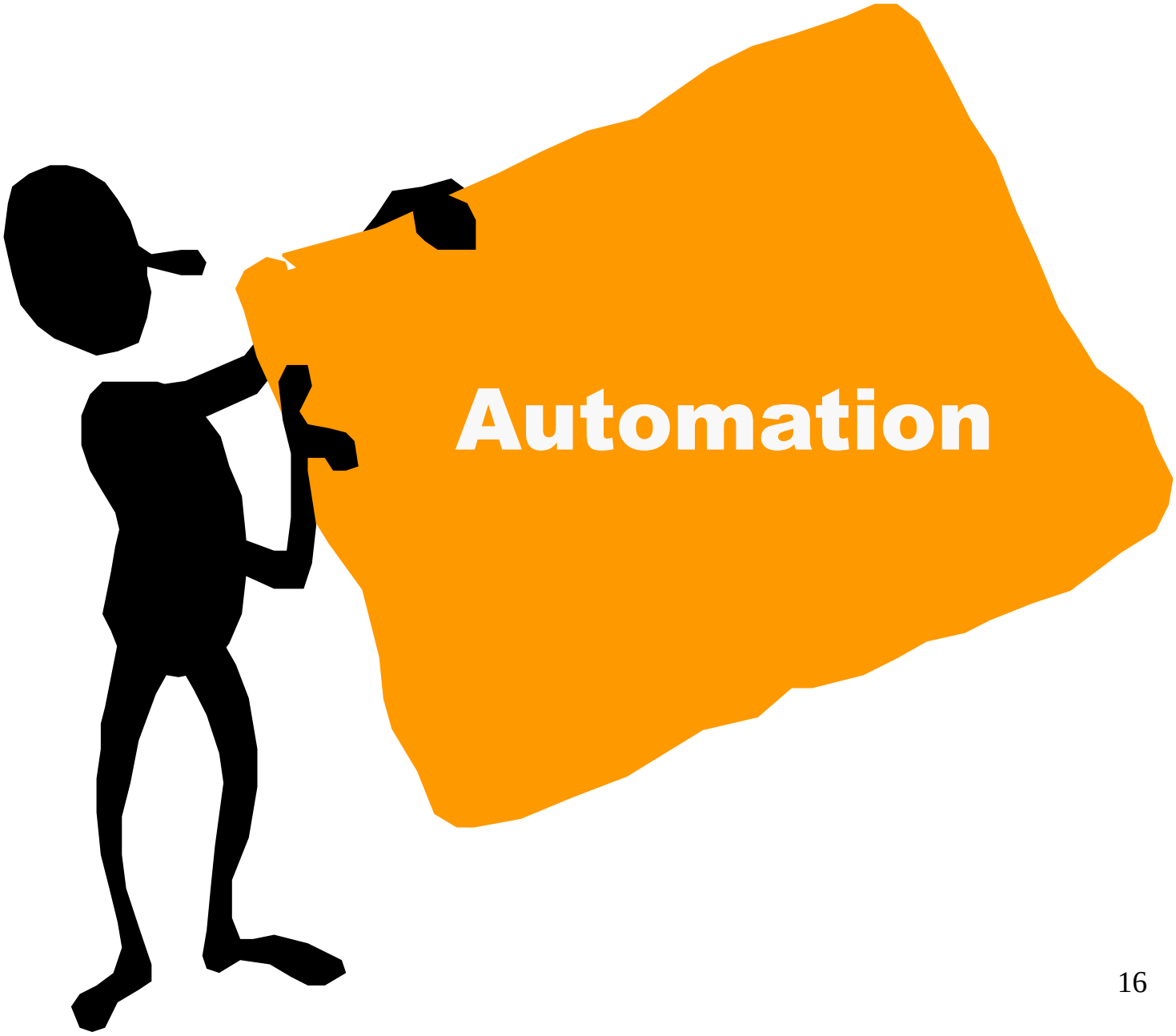
# Example of connectivity

- Before there was a lot of manual labor
- In some cases, products' expiration dates should be monitored
- The loss of stock can lead to a lot of time spent on conducting inventory checks

# Example of connectivity

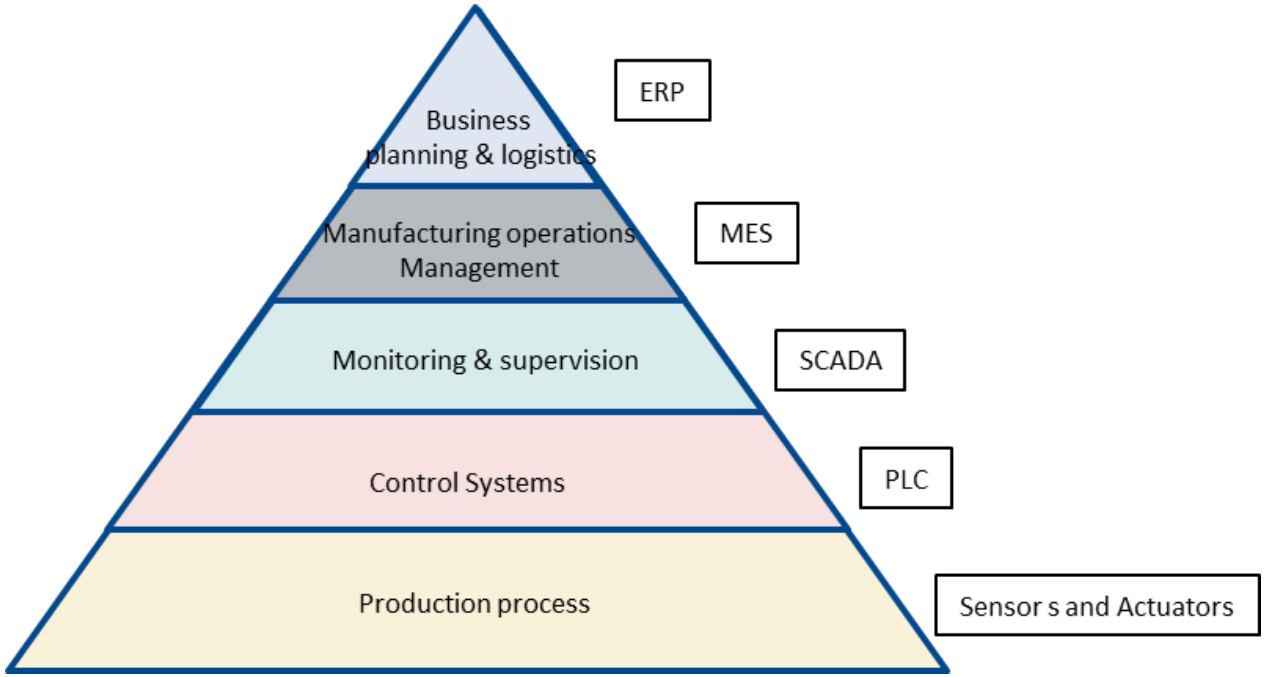
- RFID tagging in 2015 at BJC
- BJC reduced the amount of stock kept onsite at each facility by 23%
- The company predicts that it will see ongoing savings of roughly 5M$
- Significant improvement in cost by implementing RFID tag




Automation

# Automation pyramid

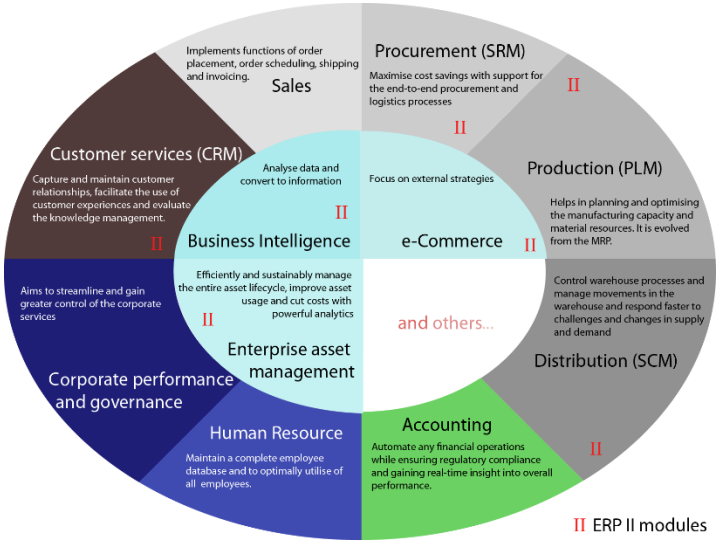
The automation pyramid provides a hierarchical structure that allows the various technologies and systems used for planning, managing, and assessing the value creation process to be assigned to various levels of the company.

