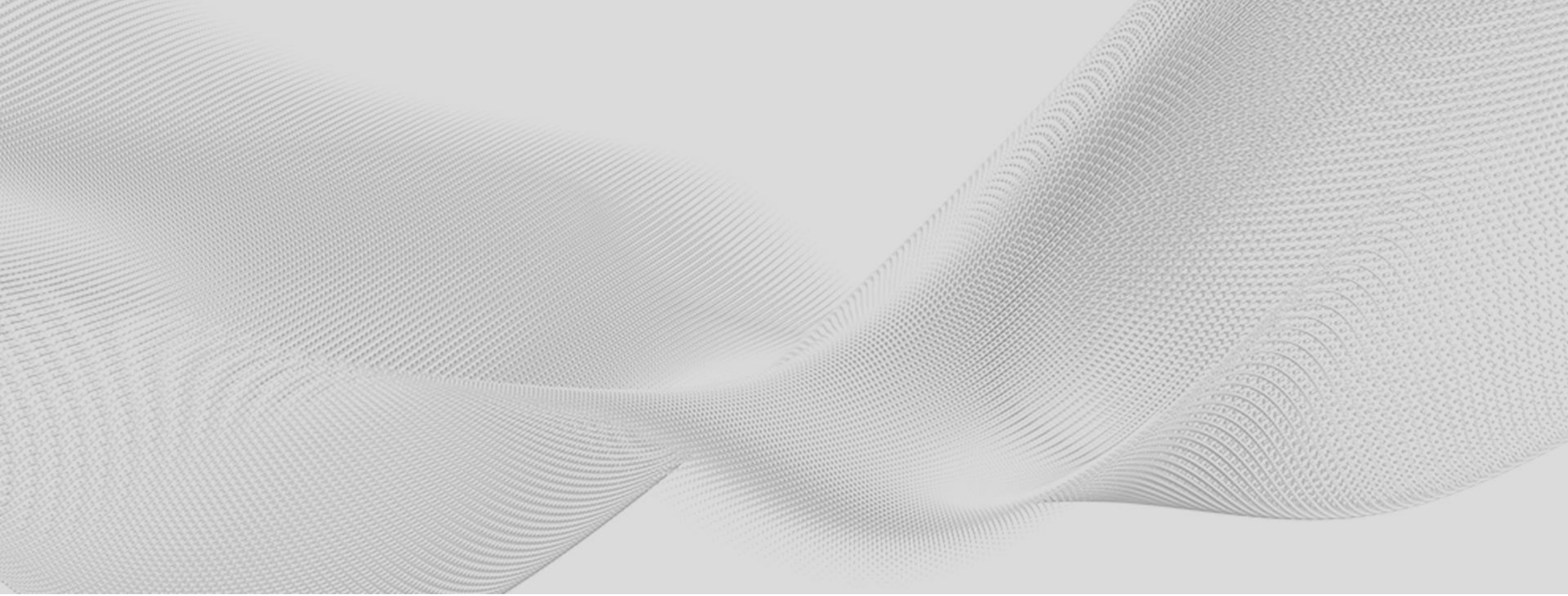


EUROPEAN WIRELESS TUTORIAL, OCT. 2ND, 2023, BY DAVID PUFFER

Real-time communication for industrial networks

Status & Outlook

B&R | A member of the ABB Group

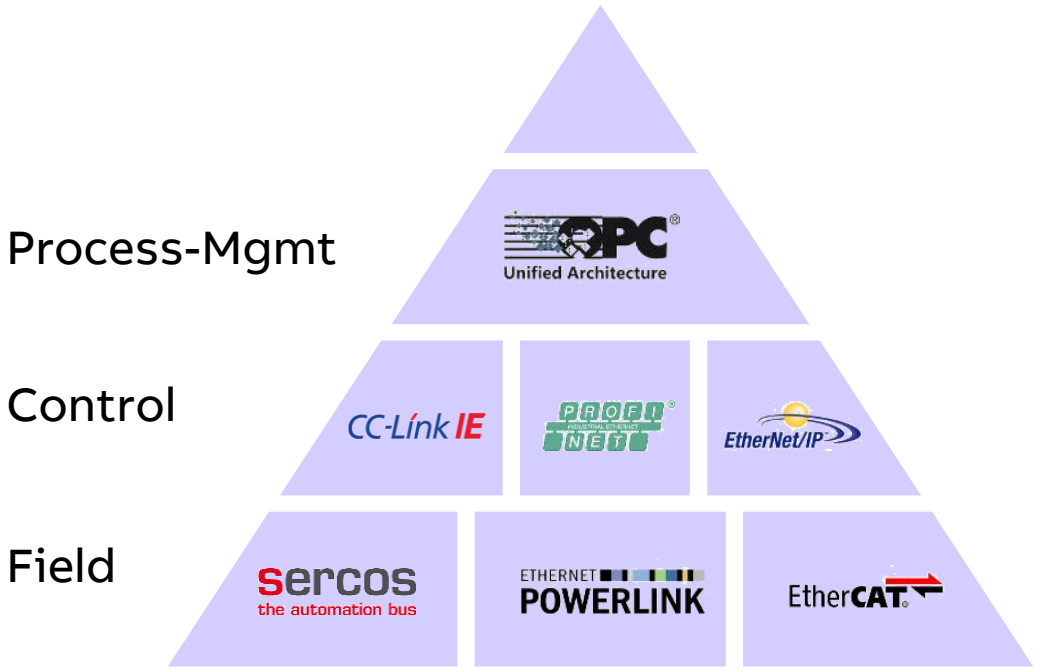
B&R

Outline

1. The past & present: Industrial Ethernet Fieldbuses and new challenges
2. The future: OPC UA & TSN applied to industrial automation
3. B&R and OPC UA / TSN: Applications & Products
4. Trends: Industrial Automation and Adaptive Manufacturing
5. Challenges: Adaptive Manufacturing & Wireless Communication

The past & present: Industrial Ethernet Fieldbuses and new challenges

The Automation Pyramid: Status Quo

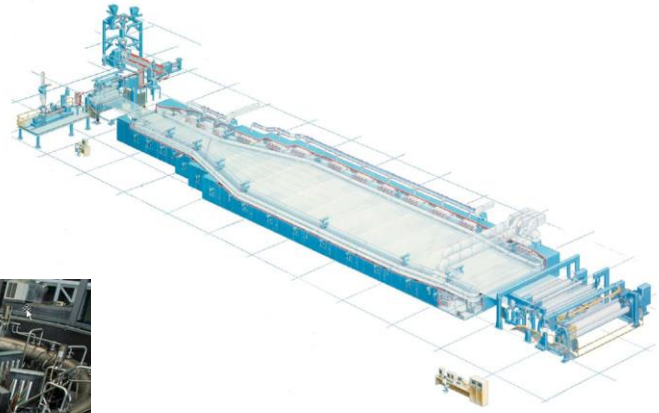


- **Different protocols employed on different levels**
  - Field Level: e.g., Sercos, POWERLINK, EtherCAT
  - Control Level: e.g., CC-Link IE, Profinet, EtherNet/IP
  - Process-Management Level: e.g., OPC UA
- **A mix of technologies**
  - High costs for development and maintenance
  - Limited device portfolio to choose from (per level)
  - Multiple experts at machine builder & manufacturer (end user)

Different fieldbuses for different application requirements. Complex and expensive to install & maintain.

The past & present: Industrial Ethernet Fieldbuses

Challenging applications



- **More and more applications demand**
  - No. of network devices >>
  - Bandwidth requirements >>
  - Cycle times << (double-digit us)
  - Increased requirements on synchronized motion control
  - Different types of communication relationships, e.g. position control vs device parameterization on same network
  - Integration of IT equipment, e.g., database servers

Todays Industrial Ethernet Fieldbuses are reaching their limits.

