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Industrial Automation, Industry 4.0 and Smart Factories

Wednesday, 29 June 2022 | Technical Topic Webinar

Presented By

Dr. Ali Marzoughi | EIT Lecturer and Unit Coordinator

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Introduction - Presenter

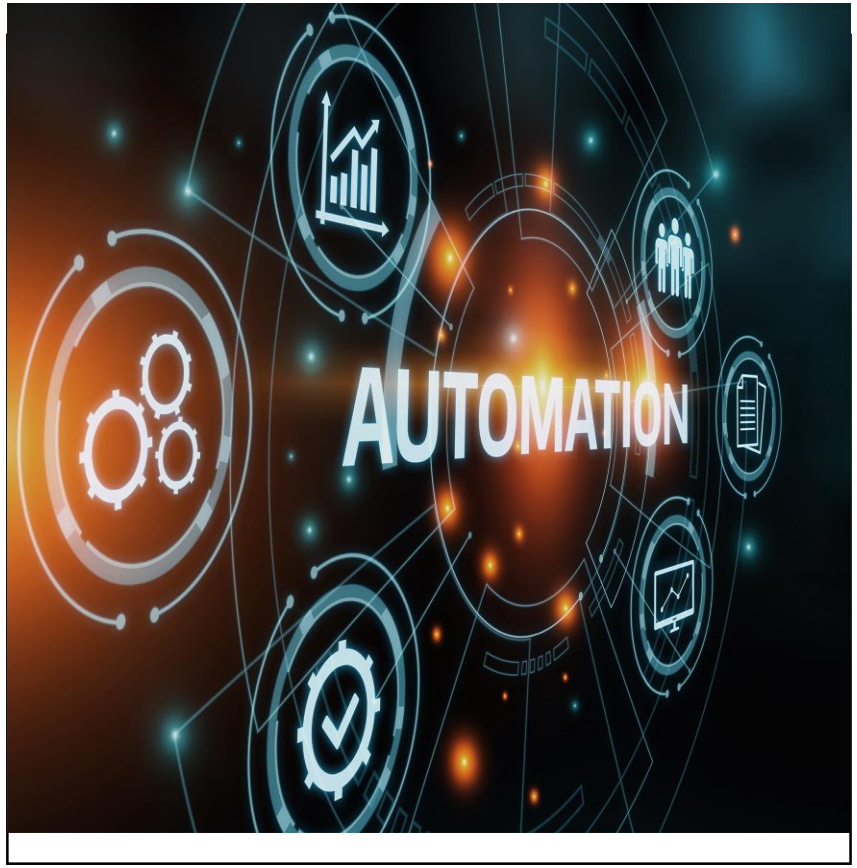
Dr. Ali Marzoughi

Ali is an experienced electrical engineer with a PhD in multi-agent autonomous mobile robot control.
He is a lecturer and unit coordinator at EIT.
Ali started his professional career as an instrumentation engineer in the oil and gas industry and was promoted to different roles in different areas of the industry.
His research interest is included multi-mobile robots' navigation, control and decision making, power electronics and drives, optimisation, sensors, measurement and instrumentation.