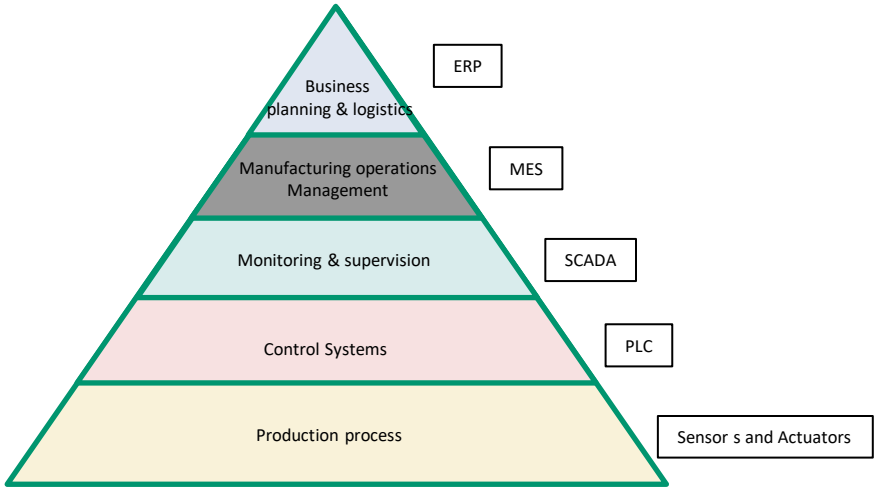



In practice, the lines between the levels are often blurred, and the individual levels can rarely be clearly identified.

# Automation pyramid

Enterprise resource planning (**ERP**): is a business management system that track resources including cash, raw materials, production capacity and the status of orders and purchase.

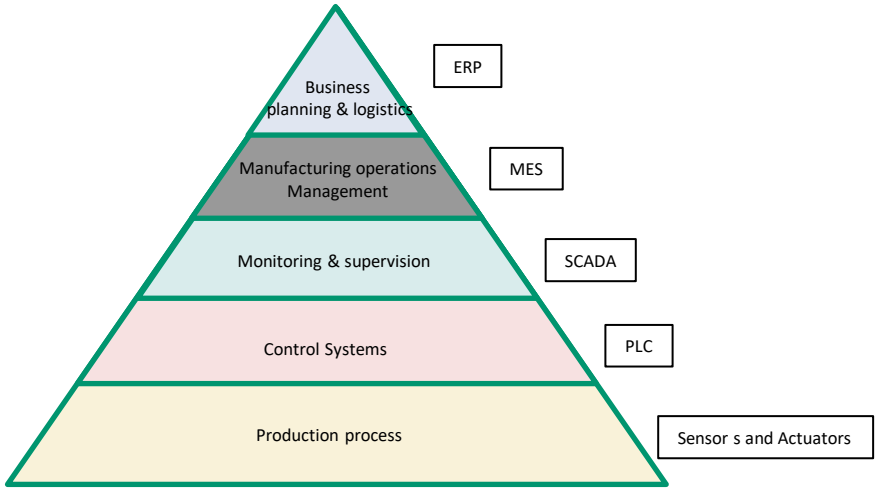



**Company level functions:** Rough production planning, sales planning, strategic procurement processes, order processing, business controlling, provision of resources, master data management

# Automation pyramid

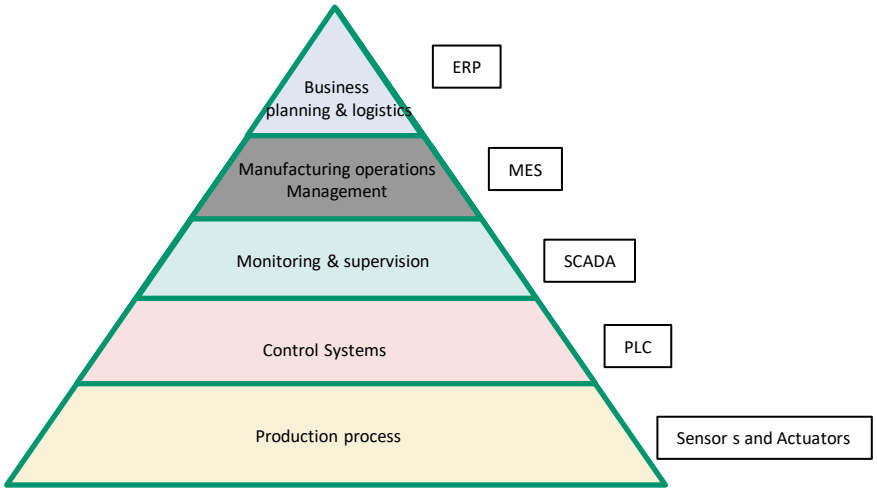
Manufacturing Execution System (**MES**): are computer-based systems used in manufacturing, to keep tracking and manage the production in the plant floor.




**Operation management level functions:** Detailed production planning and management, scheduling, determining production-specific metrics (KPIs), quality management, recording production data.

# Automation pyramid

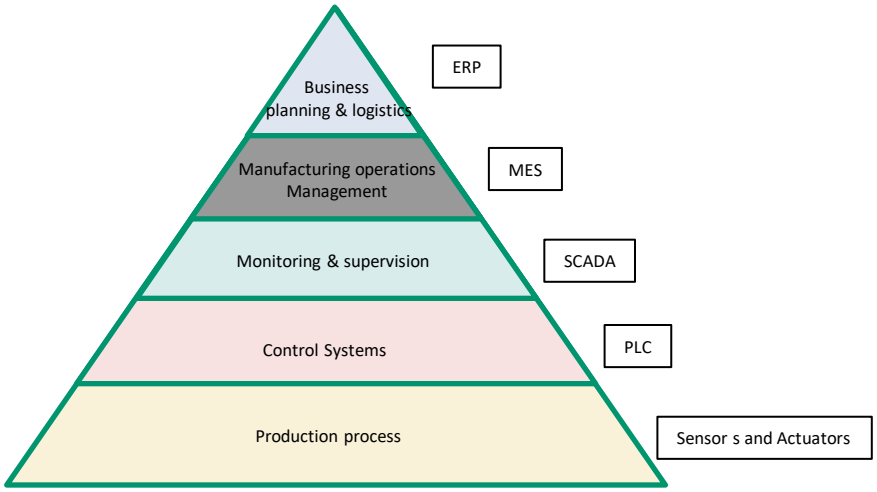
Supervisory Control and Data Acquisition (**SCADA**): is an architecture of the control system that collect data from several control systems for monitoring and control.




**Process management level functions:** Operating, observing, visualizing, formula management, measurement archiving

# Automation pyramid

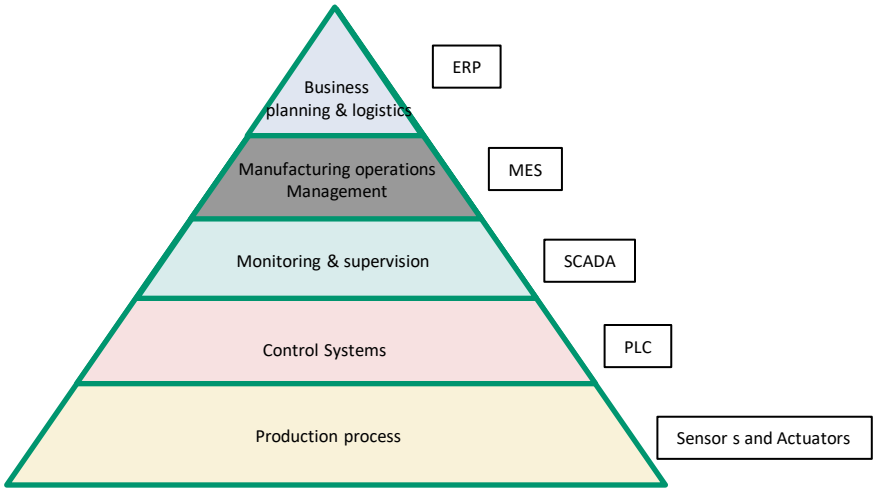
Programmable Logic Controller (**PLC**): is a computer which is used to control the manufacturing processes.