The future: OPC UA & TSN applied to industrial automation

OPC UA: Benefits & USPs

Companion specifications → Robot with tools for Welding, currently homing

Information model → Object with variables, methods and events

Security → ********** ********** ********** **********

Current Fieldbuses → 10100100100100101010010111011010101101100101001010100101010010101001010

Sensors and Actors

Machines

Robots

Plants

The future: OPC UA & TSN applied to industrial automation

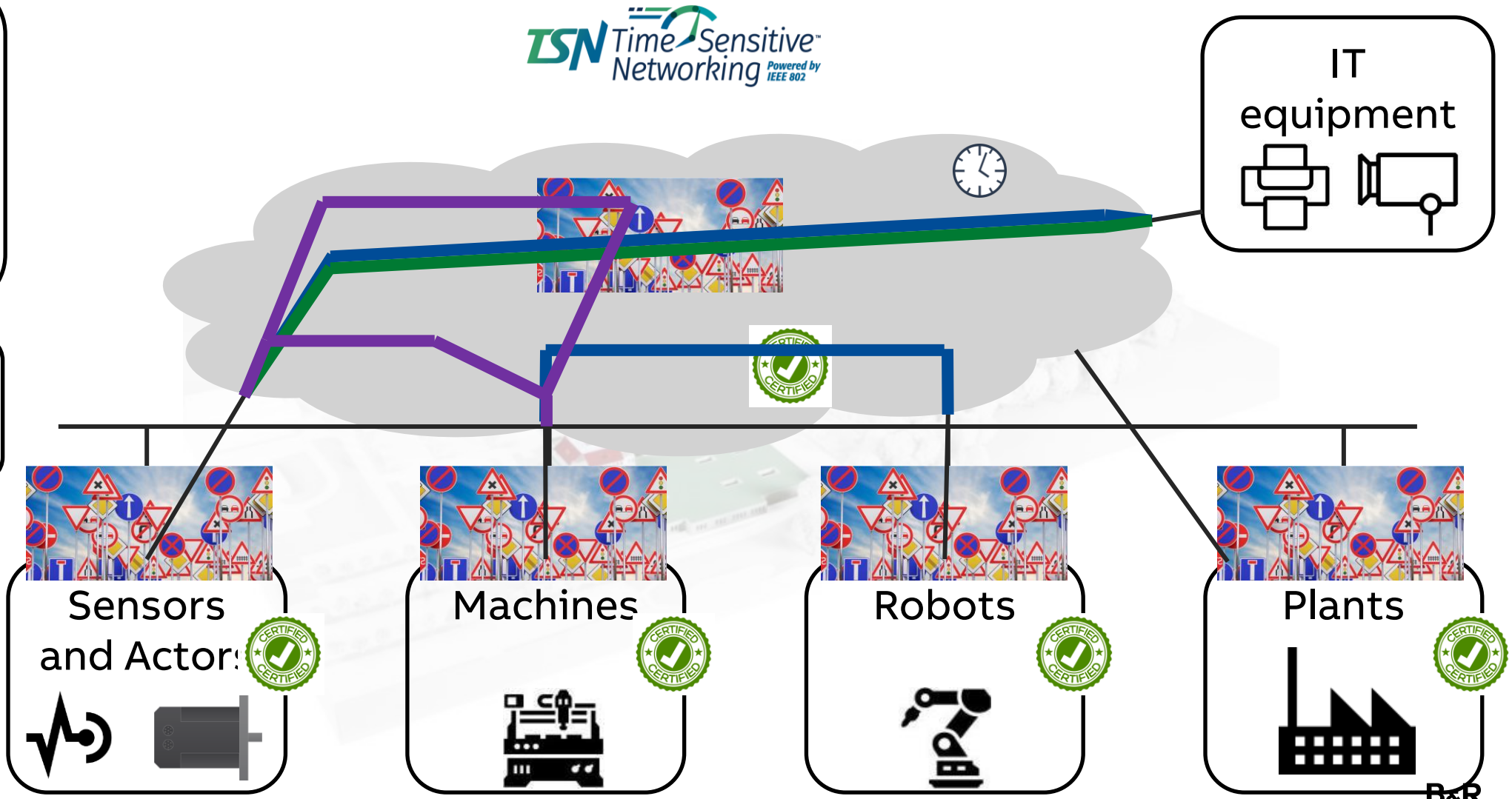
TSN: Benefits & USPs

Deterministic communication

Mixed criticality traffic

Managed NW Infrastructure

Current Fieldbuses



B&R – OPC UA / TSN in practice - today
Controller to Controller Communication

- **Controller to Controller communication with:**
  - Time Synchronization via IEEE 802.1AS-2020
  - Cyclic exchange of RT data with bounded latency via OPC UA PubSUb
  - Exchange of data with mixed criticality
  - Supporting 3rd party OPC UA controllers and applications
  - High communication bandwidth of 1Gb/s

Infrastructure

IO System

Controllers

Industrial PCs

Deterministic controller to controller real-time communication.