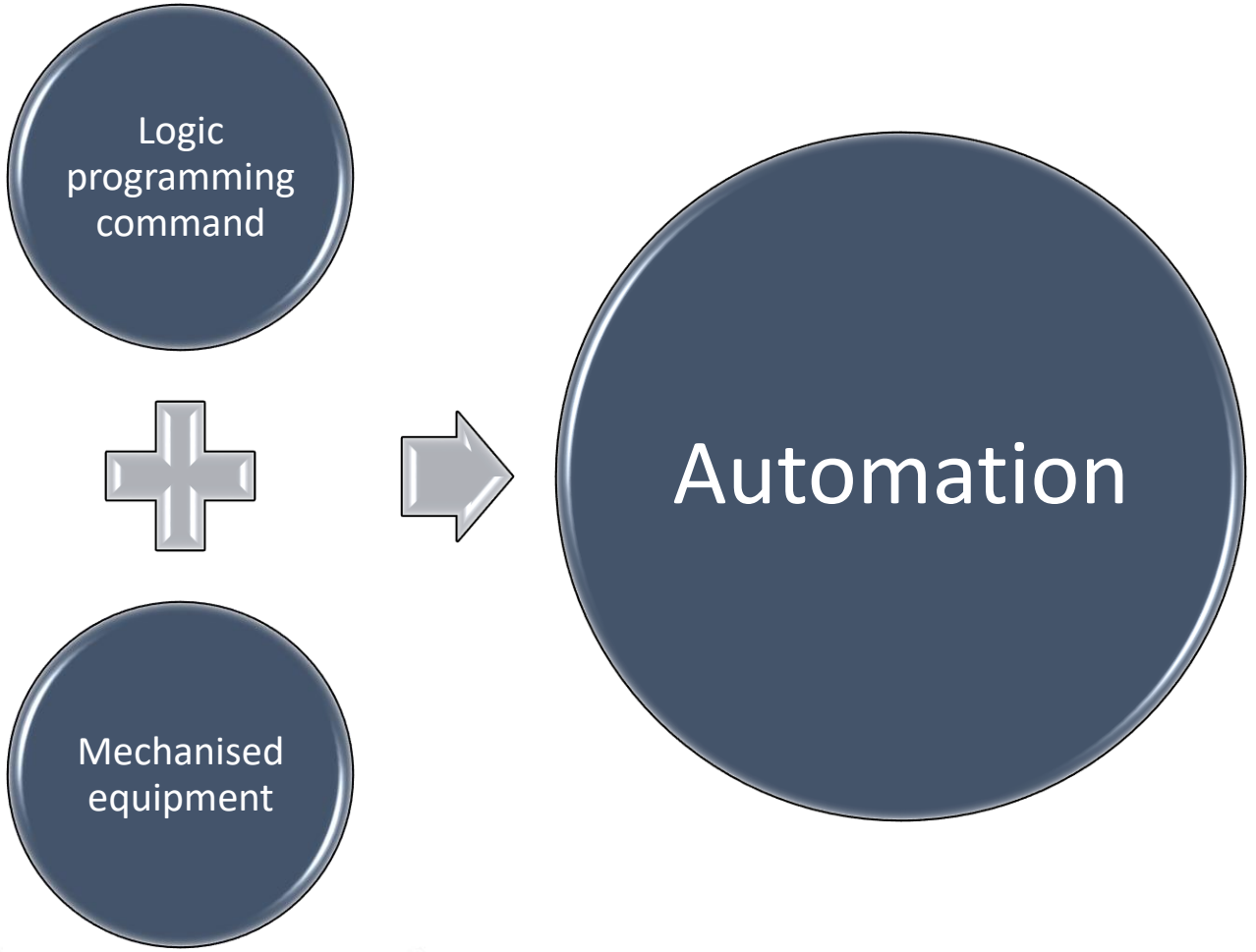
Agenda

1	Welcome and Introduction
2	Introduction to Industrial Automation
3	Industrial Internet
4	Industry 4.0
5	Smart Factories
6	Conclusion and Q&A

Introduction to Industrial Automation



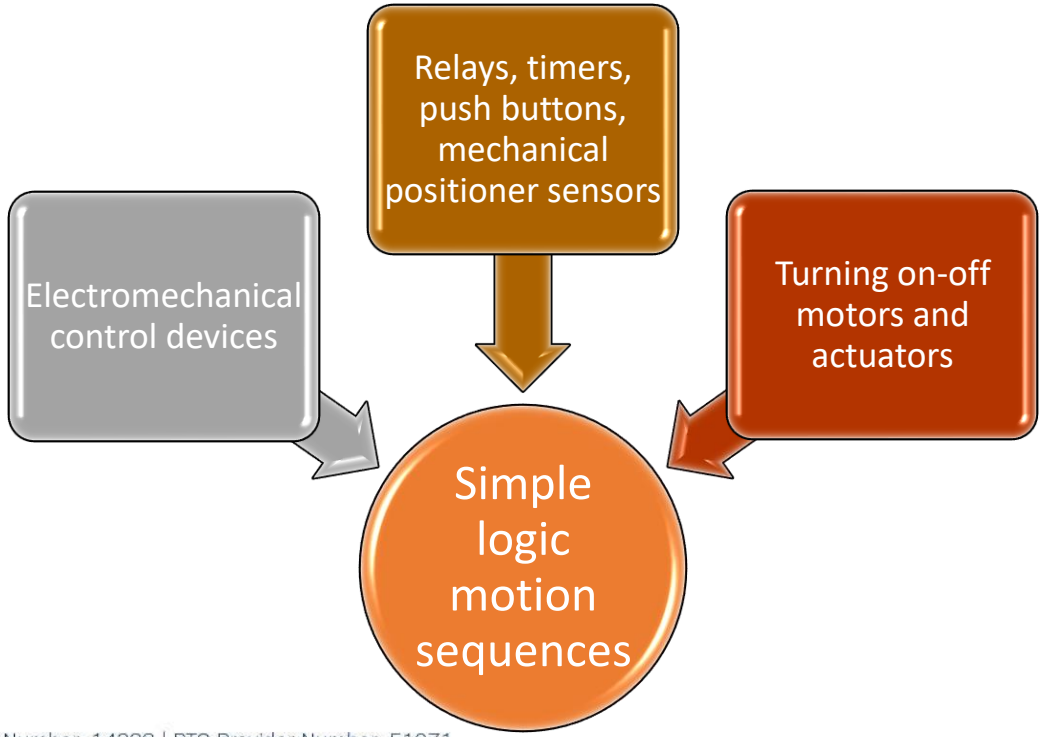
Industrial Automation. Source:[www.utthunga.com]



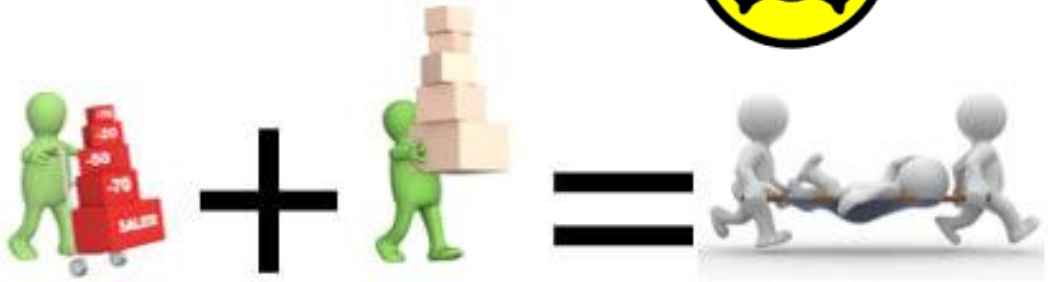
Introduction to Industrial Automation

Ford assembly line 1940. Source:[www.windsorprints.com]

In 1946, Delmar S. Harder (1892–1973), Vice-President for Manufacturing at the Ford Motor Company in the US, introduced a new word, ***'automation'***, into the English language[1].



Introduction to Industrial Automation



Advantages:

- The capability of doing hard physical and monotonous works
- Working in hazardous, extreme temperatures, radioactive, toxic atmospheres and so on.
- Heavy load handling, tiny object manipulating.
- Faster production and fewer labour costs.
- Incorporating quality checks and verifications

Introduction to Industrial Automation

Disadvantages:

- Some of the tasks can not be easily automated such as tasks with manual dexterity
- For some tasks, automation is more costly than manual operation
- The cost for research and development is not predictable
- High initial cost
- The skilled maintenance department and operators are required

Evolution of Industrial Automation

Industry 1.0

Mechanical manufacturing

Steam powered machines replaced human labour

Industry 2.0

Mass production

Electric powered machines aided the production of goods in massive quantities

Industry 3.0

IT enabled the use of geographically disparate systems, reducing production cost

Industry 4.0

Cyber-physical system use

Technologies like ML/AI enabled automated information sharing and even decision making