**Control Level:** Controlling the technical manufacturing and transportation process, linking input data with the production of output data

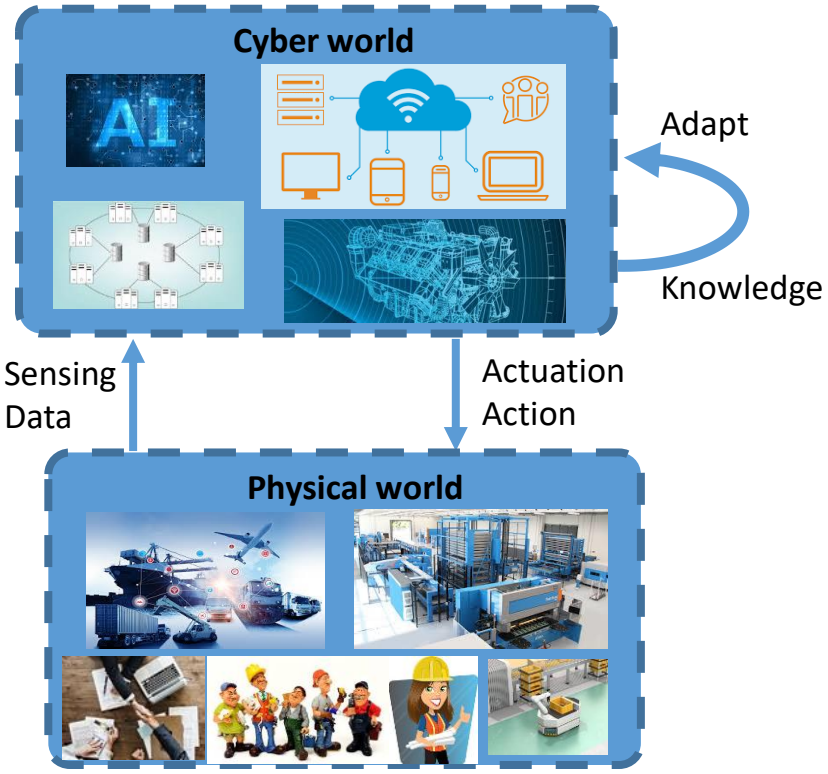
# Automation pyramid

Sensors and actuator level contains the physical devices including robots, various sensors, valves, etc.

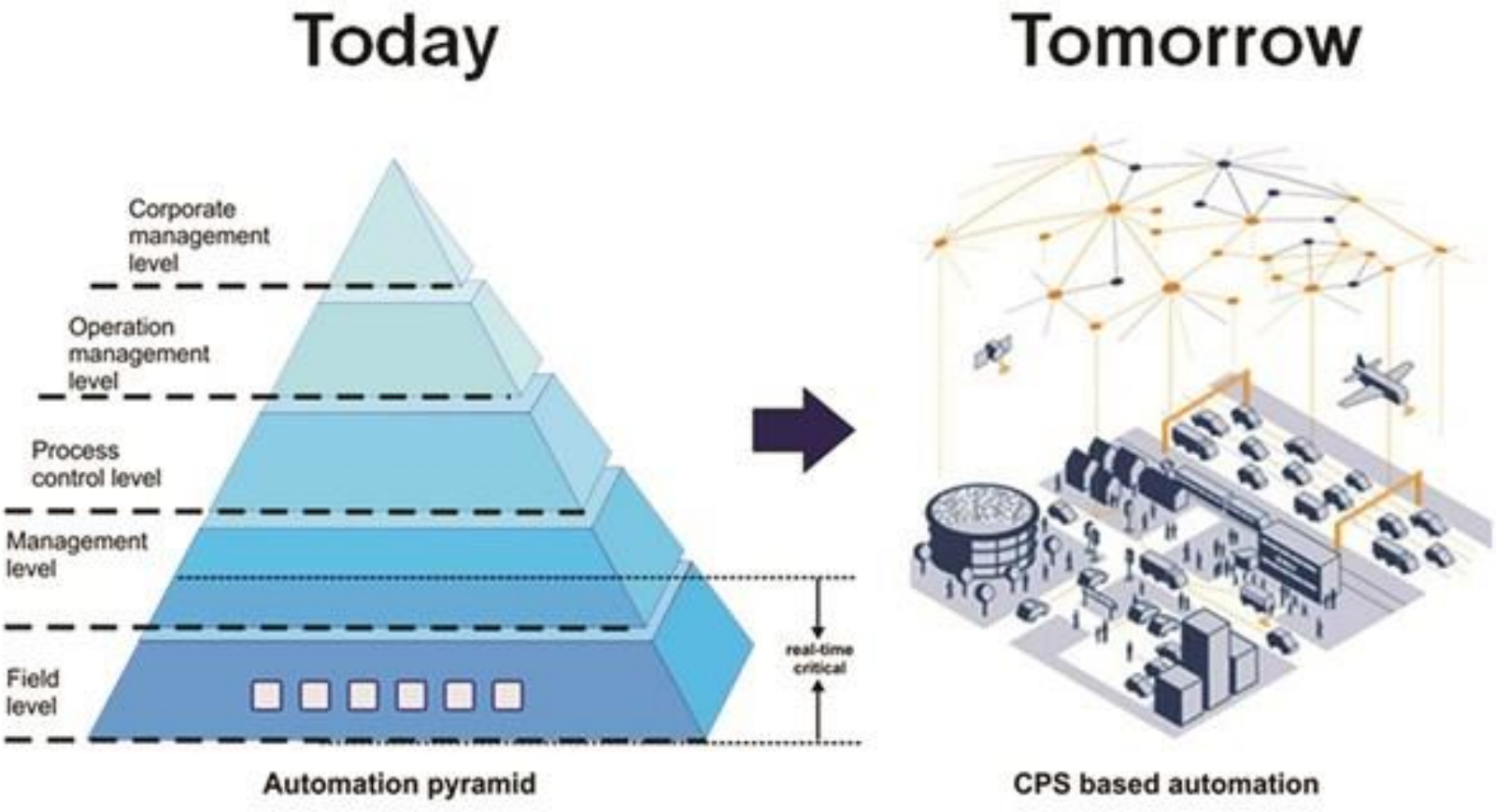


# Cyber Physical System (CPS)

- CPS: It is the integration of Cyber world, computation & network, and physical processes.
- Its purpose is to **control** a physical process and **adapt itself in real-time to new conditions** in order to **optimize** the performance.
- It allows creation of **autonomous and cooperative** elements and sub-systems, with the purpose of optimization production processes.



# CPS-based automation




**Courtesy of:** https://www.mmsonline.com/columns/valid-data-demanded

# CPS-based automation

- CPS can be very flexible
- New nodes can join or leave the network, hence there will be a dynamic system (example: a tablet to join the network to observe the process data)
- New communication concepts to connect to shop floor devices
- Failure detection becomes easy
- Access to different software and system becomes easy

