# Edge and Big Data technologies for Industry 4.0 OT/IT integration

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ALMA MATER STUDIORUM
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# What is Industry 4.0?

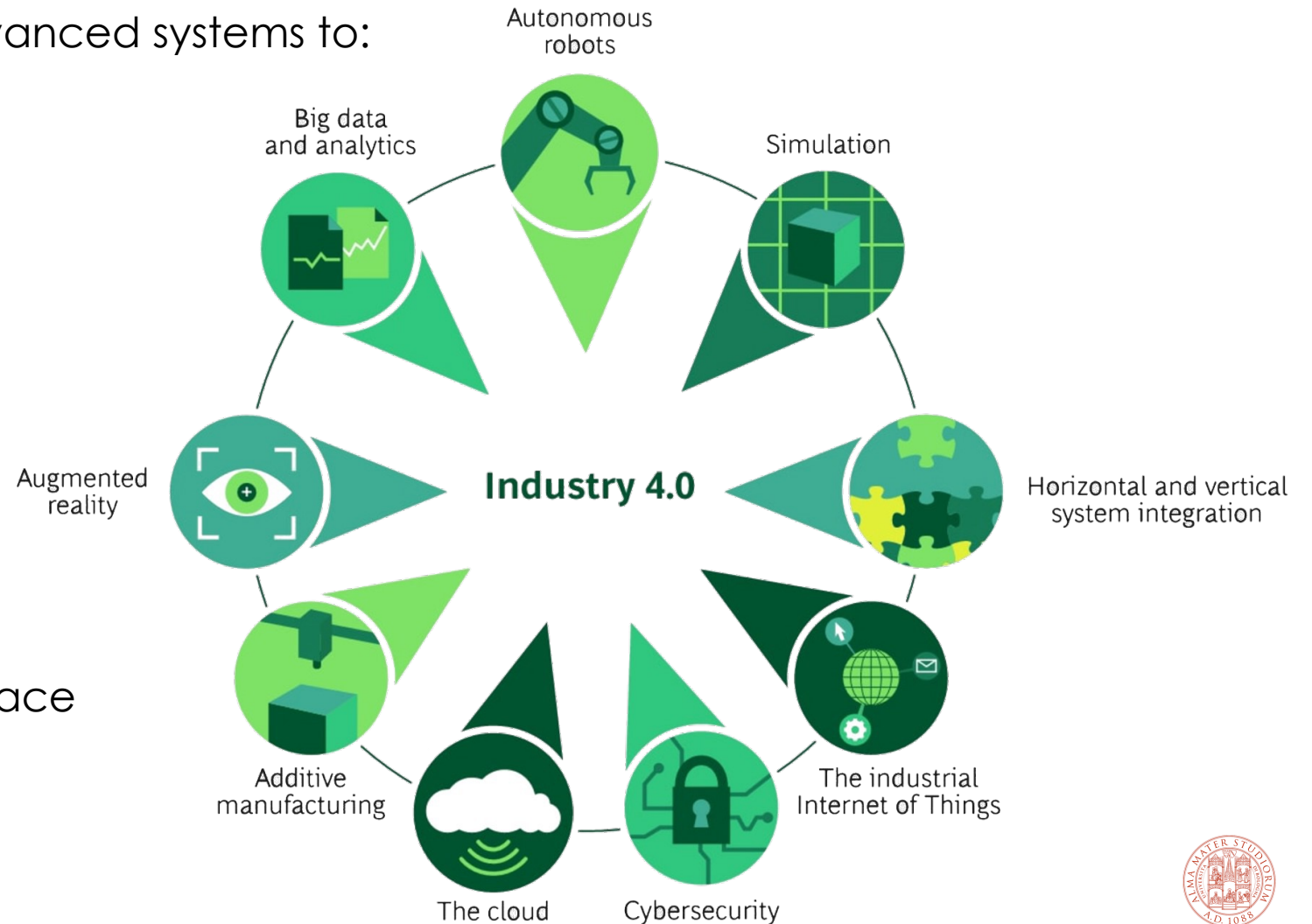Integrate new technologies and advanced systems to:
- ✓ **Optimize** industrial processes
- ✓ **Improve** product quality

Information Technologies - IT
- Industrial Internet of Things
- Industrial Analytics
- Cloud Manufacturing

Operational Technologies – OT
- Advanced Automation
- Advanced Human Machine Interface
- Additive Manufacturing

# Manufacturing Industries

Outdated machine field:

- Not designed with **advanced integration logic**
- **Low level** communication protocols (when present)
- Very expensive machines, difficult to be replaced with advanced models
- Extremely **vulnerable** to cyber attacks
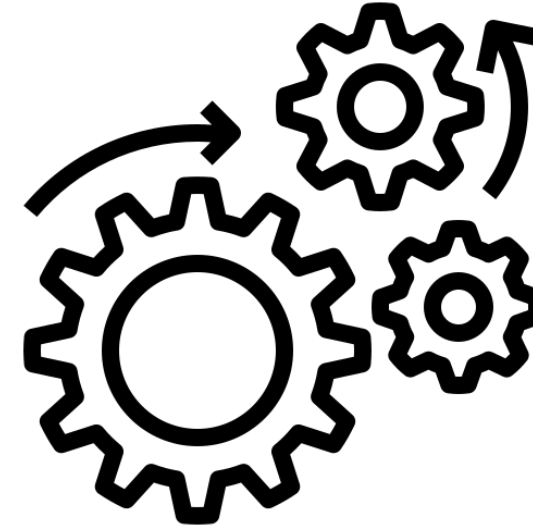
SMART
APPROACH

- Develop **middleware** software
- Software to interface with **legacy protocols**
- **Don't change machinery**

…with particular attention to data security!