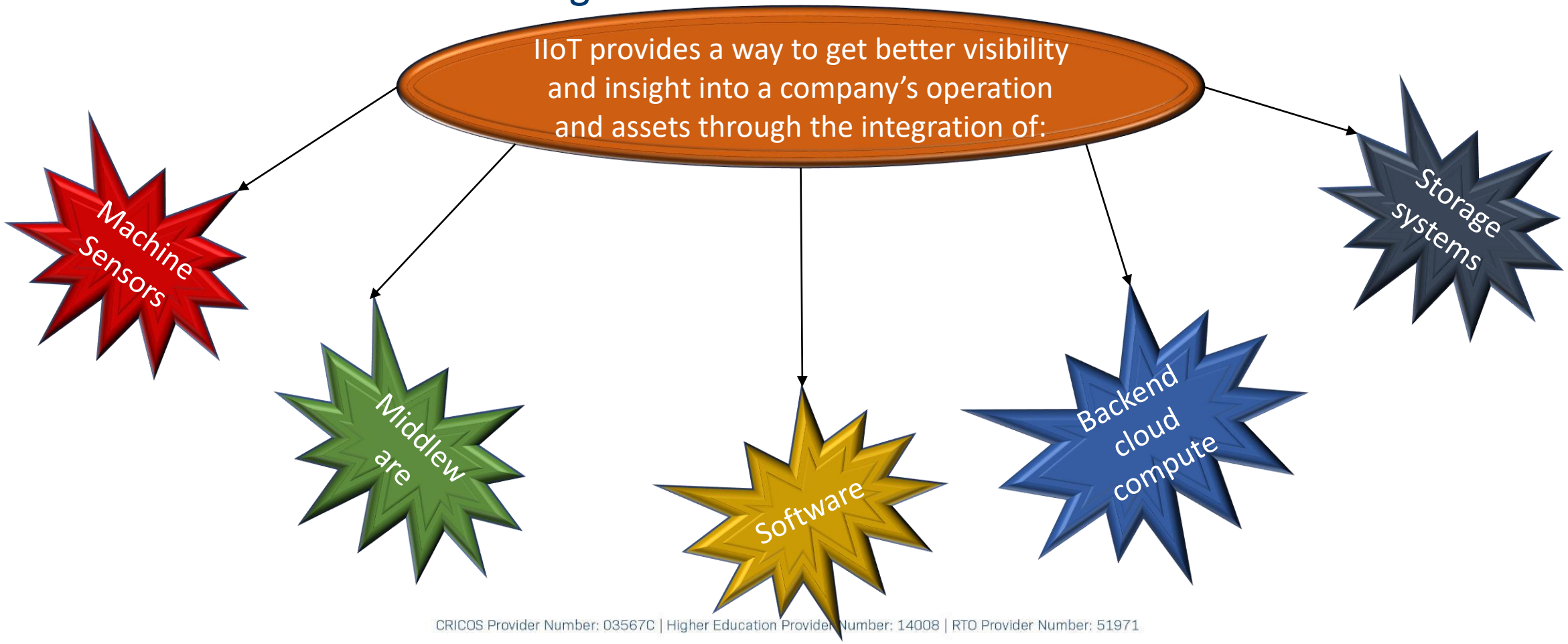
Industry 5.0

Personalisation

Co-operating between man and machine by putting human back into industrial production with collaborative robots

Industrial Internet

What is Industrial Internet of Things



Industrial Internet

IIoT-Key Technologies:

Advance technology of sensors

Smart sensors:
Collect data
Take measurement
Transmit data to cloud computing for analysis

Intelligent sensors:
Signal processing techniques
Data fusion techniques
Intelligent algorithms
Artificial intelligence and machine learning

Big Data

Volume: Size of data collected and stored
Velocity: Streaming analysis
Variety: Data imported from new varieties (PDFs, emails, voices, videos, …)

Variability: Examine the data sets more closely
Veracity: Verify if the data is suitable
Value: Identify the purpose, scenario or benefit

Industrial Internet

Example of Intelligent Sensors:

Smart level sensors:
Fuel gauge to communicate and indicate the amount of fuel left in the vehicle

Smart tracking sensors:
Tracking production and process system and monitoring factory production

Machinery health sensors
Tracking the health of machines and predicting the future trends of the fault

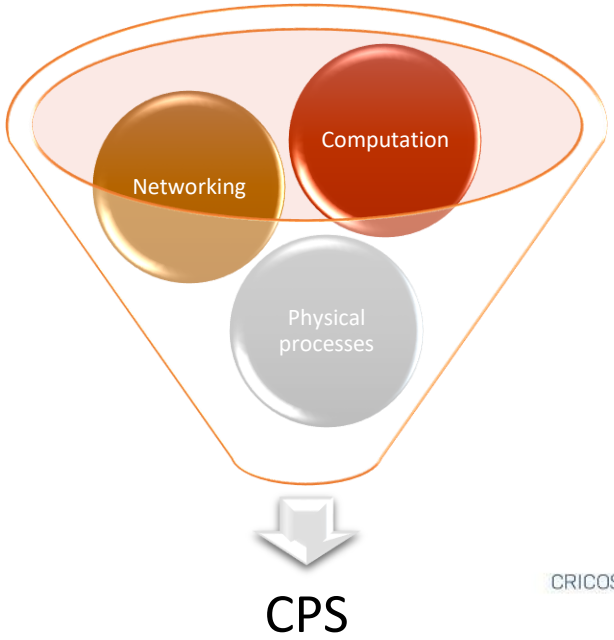
Radio frequency Identification sensors:
RFID captures data and stores them in a database