B&R – OPC UA / TSN in practice - future

2023/24

- Automatic device configuration
- Network diagnostics
- Topology Detection
- User Experience

2024 & beyond

- Portfolio: e.g., Motion, Safety, Vision
- PubSub Security / MQTT transport
- Automatic schedule calculation

Trends: Adaptive Manufacturing
Challenges, Definition

Market Challenges

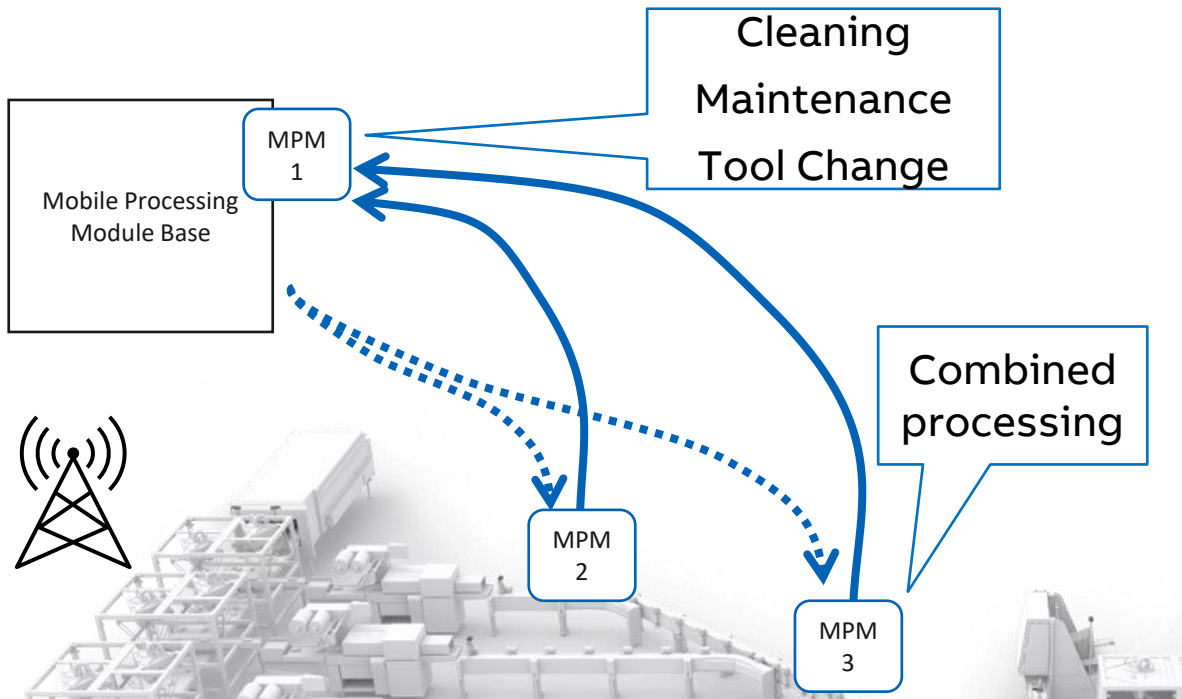
- Increasing demand for product customization / **small batch sizes**
- **Direct-to-consumer** sales channels instead of distributors
- **Time to market to catch new product trends**
- Skilled personnel/labor shortage

The pillars of Adaptive Manufacturing

- **On-the-fly changeover** / no downtime
- **Readiness for unknown future products (size, shape, prints..)**
- Smaller footprint
- **Cost-Effective batch size 1 from the production line to the customer**

Adaptive Manufacturing & Wireless Communication

Use-Case: Mobile Processing Modules (MPMs)