# Manufacturing Industries Necessities

**Need to export the data on board the production machines from the plant to the vendor of the machine**

ENABLING

BOUND BY

- Predictive maintenance
- Remote assistance
- Production analysis
- Study of possible optimizations
- Feedback on the production chain
- Cross-analysis on data from different machines and companies
- Integration with external software
- ...

- Numerous machines distributed on a **global scale**
- Several protocols and **low-level communications**
- Machines particularly sensitive to **cyber attacks** and subject to firmware checks to ensure the **safety of workers**

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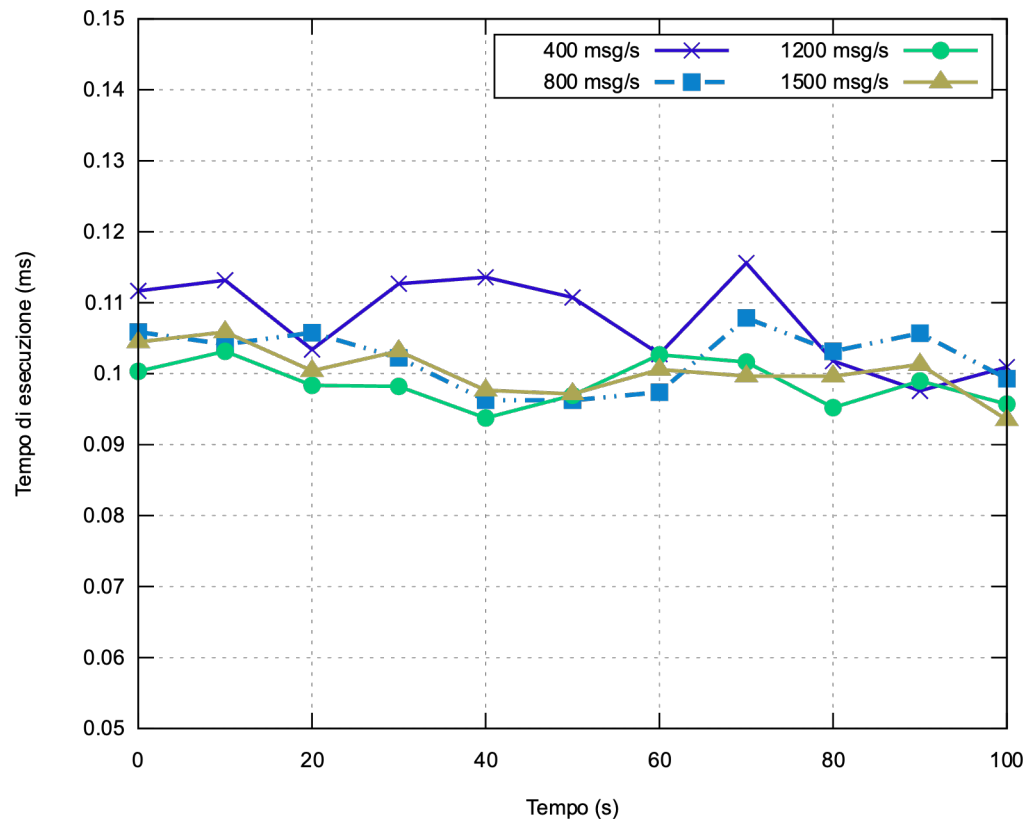
# Automation and Cloud Continuum
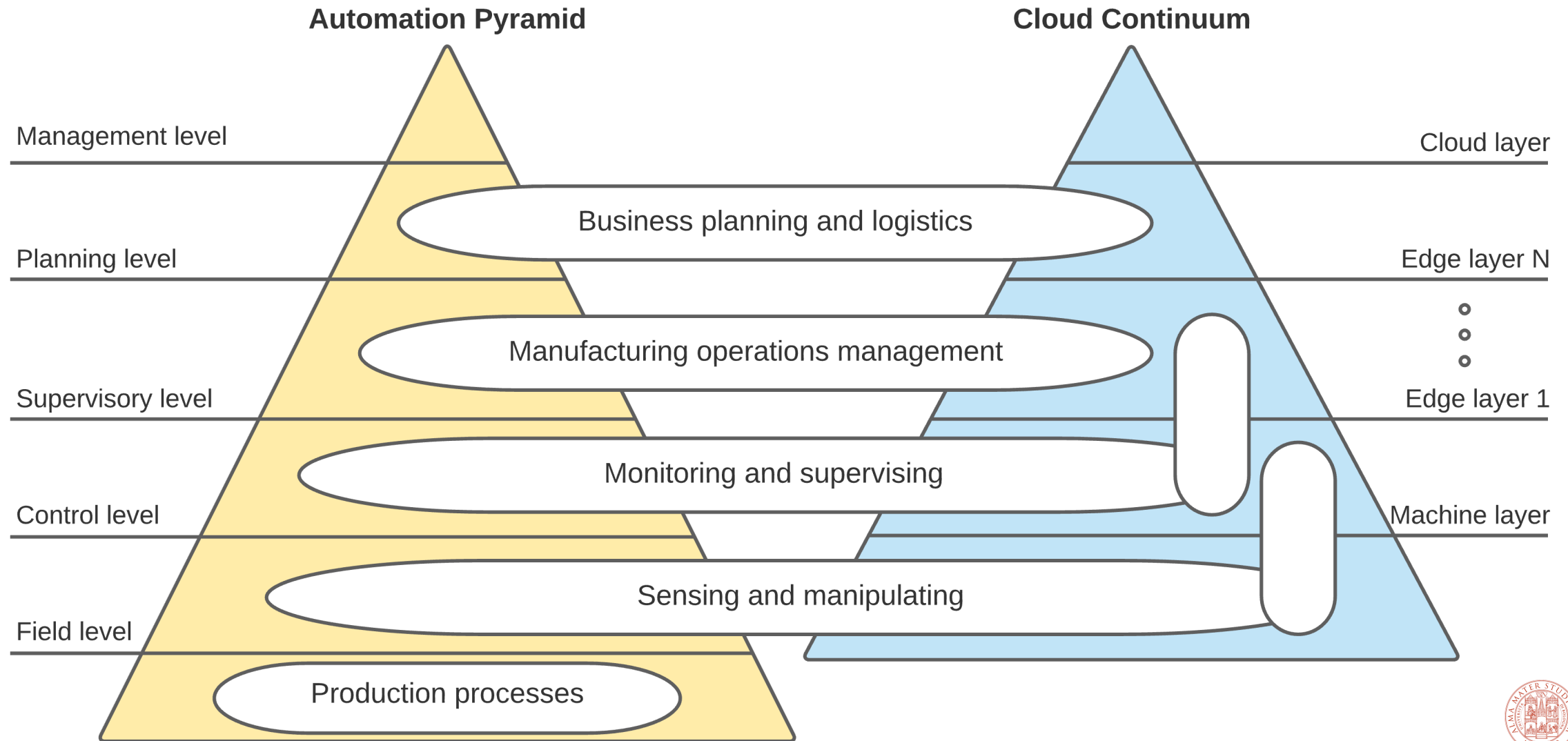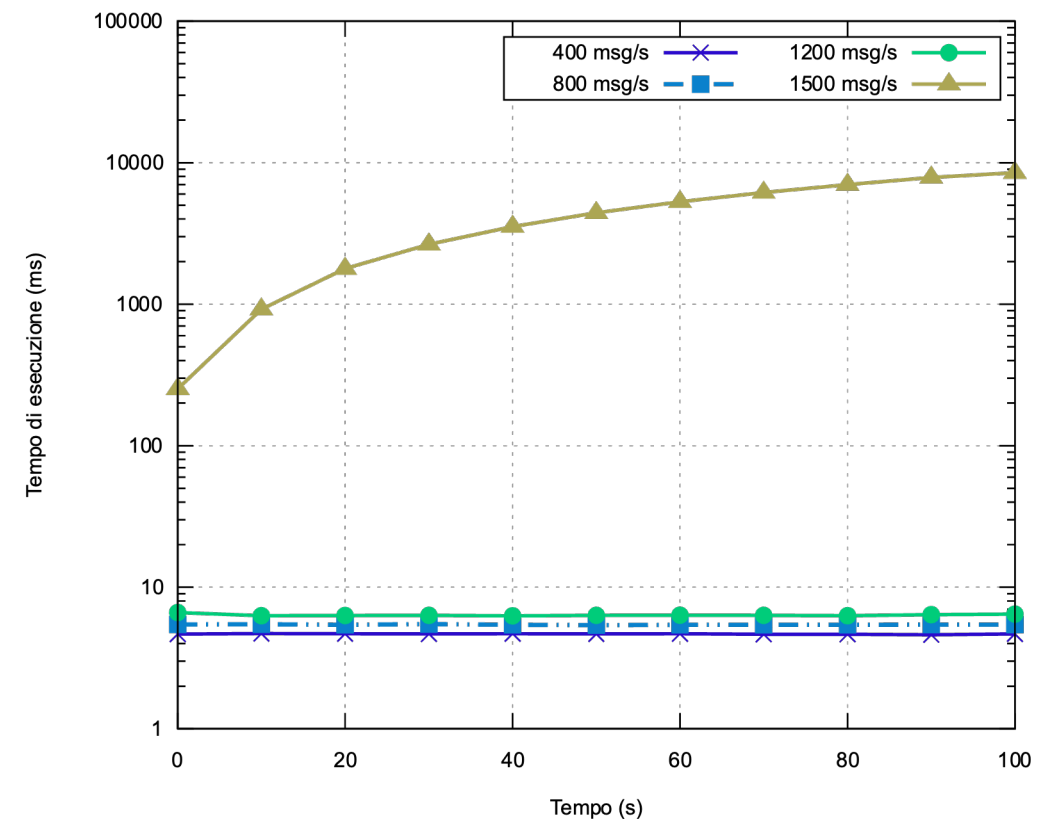
# Data gathering distributed architecture
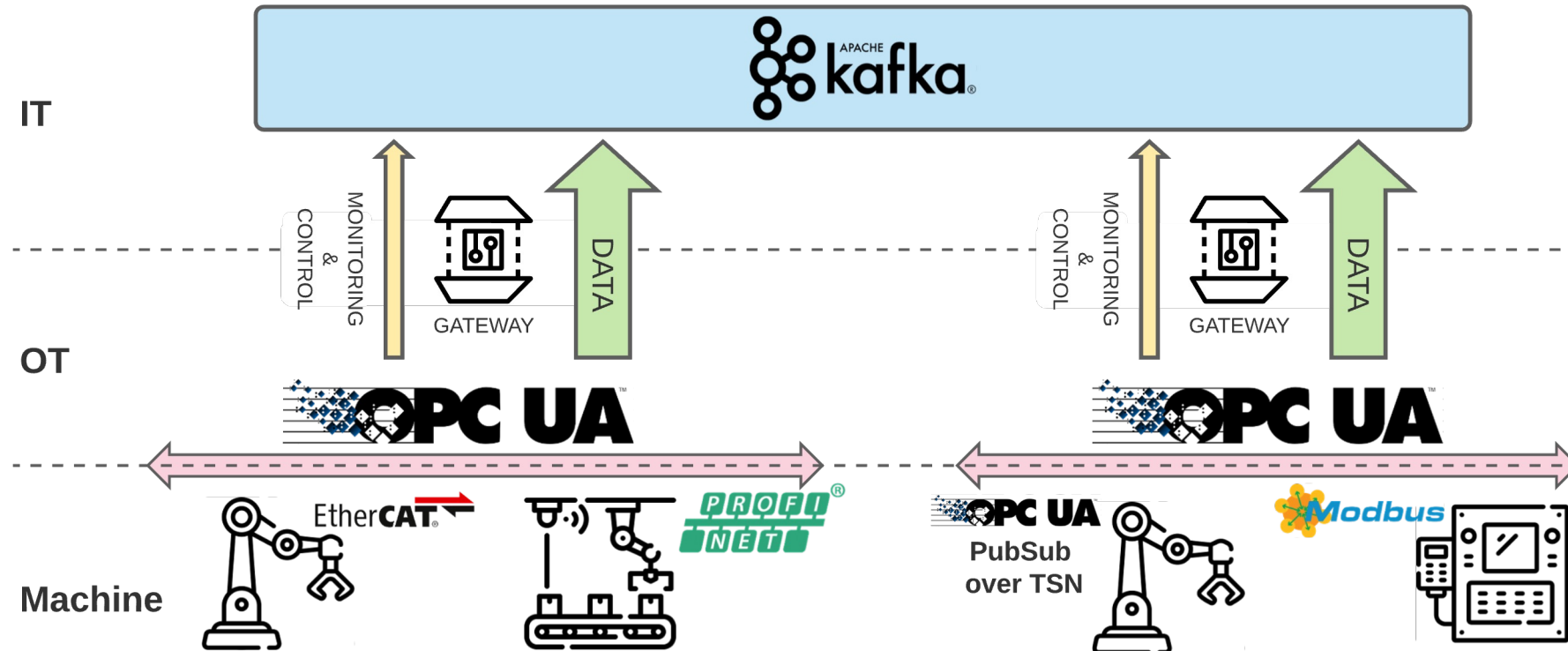