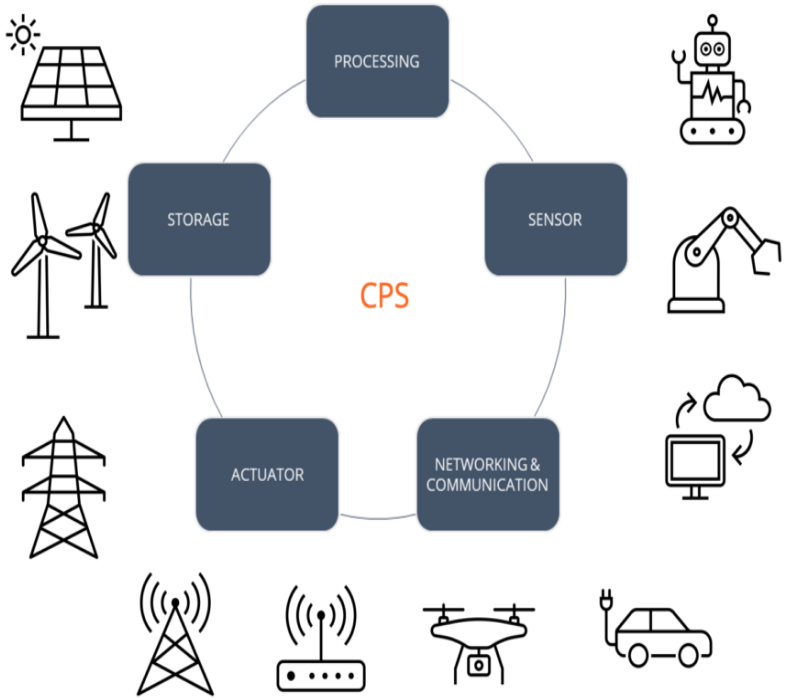
DUT-E GSM level sensor-Source[www.technoton.com]

Industrial Internet

Cyber-Physical Systems (CPS):

Cyber-physical systems enable the virtual digital world of computers and software to merge with the physical analogue world through interaction—process management and feedback control— which results in IoT, Big Data and Services.





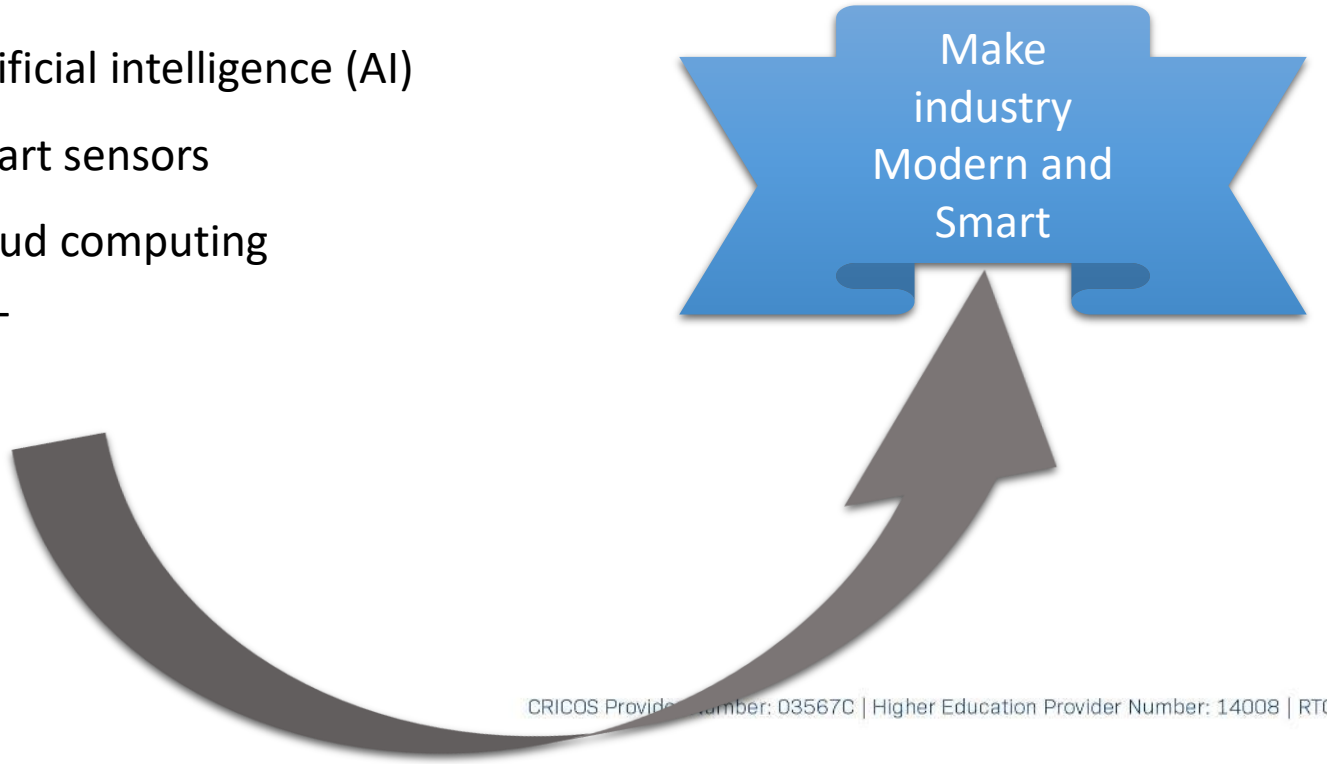
Cyber-Physical Systems Examples Source[www.Cleantech.com]