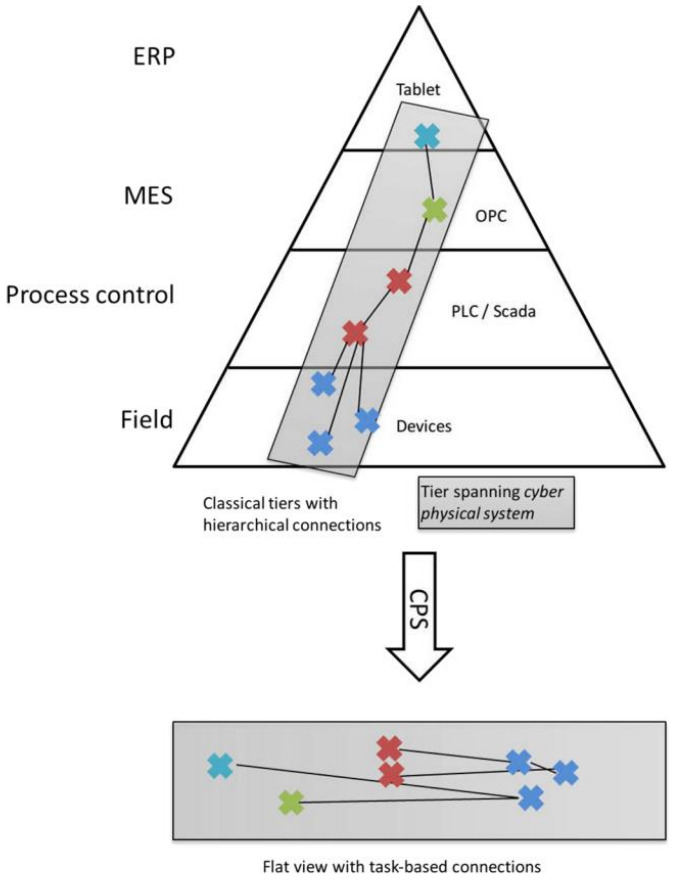
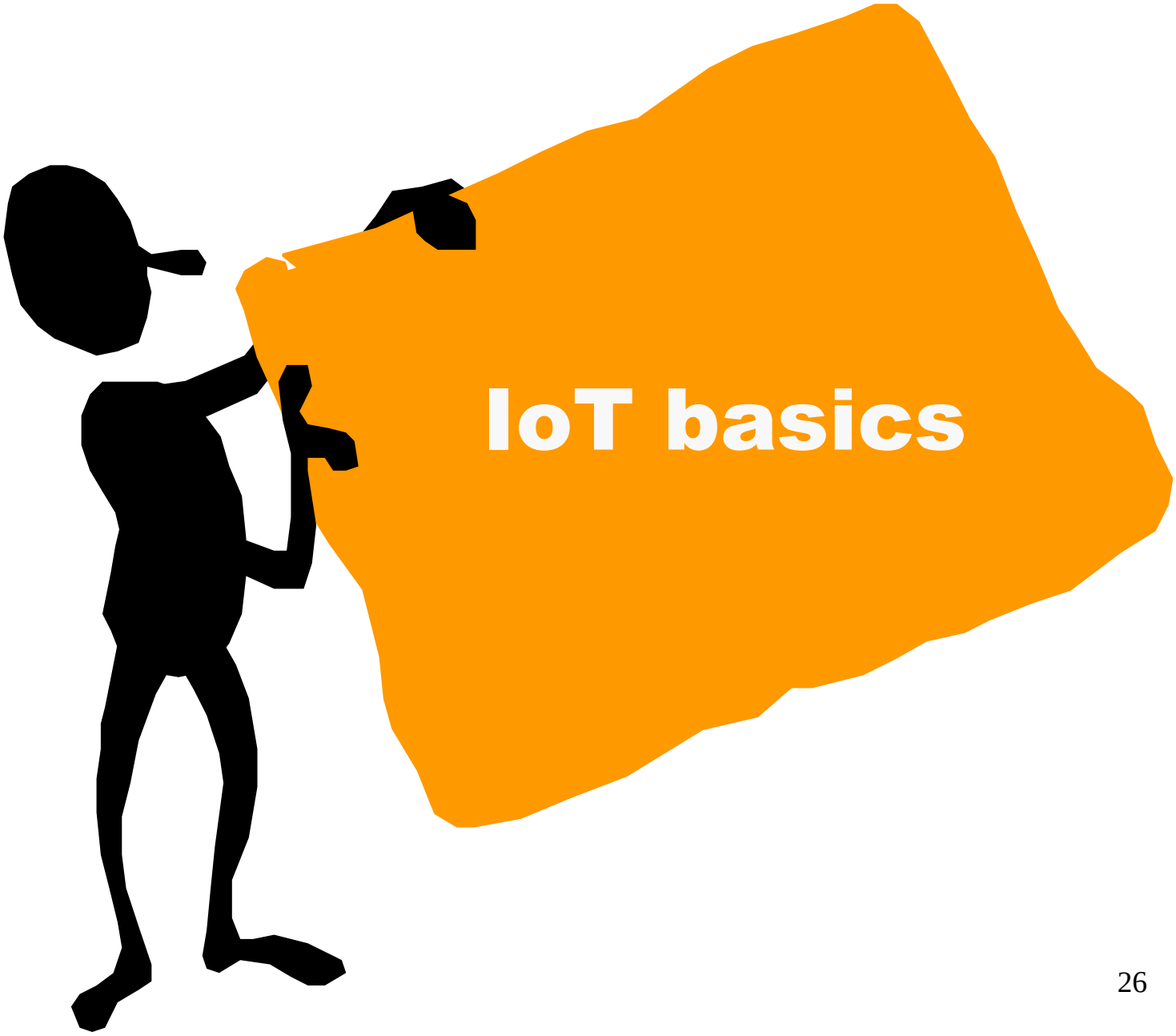



Fig. 1. Evolution from a plant hierarchy to a flat network

Matthias Riedl, Holger Zipper, Marco Meier, Christian Diedrich, ”Automation meets CPS”, IFAC Proceedings Volumes, 2013.


IoT basics

# Internet of Things

Internet of Things refers to a new computing paradigm in which devices are connected through a variety of communication protocols.

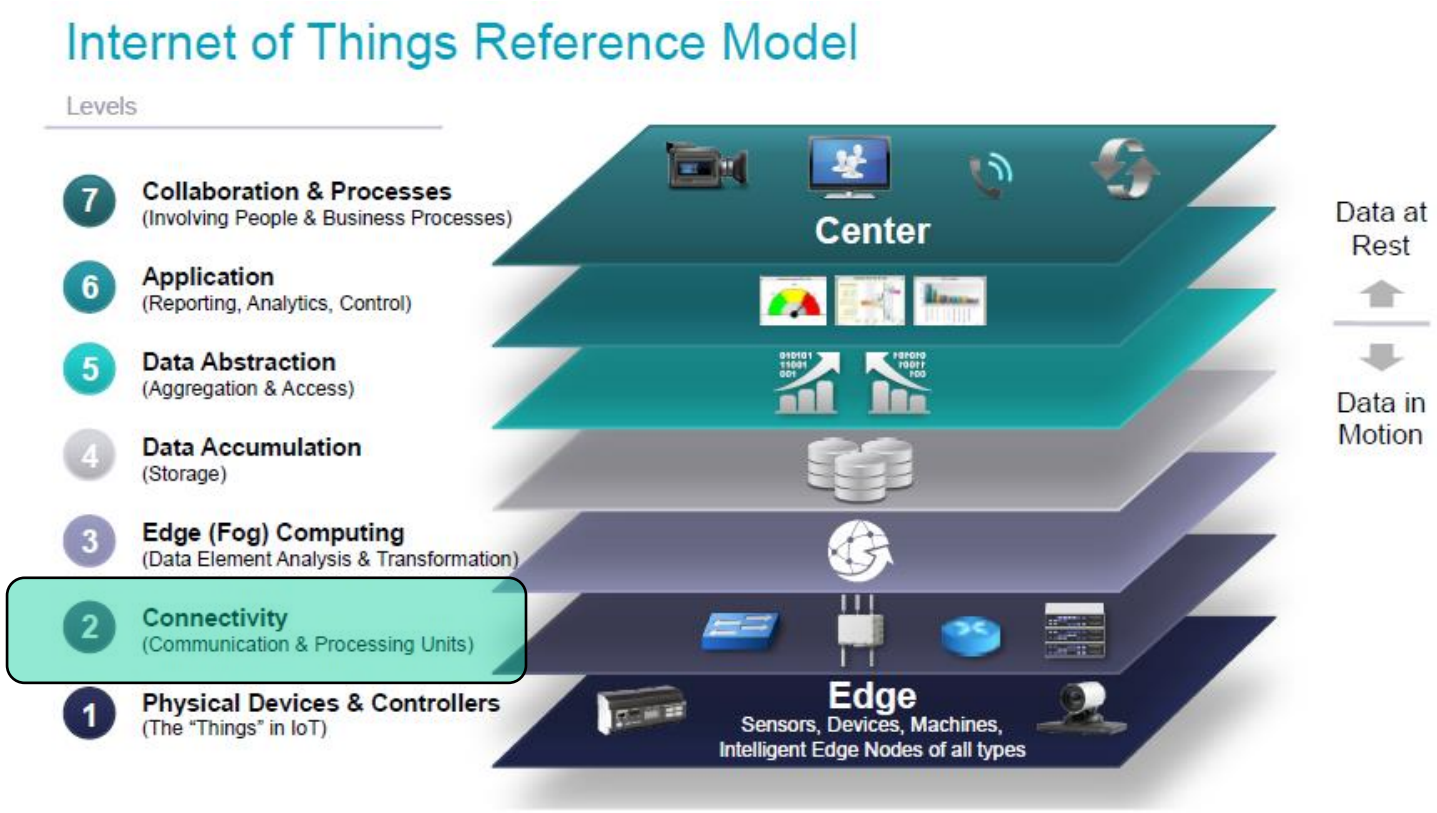
The Internet of things (IoT) is also the network of devices such as vehicles, and home appliances that contain electronics, software, sensors, actuators, and connectivity which allows these things to connect, interact and exchange data.