- IT layer for **near-real-time** control of the production lines
- OT Levels delimited by **firewall**
- OPC UA data in OT
- Fast and **real-time update rates** in machine layer

# Data gathering distributed architecture performances



1. Machine-to-machine communication latency under varying message load of the **OT layer**.

2. Machine-to-consumer communication latency under varying message load of the **IT layer**.

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# QoS in heterogeneous SDN/MOM architectures 1/3

**SDN-MOM Distributed Architecture**

Control Plane                    Data Plane
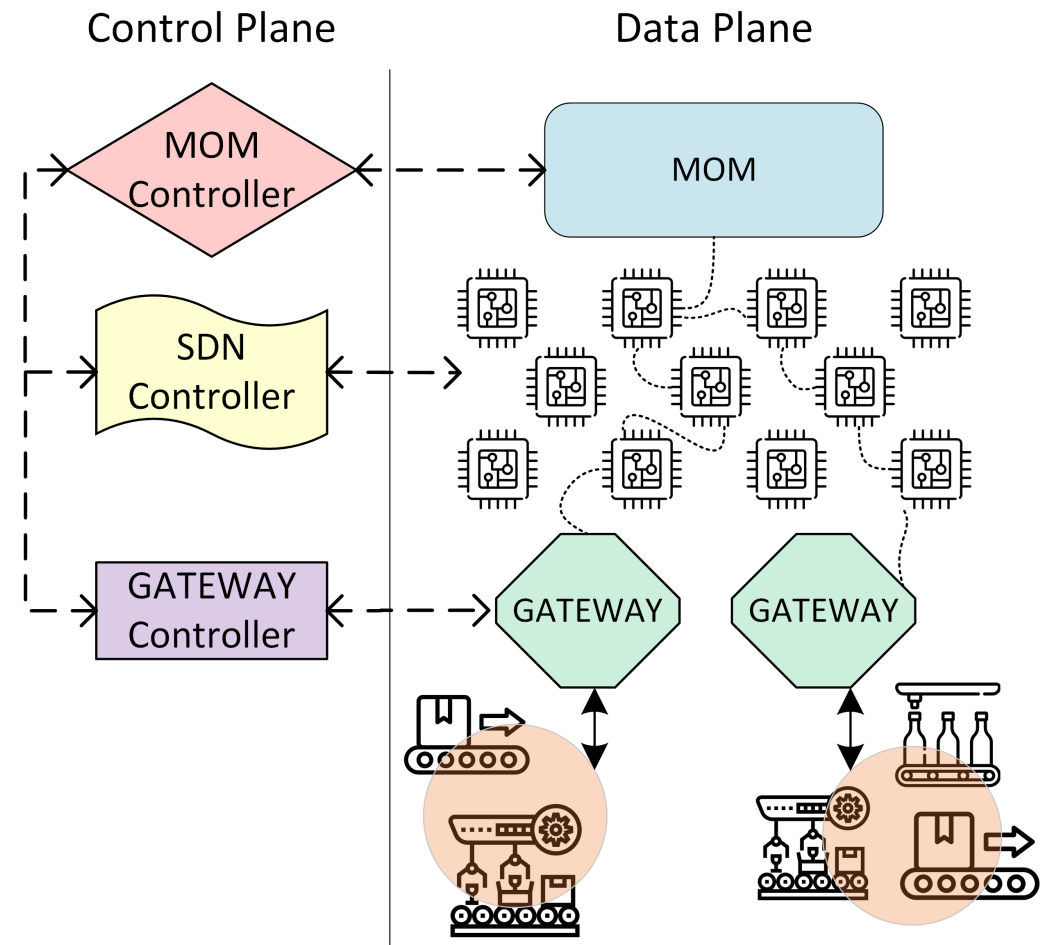
<u>Two main areas</u>

* Control Plane
* Data Plane

<u>Goals</u>

* Exploit dynamically deployed traffic rules
* Enable proper rerouting, per-traffic flow prioritization
* Elastic and data-driven processing of data

… with the objective of significantly improving networking performance and reducing the overall network overhead

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# QoS in heterogeneous SDN/MOM architectures 2/3

**Control Plane**

Three main components with different duties:

- <u>MOM Controller</u>

Is demanded to sniffing and rerouting the traffic flowing into the MOM topics

- <u>SDN Controller</u>

Centralizes network intelligence in a separate component, disassociating the packet forwarding process from the routing processes

- <u>GATEWAY Controller</u>

Is demanded to checking of the state of all the gateways, synchronize metadata with SDN and MOM controllers
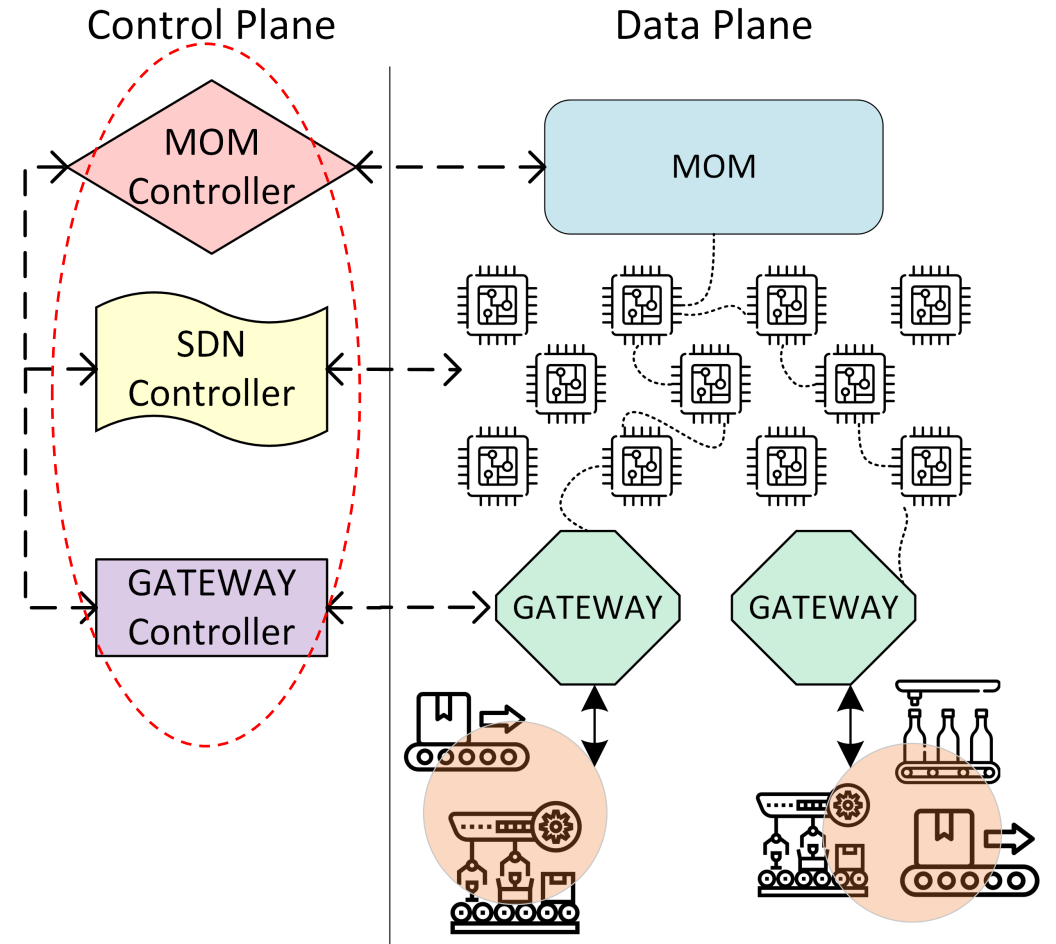
# QoS in heterogeneous SDN/MOM architectures 3/3