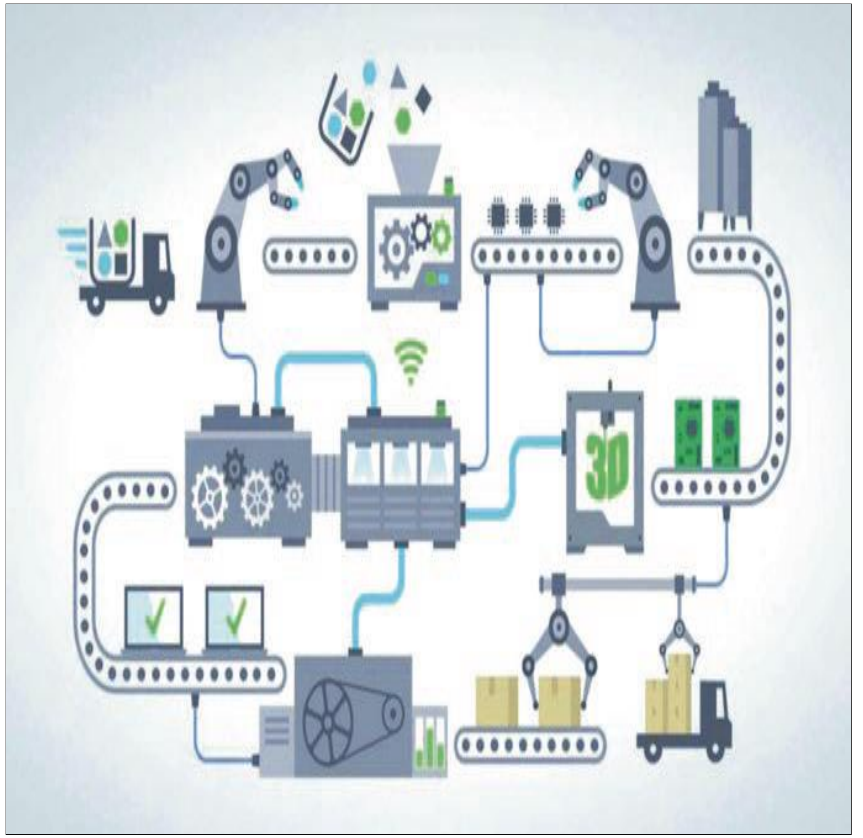
Industry 4.0

What is Industry 4.0

Industry 4 can be defined as an umbrella that covers different technological trends such as:

- Advanced robotics
- Artificial intelligence (AI)
- Smart sensors
- Cloud computing
- IIoT





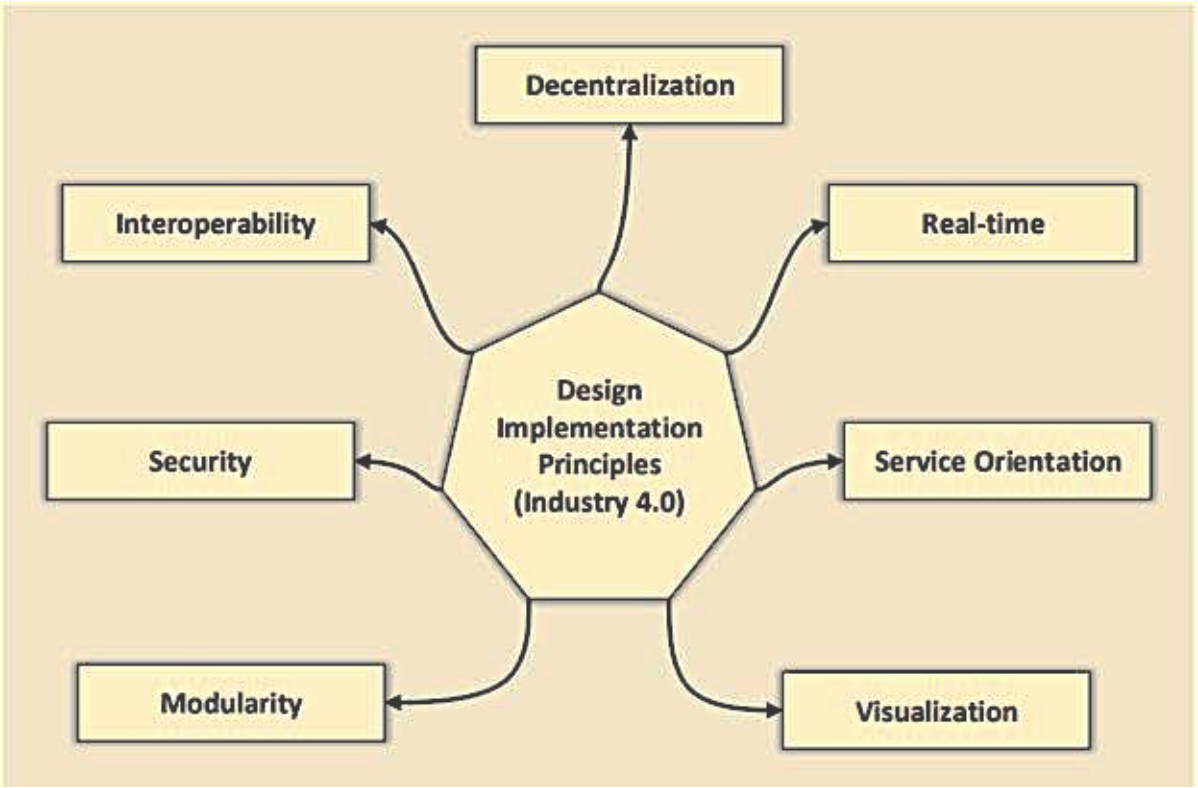
Industry 4.0: Solutions for Proper Factory Operations. (Source: Cisco Canada Blog-Manufacturing- Industry4.0- Jennifer Rideout)