According to many research sources the world is adopting digital infrastructure, including IoT devices, five times faster than it adopted electricity and telecommunication.

An estimation shows that the number of smart devices will become around 50 billion by 2020.

# IoT reference model

The reference model describes an IoT according to seven layers:

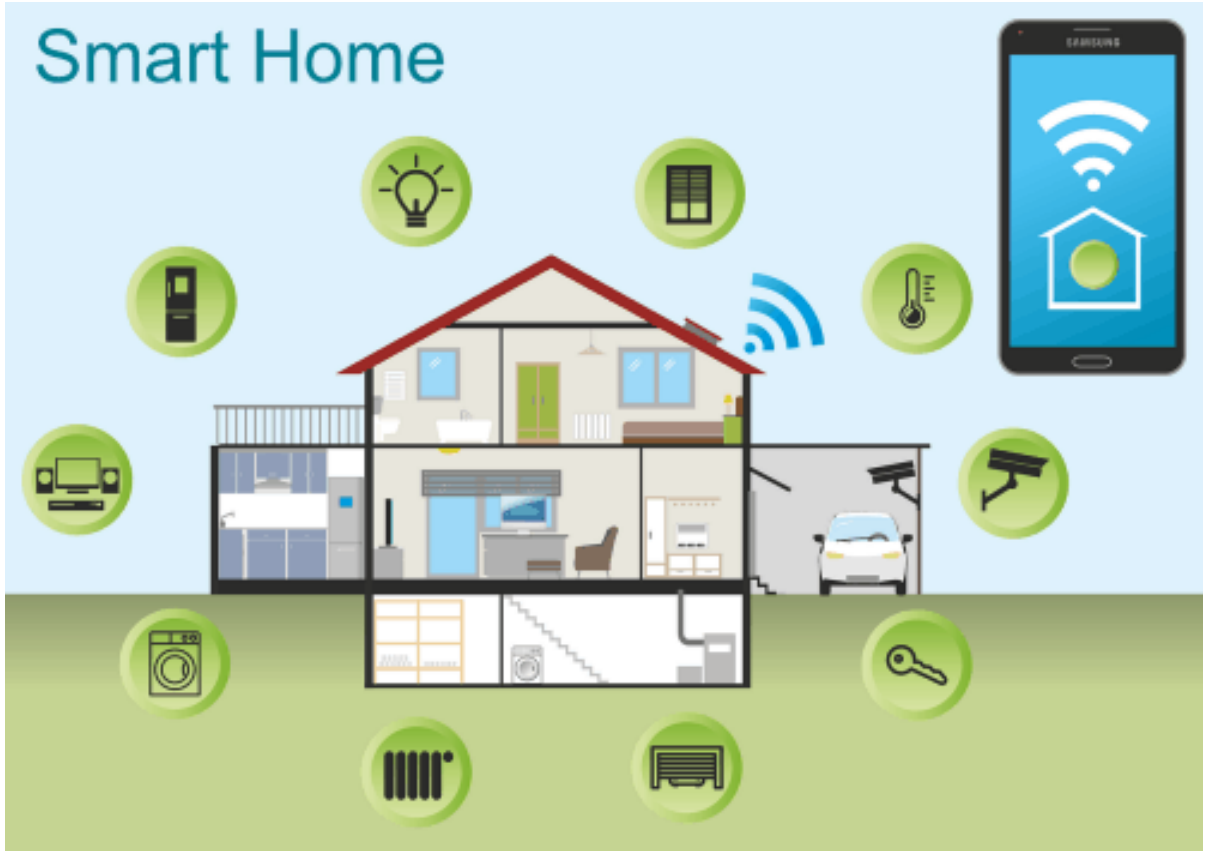



Courtesy of Cisco IoT reference model

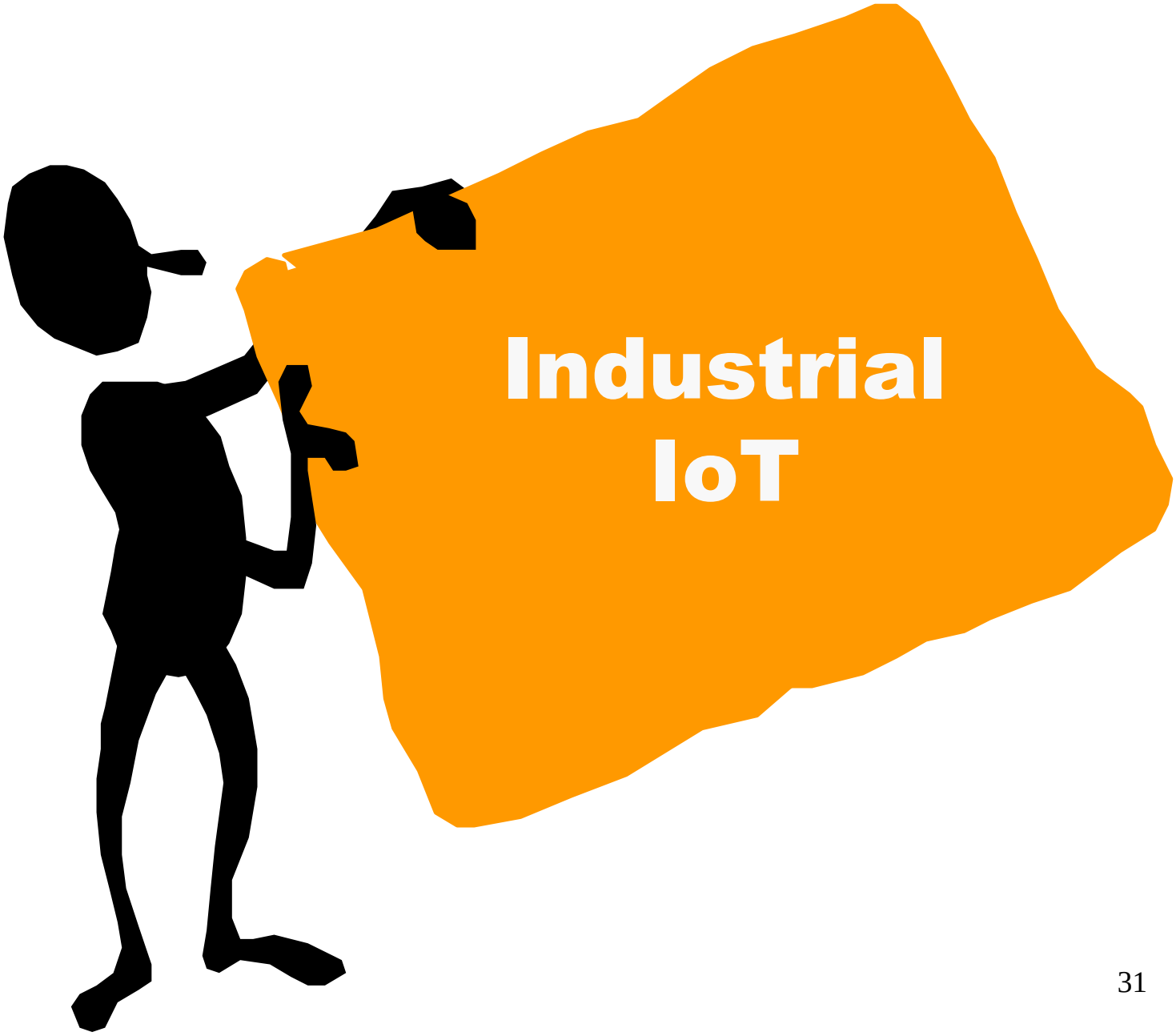
# IoT applications

Examples of IoT can be found everywhere. In fact, we can grasp the impact of IoT on several domains including:

- Industry
- Agriculture
- Municipalities
- Buildings
- Health
- Vehicles



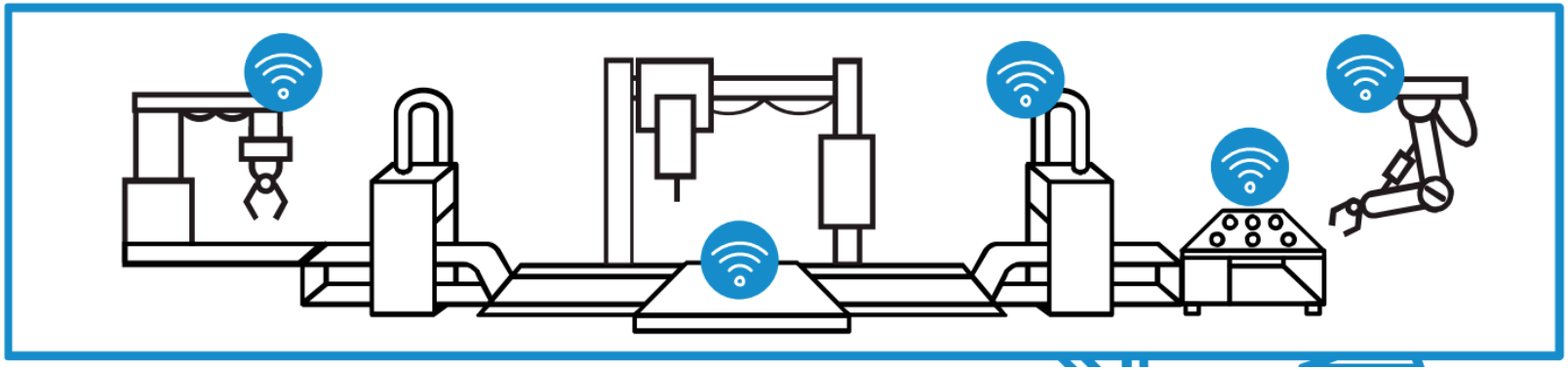
# Live Demo of a Smart Home On Simulation


Industrial
IoT

# Industrial IoT

**Advantage:**

- Collecting machines data
- Exchange and analysis
- improvements in productivity, efficiency and decreasing the cost.



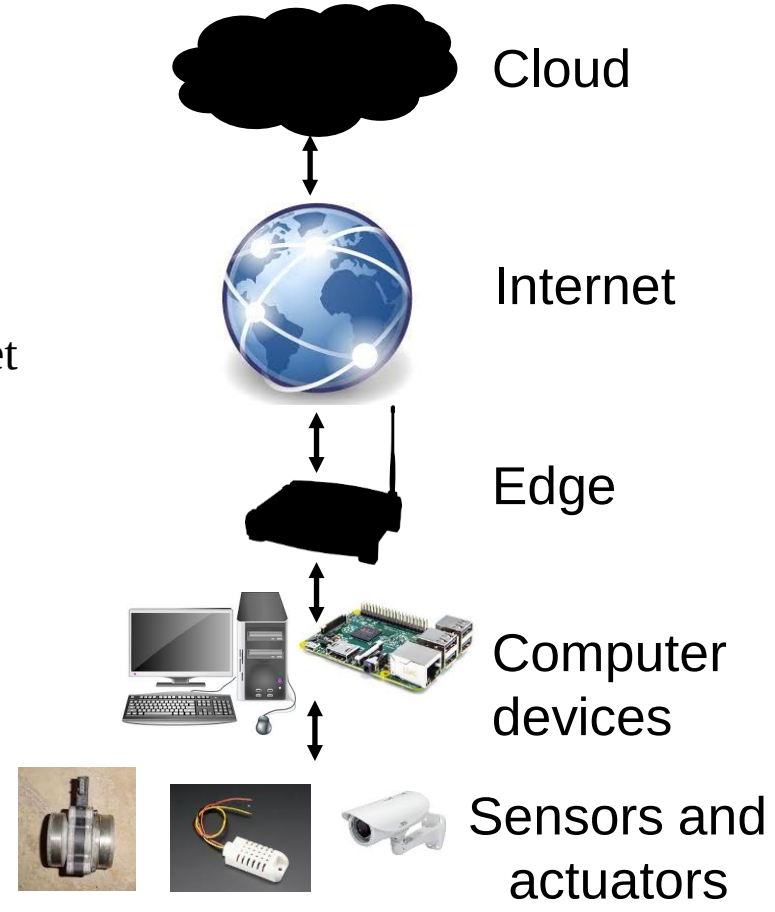
# Industrial IoT

**Capabilities:**

- Monitor: collecting sensor and external data enable monitoring of many aspects including production status, processes, and external environment.
- Control: using the monitored data and with decision making algorithms enable control and personalization.
- Optimize: Monitoring and controlling capabilities enable optimization algorithms to enhance product performance and perform remote service and repair.
- Automate: Using the three above capabilities in addition to algorithms and business logic allows the production system to be performed autonomously.

# IoT Arcitucture

- Sensors: used to measure the environment, actuators are taking actions to change the environment
- Computers: Read the sensor measurements and transfer it to the internet
- Edges: connect the computers to the internet
- Internet: transferring the data to the Cloud
- Cloud: provides storage and computation power for the analysis and decision making
- Different data communication technologies are used between levels



# IoT opportunities in Industry

- Alarm for operators and maintenance:
  - Alarm to operators about abnormal situation so that the operator can decide if a direct action is needed
  - Alarm for maintenance group to be able to optimize the maintenance tasks

- Real-time update of products location
  - Every product's location will be known and can be compared with the planned location. This will lead to faster reaction time.

- Mixed-model production sequencing
  - Optimizing a mixed-model production to find optimal sequences quickly using AI and Machine Learning models

- Any more?

Go to **www.menti.com** and use the code **99 50 85**

Mentimeter

# Any opportunity you can think of?

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PADME

# What is PADME

# PADME

## We target discrete manufacturing

## How can we

- collect the data?
- extract the information?
- visualize the information?

## Considering the current and available technologies

- Support for legacy equipment
- Customized solution

## TRL (Technology Readiness Level) of 7

- Implemented and integrated to the pilot system

**PADME (Process Automation for Discrete Manufacturing Excellence) project**

- 2 years (May 2017-May 2019)
- ABB Robotics, ABB Corporate Research, ABB Control Technology, Mälardalen University, RISE SICS, Level 21.

# OPC UA

## OPC UA protocol:

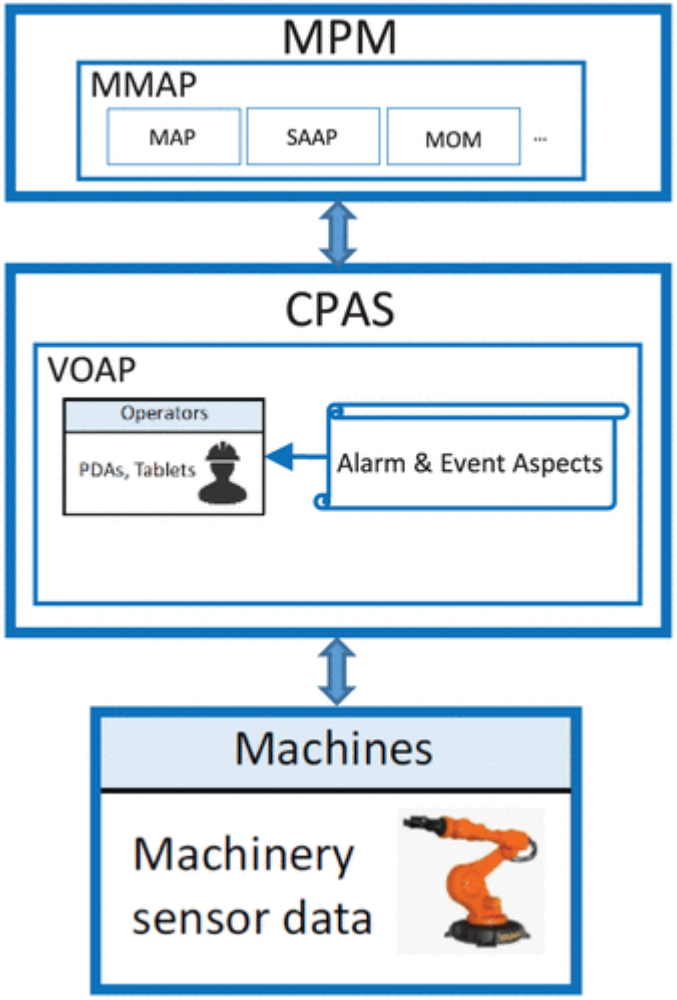
- Open Platform Communication
- Connecting shop floors to other systems
- Connecting machines to machines
- A set of standards to enable communication between devices in manufacturing.
- Communication in the automation layer
- Running by OPC foundation: https://opcfoundation.org/