**Data Plane**

Contains the implementation of:

- Machine Gateways

Their duties comprehend the data gathering, the data transformation, the header addition, and the interconnection between industrial machinery and MOM.
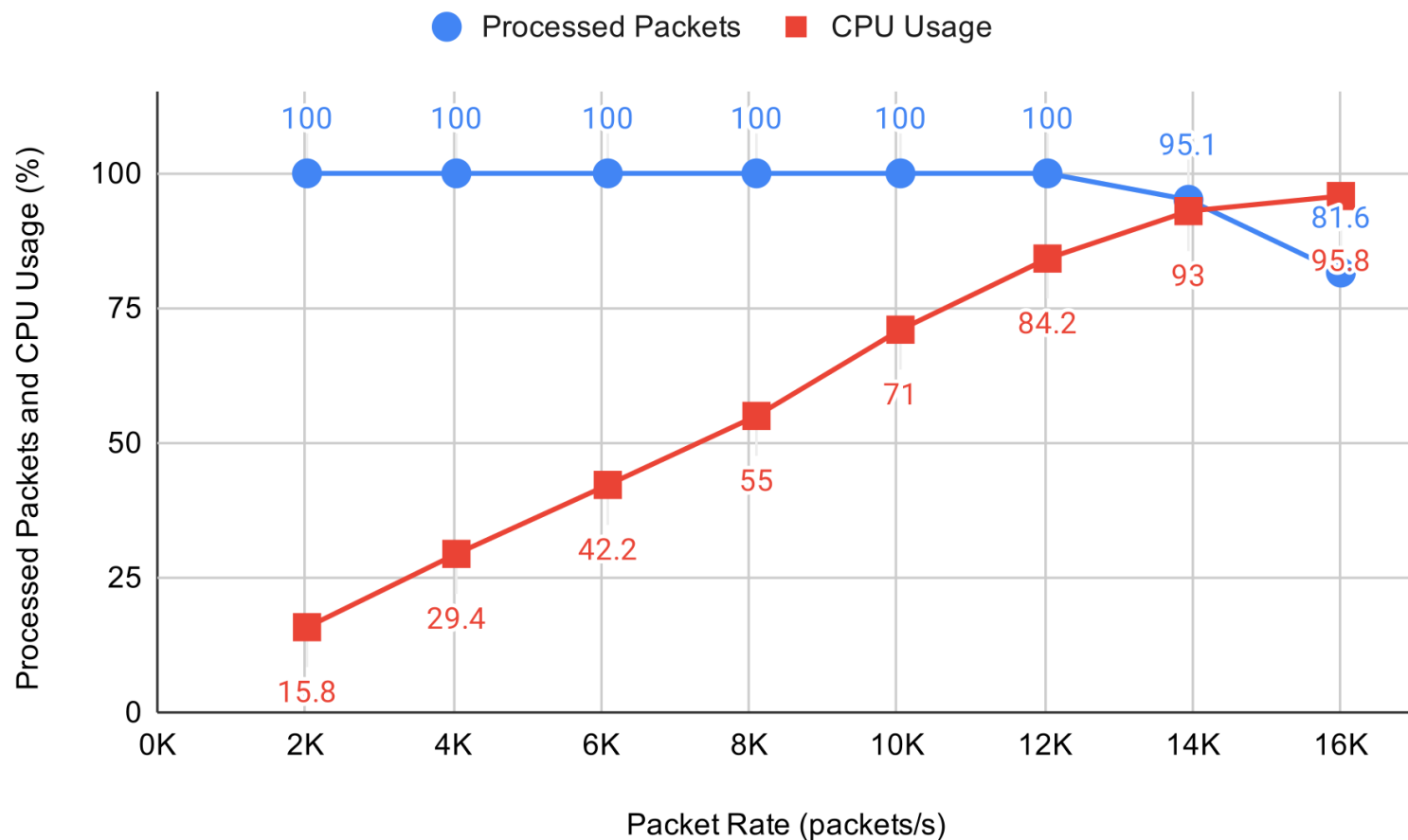
- In-network processing modules

They perform in-network processing of the incoming traffic, apply the aggregation rules defined on top of each flow.