Industry 4.0

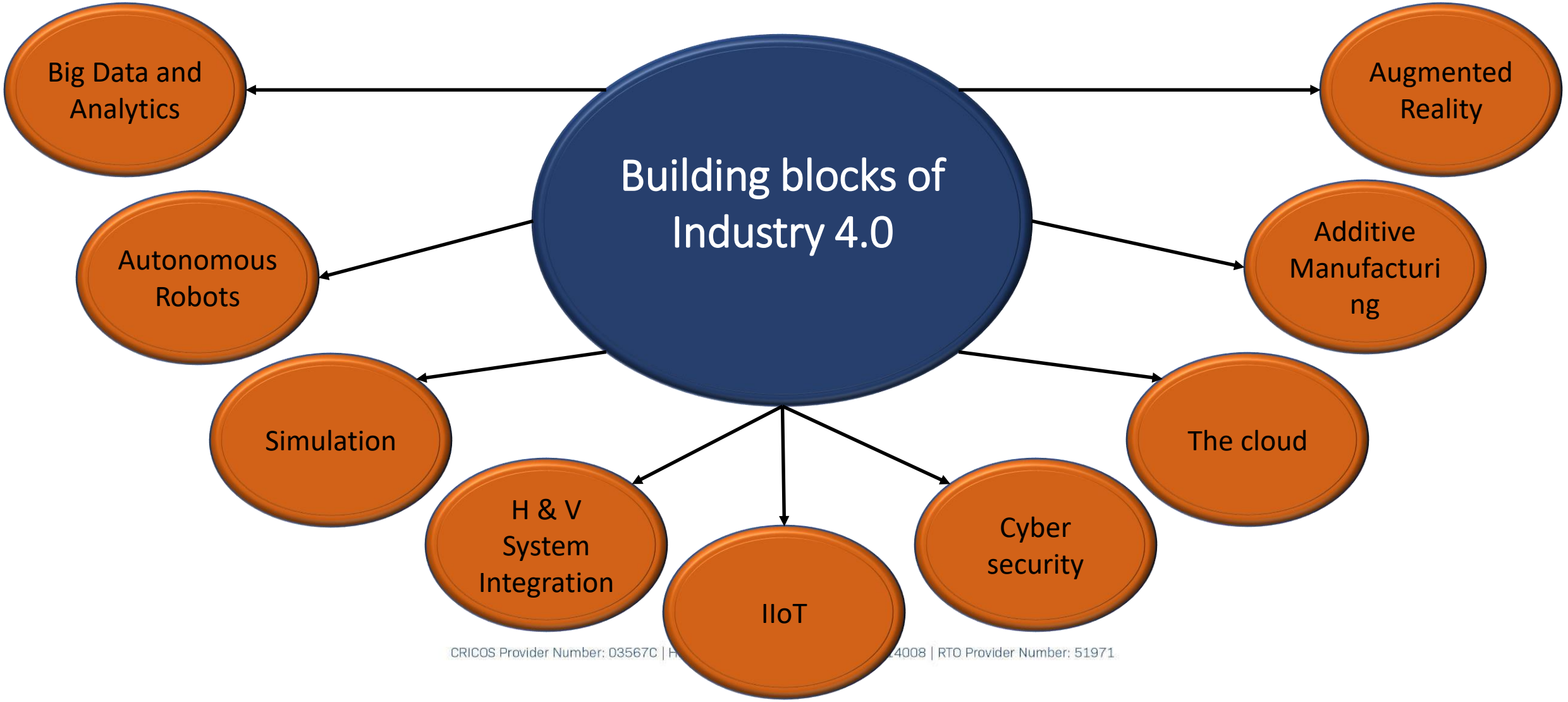
The design principle of Industry 4.0

Connecting systems, machines and units to create decentralised networks to be able to control each other autonomously

1. Interoperability
2. Virtualization
3. Decentralization
4. Real-time Capability
5. Service orientation
6. Modularity
7. Security



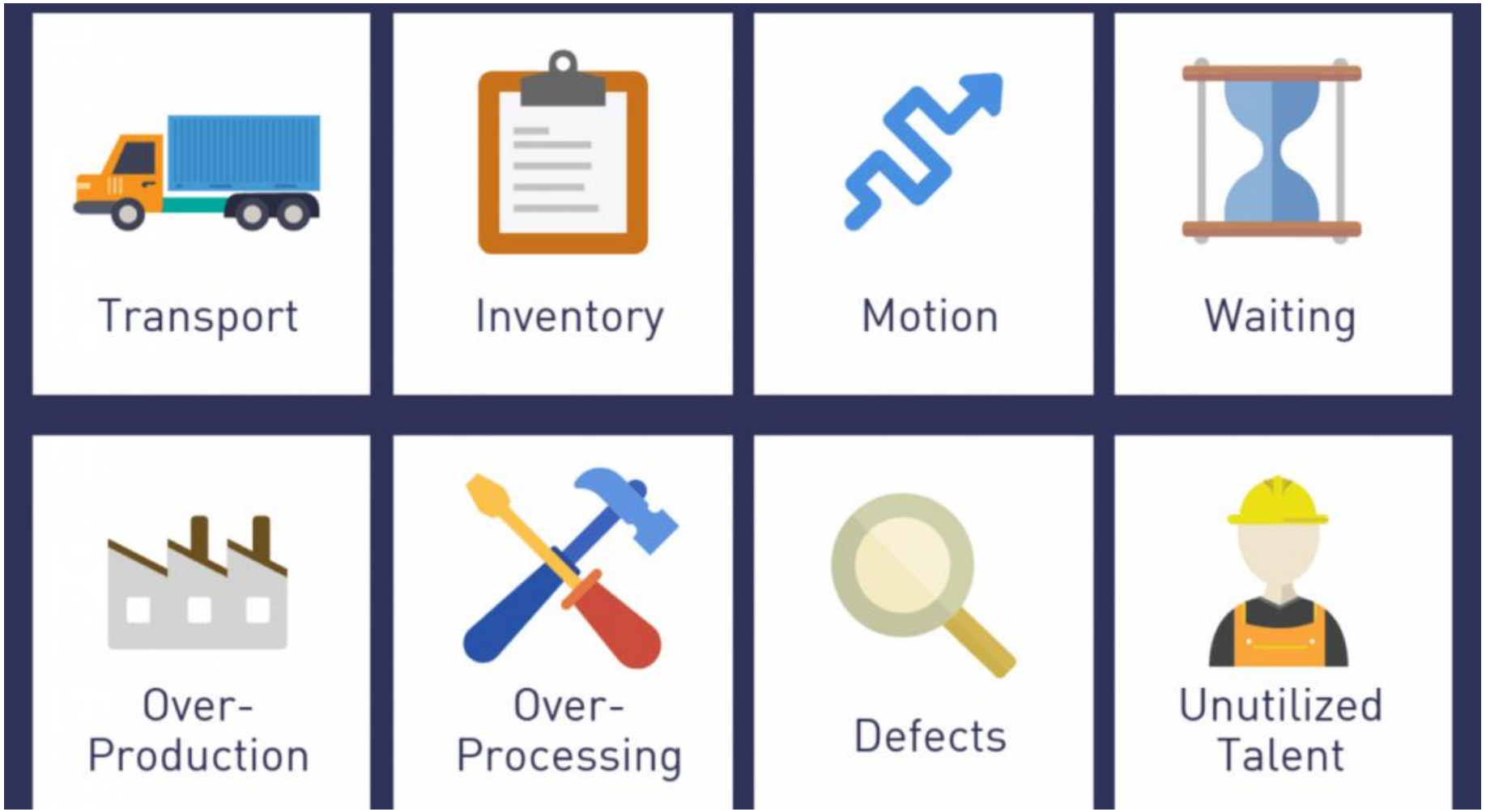
Industry 4.0


Building blocks of Industry 4.0
Big Data and Analytics
Augmented Reality
Autonomous Robots
Additive Manufacturing
Simulation
The cloud
H & V System Integration
IIoT
Cyber security