# CPAS

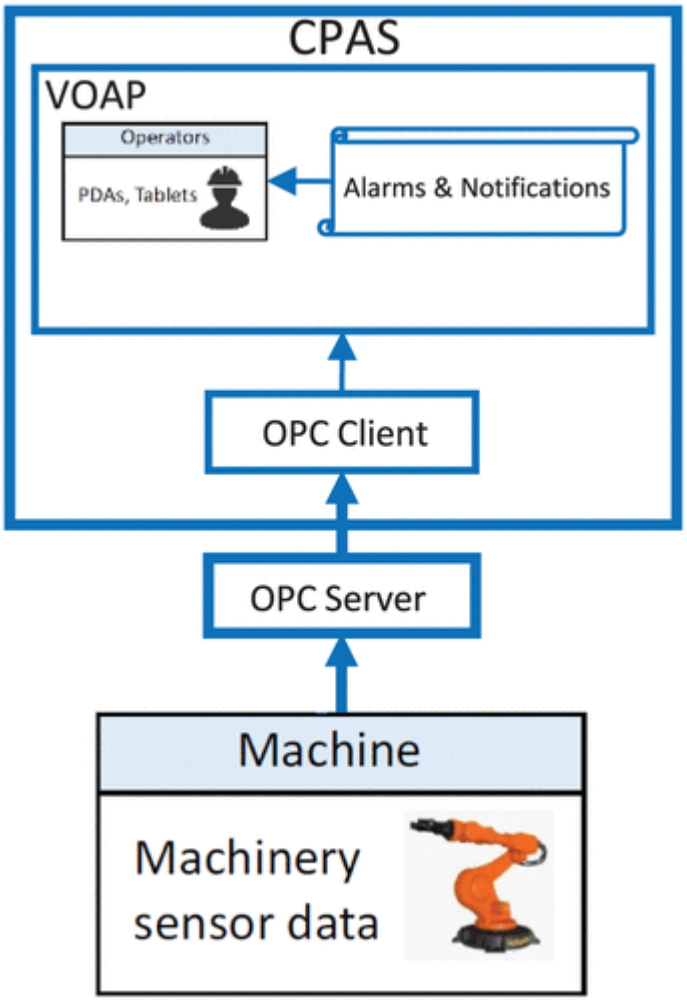
**CPAS:**

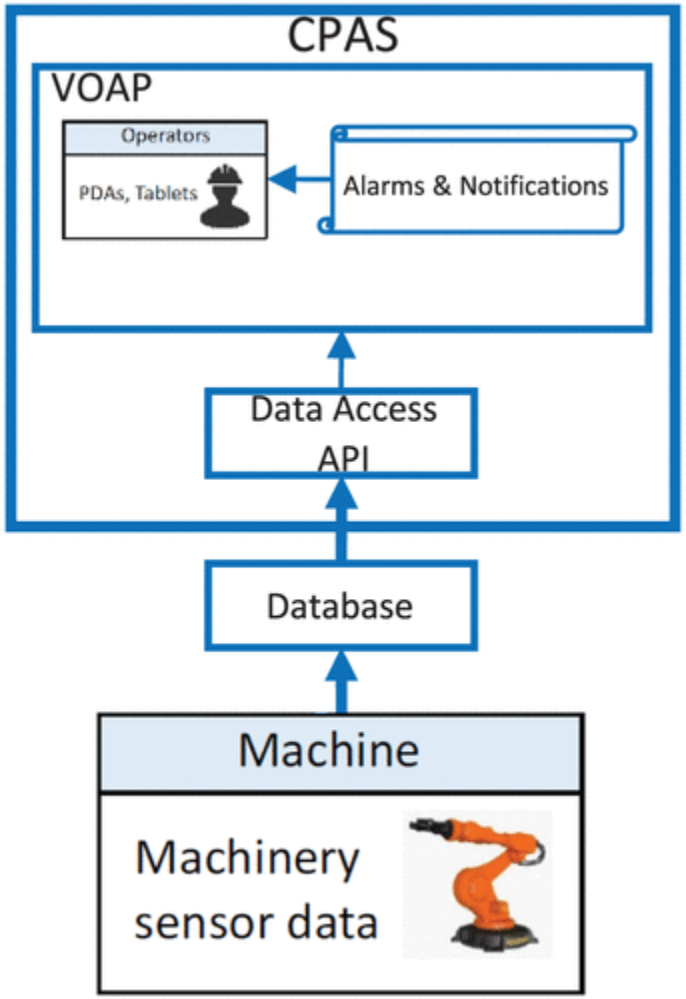
- Collaborative Process Automation System
- Distributed control system
- Commonly used in process industry for a long time
- To control large and complex systems
- It consists of sensors, actuators, computers, monitoring systems, etc
- ABB 800xA