- MOM

It is the logical single point of communication between several firm sectors with differentiated QoS.
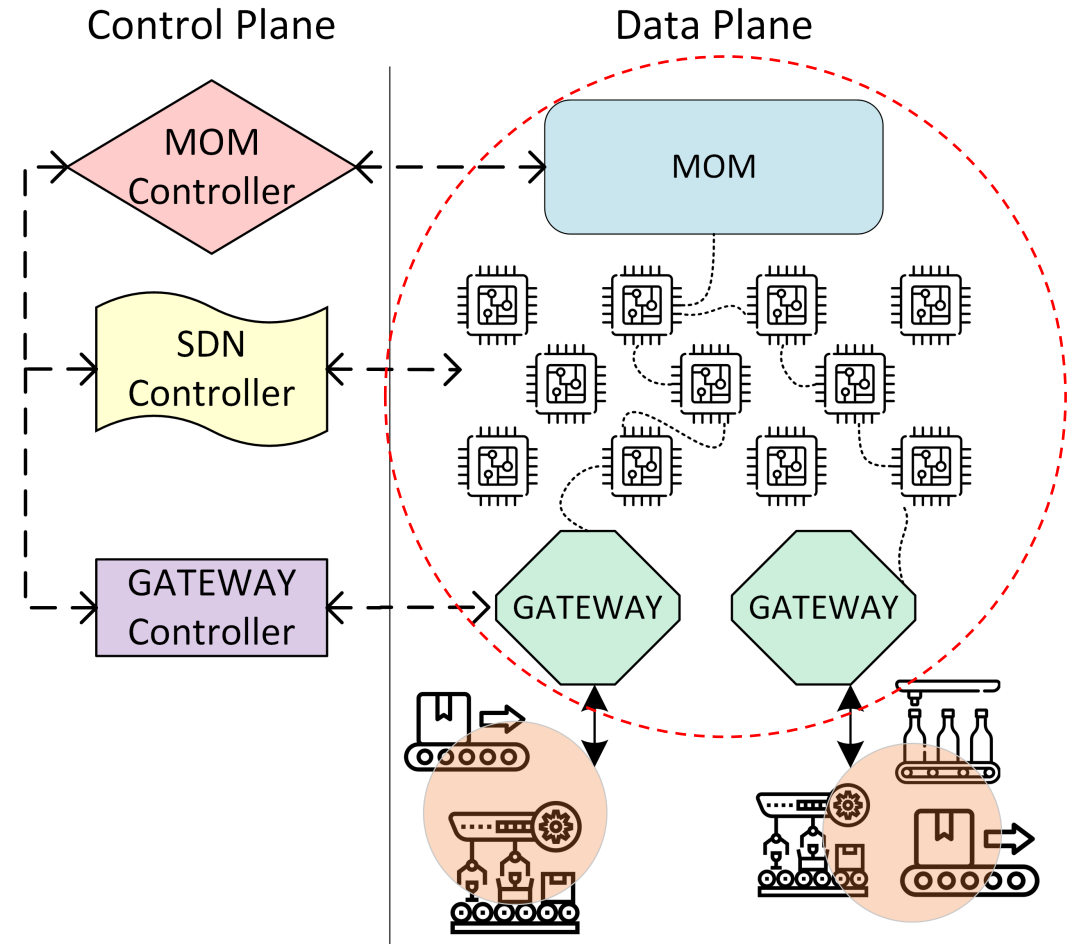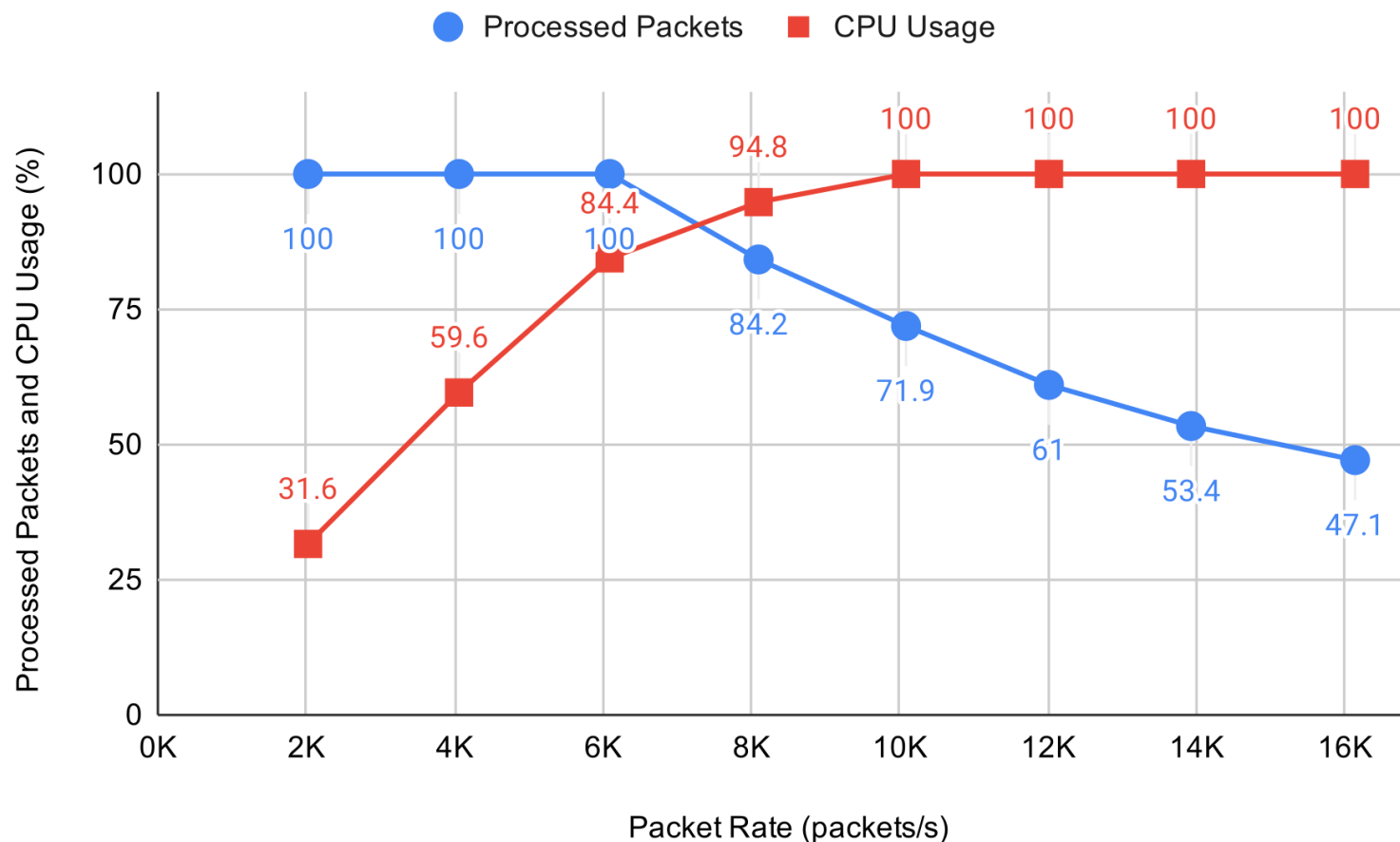
# In-network Processing performances results 1/2