Smart manufacturing

Lean manufacturing:

The goal of lean manufacturing is to produce goods smoothly and consistently



Smart manufacturing

Smart manufacturing:

- Similar to lean manufacturing
- Merging analogue to the digital world
- Providing an enhanced process
- Delivers goods smoothly and consistency

- Lean and Smart are complementary process improvement strategies working side by side in the factories of the future

Smart manufacturing

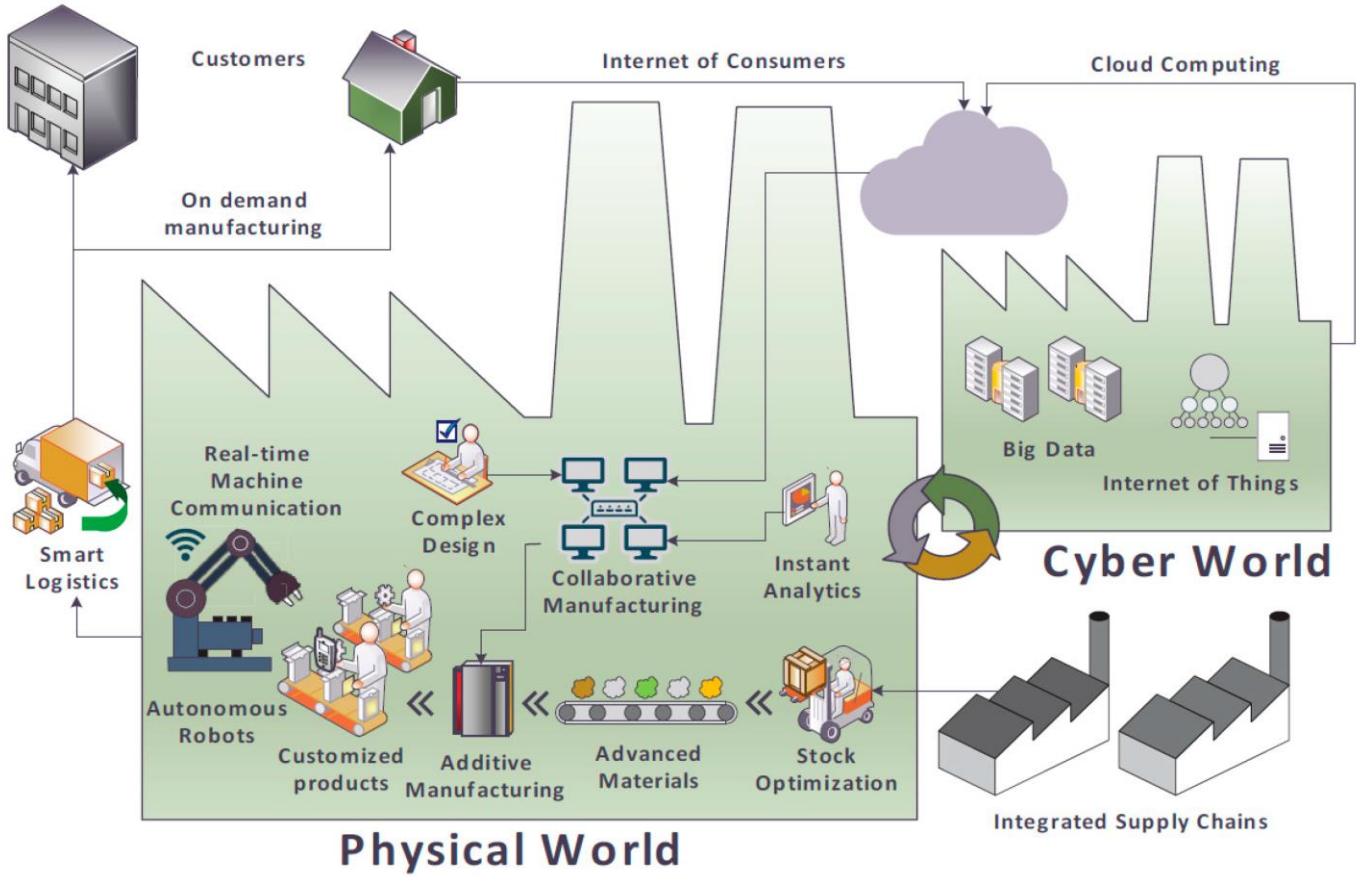
Smart manufacturing:

1. Products: Parts of components should be identifiable and intelligent.
2. Business Processes: Parallel processing, real-time responses to process control, collaborative machines (CPS) on the production line.
3. Optimising the supply chain: Trends shift from make-to-stock ➡ make-to-order, configure-to-order, or engineer-to-order
4. Customers: The customers' evaluation of the product is everything

Smart Factories

What is a smart factory?

- Host smart manufacturing process
- Produce and deliver beyond our expectations
- Machine to Machine collaboration and communication through advanced software, algorithms, and industrial processes



Smart Factories

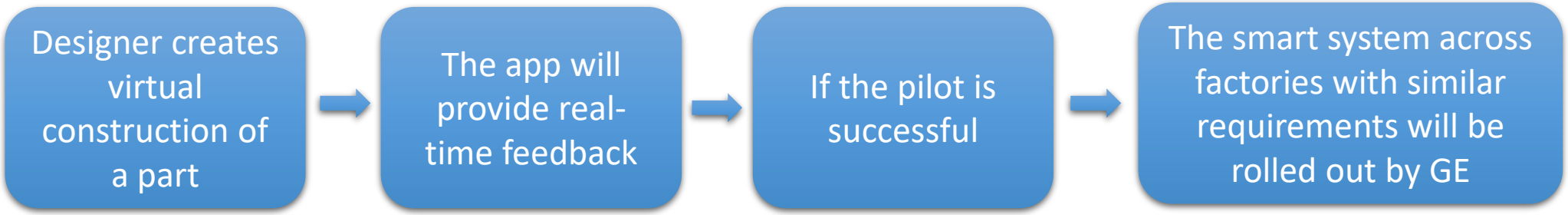
Requirements for a smart factory (A research approach):