# Alternatives

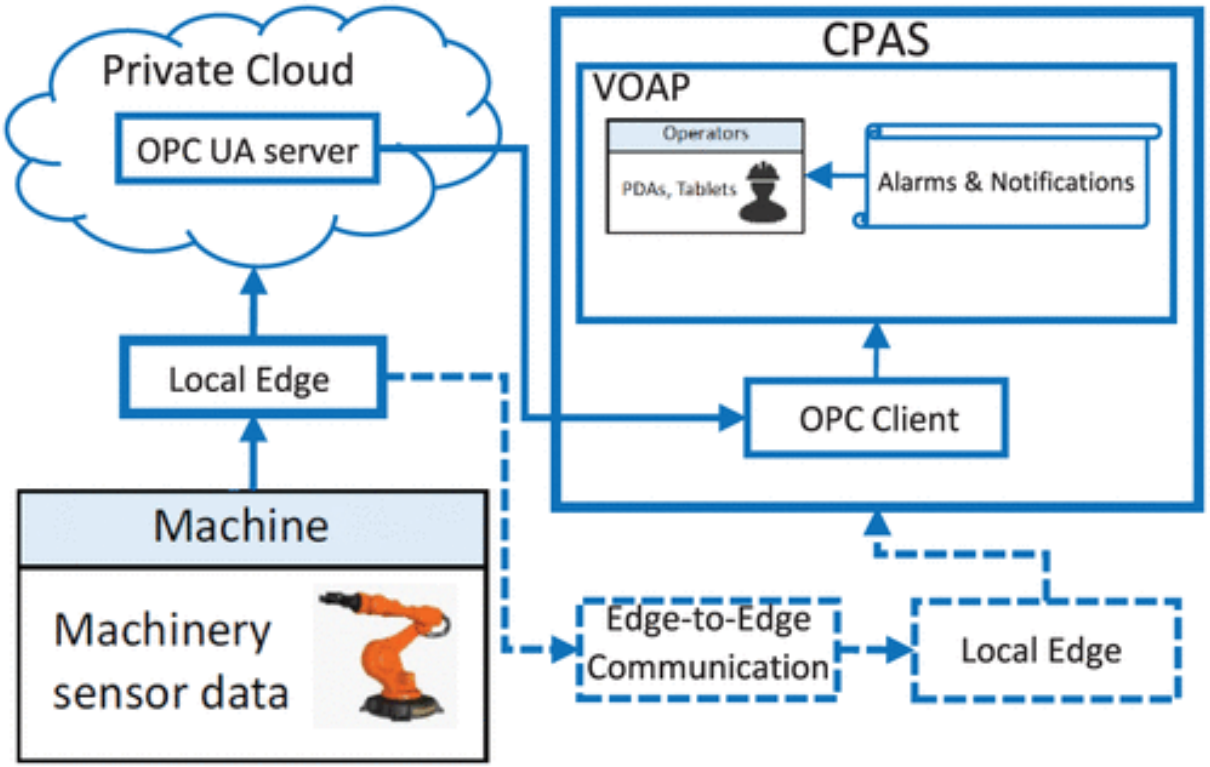


# Alternatives



# Alternatives



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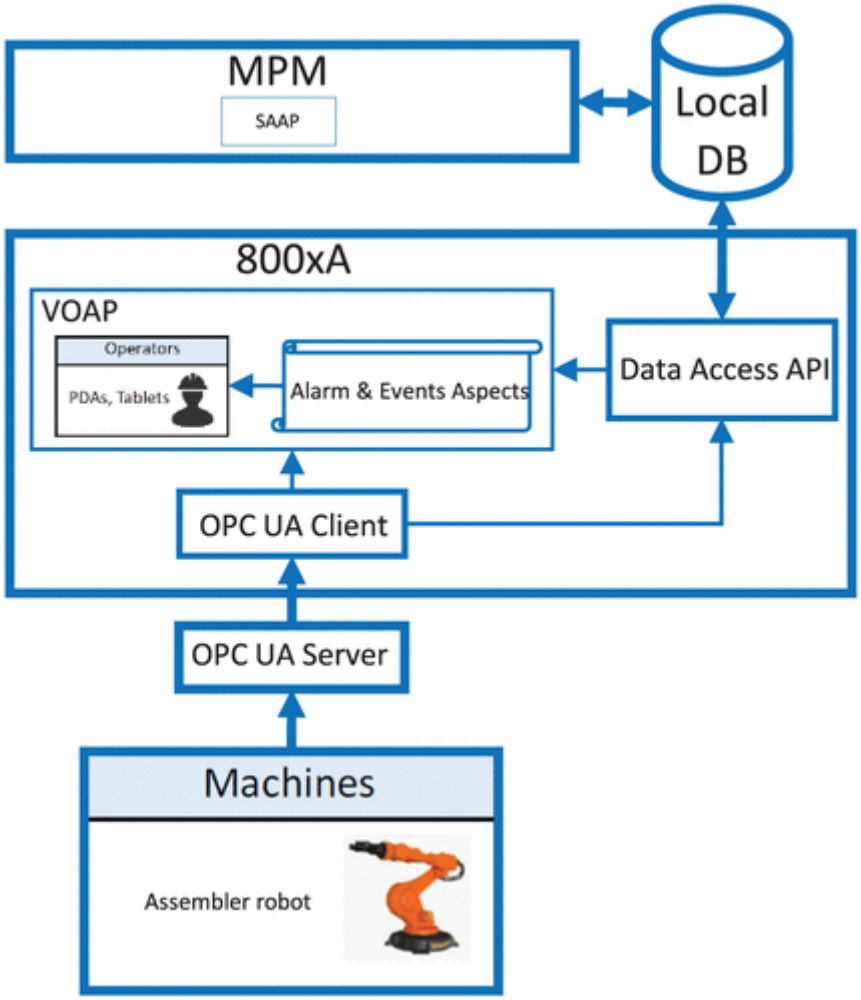
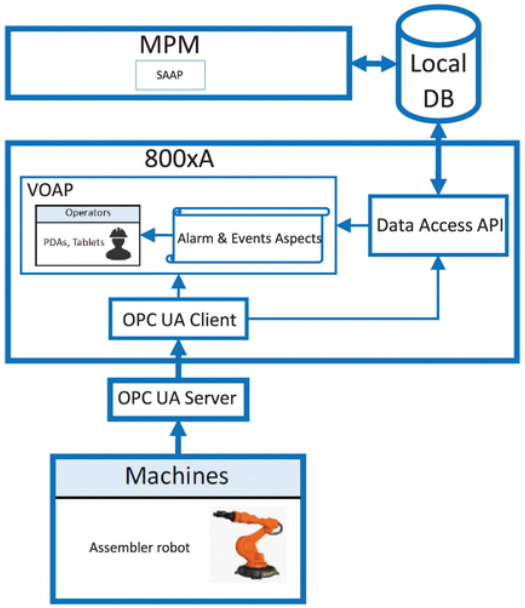


# Visualization

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| Control Structure | 11/19/2018 1:49:... | 800xAInstaller | [Con... | False |
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| Name | 11/19/2018 1:49:... | 800xAInstaller | The ... | False |
| Object Icon | 11/19/2018 1:48:... | 800xAInstaller | Icon ... | False |
| OPC Source Name | 11/19/2018 1:49:... | 800xAInstaller | | False |
| PLC_Short Type Reference | 11/19/2018 1:49:... | 800xAInstaller | This ... | False |
| Signal Configuration | 11/19/2018 1:48:... | 800xAInstaller | | False |

SpeedRatio:Integer PCA

Property Info

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|---|---|---|---|---|---|
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| IsDisabled | False | Good/Non-specific | 11/27/2018 12:10:28 PM | VT_BOOL | R |
| IsUsed | True | Good/Non-specific | 11/27/2018 12:10:28 PM | VT_BOOL | R |

# More information

https://new.abb.com/se/padme/projektrapporter

# Lifelong Learning at Mälardalen University

- **Courses for professionals**
- **Developed in close cooperation with industry**

- **Gives university credits**
- **Free-of-charge for employees in Sweden and EU/EEA and Swiss citizens**

**Production Engineering**
- Industry 4.0
- Lean Production
- Simulation

**Software Engineering**
- Dependable Software
- Internet-of-Things
- Software Test

**Applied AI**
- Big Data
- Machine Learning
- Predictive Analytics

**Environmental and Energy Engineering**
- Circular Economy
- Climate Change
- Sustainable Development

**Innovation Management**
- Trendspotting and scenariodesign
- Innovation Management

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MÄLARDALEN UNIVERSITY
SWEDEN

# Seminar series Industry 4.0

| Date | Title | Teacher |
|---|---|---|
| May 15 | Industrial Internet of Things and the Opportunities in Manufacturing | Mohammad Ashjaei & Moris Behnam |
| May 29 | Artificial Intelligence — A driving force in Industrial 4.0 | Shaibal Barua |
| June 5 | Simulation for evaluation and improvement of production systems | Ioanna Aslanidou |
| June 12 | Introduction to industrial cybersecurity | Francesco Flammini |
| June 26 | AR and VR for Industry 4.0: From Development to Maintenance | Leo Hatvani |
| August 14 | Is maintenance value adding? | Antti Salonen |
| August 21 | Additive Manufacturing – The MDH way | Christopher Gustafsson |
| August 28 | Cobot | Mikael Hedelind |
| September 4 | Optimization of Production Systems | Konstantinos Kyprianidis & Yuanye Zhou & Stavros Vouros |
| September 11 | Industrialization: a multiple perspectives | Koteshwar Chirumalla |

# Production engineering courses autumn 2020

**(5 credits/course)**

- **Lean production**

Study period 2020-08-31 - 2020-11-08

- **Internet of Things for the manufacturing industry**

Study period 2020-08-31 - 2020-11-08

- **Simulation of production systems**

Study period 2020-08-31 - 2020-11-08

- **Big Data and Cloud Computing for Industrial Applications**

Study period 2020-11-09 - 2021-01-17

- **Industrial maintenance development**

Study period 2020-11-09 - 2021-01-17

**For more information, visit mdh.se/premium**

# Production engineering courses spring 2021

**(5 credits/course)**

- **Optimization of production systems**

Study period 2021-01-18 – 2021-03-28

- **Visualization for industrial applications**

Study period 2021-01-18 – 2021-03-28

- **Industry 4.0 – Introduction**

Study period 2021-03-29 - 2021-06-06

- **Industry 4.0 – Realisation**

Study period 2021-03-29 - 2021-06-06

- **Industrialization and Time-to-Volume**

Study period 2021-03-30 - 2021-06-08

**For more information, visit mdh.se/premium**

MÄLARDALENS HÖGSKOLA
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