In-network processing results in a constrained environment with CPU usage limited to 50%

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# In-network Processing performances results 2/2

In-network processing results in a constrained environment with CPU usage limited to 25%

# Conclusions and future developments

- ✓ **Modular** and **scalable** layer architecture
- ✓ Respect for **any secrecy** of the production process
- ✓ Possibility of interconnection **to any platform**
- ✓ **Average delay** in operation layer less than 1ms
- ✓ Availability of policies to manage **QoS**
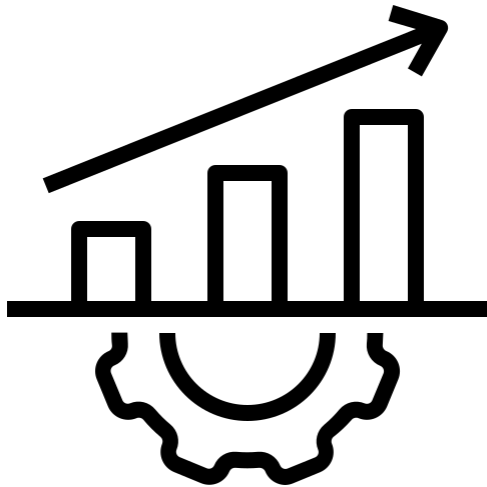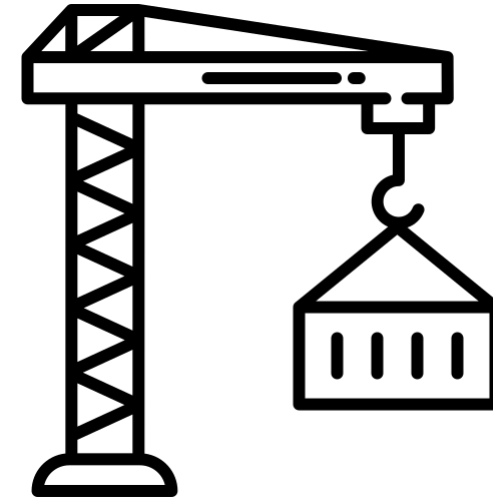
- ▫ Development of components with **retroaction** on the production chain
- ▫ Development of **zoomIn-zoomOut** techniques directly in OT
- ▫ Standard mechanisms for **third parties** integration
- ▫ **Intrusion detection** and **Artificial Intelligence** integration
- ▫ Learning algorithms for **self-management** of the entire chain
- ▫ Remove **logically centralized MOM** and implement distributed protocols

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