Modular machine tools or workstations	**Modular and decentralized control architecture**	**Multi-skilled workforce**	**Online data analysis**	**Reconfigurable tools**	**Standard infrastructure**	**Standard communication and CPS**	**Embedded computer**	**Sharing meaningful information**	**Secure communication**
Collaborative behaviour	**Customization and real-time capability**	**Smart product**	**Virtual system builder**	**Online monitoring and control**	**Standardized virtual modelling language**	**After-sale services**	**Offering core processes as services**	**Cloud computing and connection**	**Heal ability**

Smart Factories (Real-World examples)

State-of-the-are factories that are already in production:

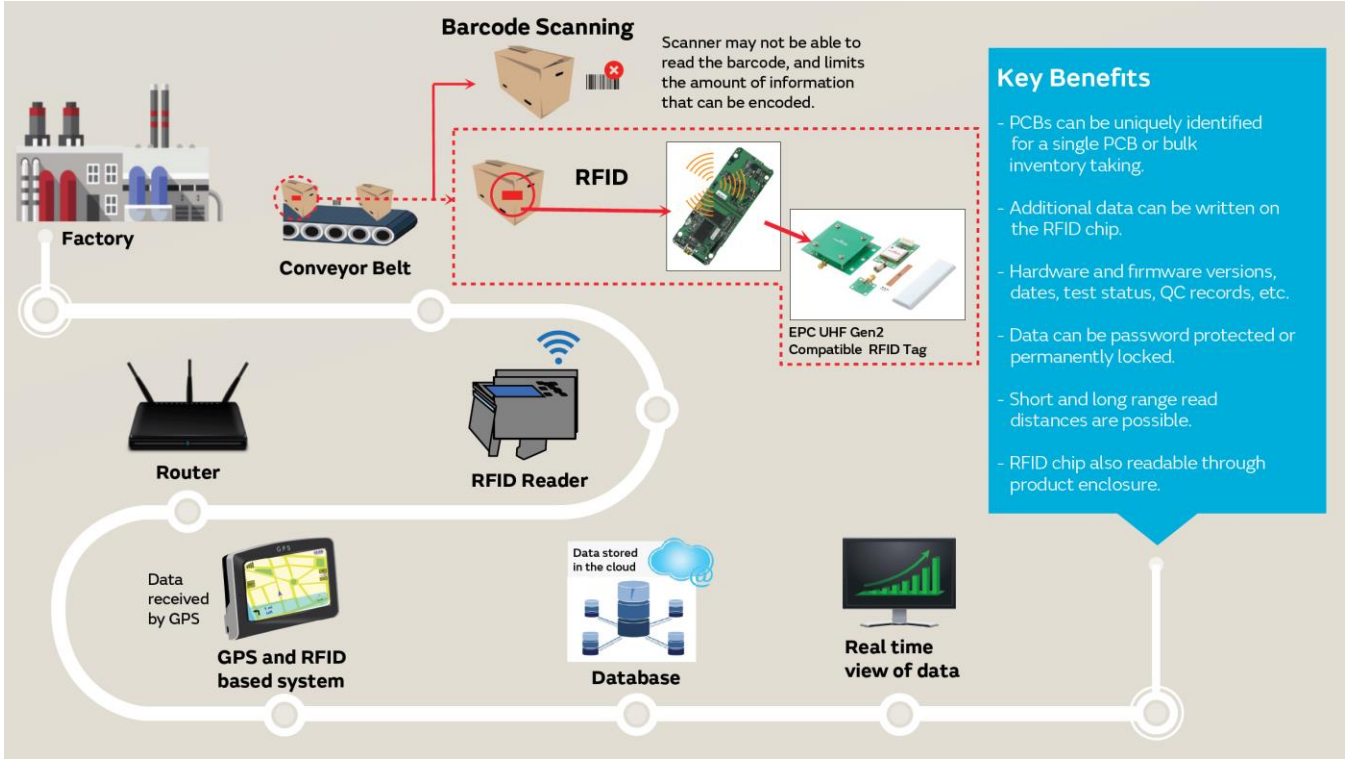
- General Electric's "Brilliant Factory" already uses IIoT.
- GE aims to build a continuous loop of real-time data sharing, enabling faster and more precise decision-making.
- Increasing its productivity, better design, manufacturing and services.
- GE developed a mobile app that connects the factory floor with engineering, allowing engineers to verify the factory is feasible to:
    - manufacture virtual products which are still in the design phase



Case study:

Printed Circuit Board (PCB) with RFID Tracking & Traceability (A case by Murata):

- Challenges:
  - PCBs use barcode which requires a line of sight between the label and the reader
- Implementation:
  - An RFID tag is mounted onto the PCB as a standard surface-mounted technology component
- Solution:
  - The programable data includes serial number, model number, manufacturing process and other product information



Source: Smart factory automation-Murata innovator in electronics

References

[1] M. Jackson, *Industrial Automation and Stress, c.1945–79 – Sarah Hayes*. Routledge, 2016.

[2] M. Mehrpouya, A. Dehghanghadikolaei, B. Fotovvati, A. Vosooghnia, S. S. Emamian, and A. Gisario, "The potential of additive manufacturing in the smart factory industrial 4.0: A review," *Applied Sciences (Switzerland)*, vol. 9, no. 18. 2019, doi: 10.3390/app9183865.

[3] A. Gilchrist, "Introducing Industry 4.0," in *Industry 4.0*, Apress, 2016, pp. 195–215.

[4] A. Gilchrist, "Smart Factories," in *Industry 4.0*, Apress, 2016, pp. 217–230.

[5] A. Gilchrist, "Introduction to the Industrial Internet," in *Industry 4.0*, Apress, 2016, pp. 1–12.

[6] https://www.ge.com/digital/brilliant-manufacturing

[7] "Market Insights on Smart Factory Automation."

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Bachelor of Science degrees	13 February 2023
Graduate Certificates	2 January 2023
Master of Engineering degrees	2 January 2023
Doctor of Engineering	13 February 2023
On Campus Bachelor's, Master's and Doctor of Engineering programs	1 August 2022

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Q&A

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Head Office
1031 Wellington Street West Perth
Perth, WA 6005

Phone
Inside Australia: 1300 138 522
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