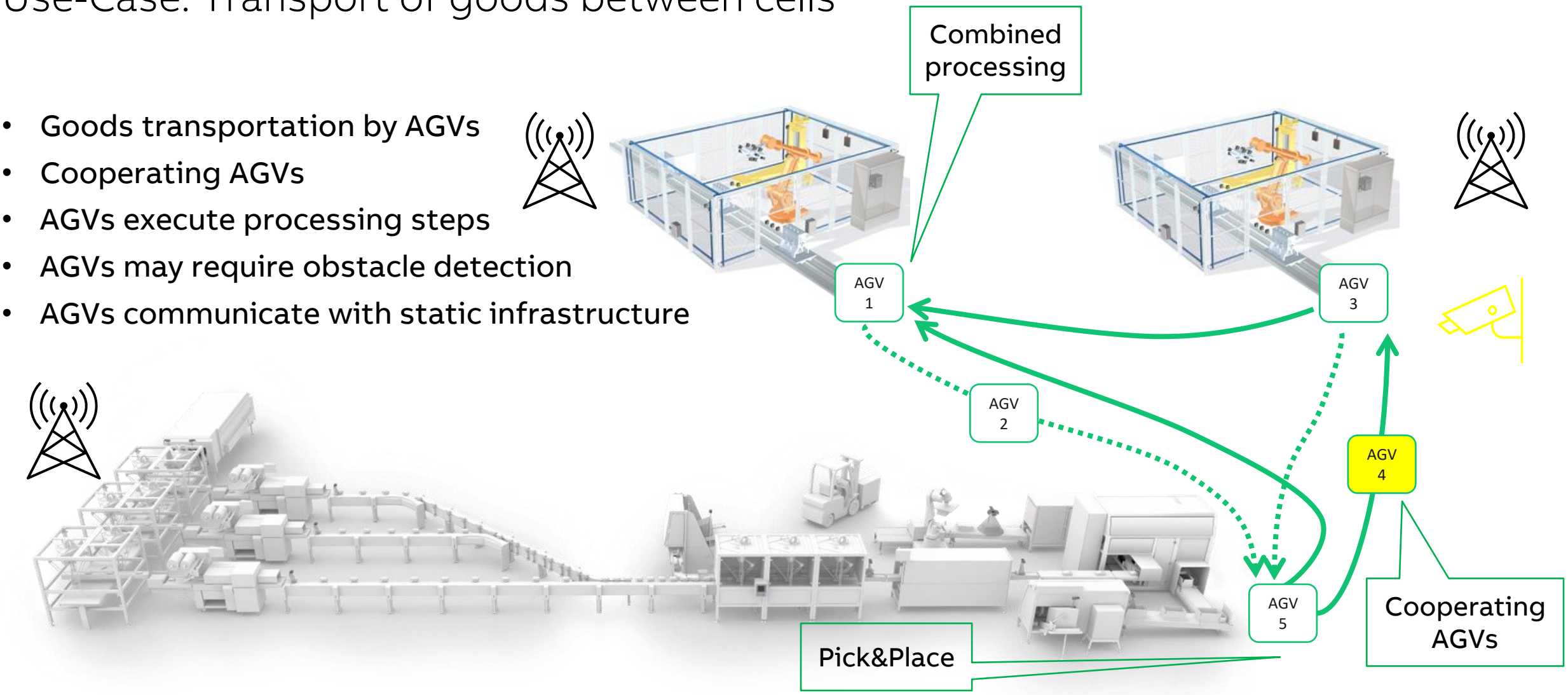


- AGVs with mounted processing devices / tools
- Exchanged, added or removed according to production requirements
- May move between processing line and a base station (maintenance, cleaning, tool change etc.)
- May move between different processing lines
- Dock to the processing line for required duration

Adaptive Manufacturing & Wireless Communication

Use-Case: Transport of goods between cells

- Goods transportation by AGVs
- Cooperating AGVs
- AGVs execute processing steps
- AGVs may require obstacle detection
- AGVs communicate with static infrastructure



Adaptive Manufacturing & Wireless Communication

Novel Challenges

- Dynamic allocation of network resources (e.g., bandwidth)
  - → Demanded by flexibility in processing/properties of wireless networks
  - E.g.: AGVs registering to video streams from surveillance cameras for obstacle detection on safety-critical paths

- Dynamic application requirements due to higher stochastic uncertainty of wireless networks
  - Spatial/temporal dependency → signal interference, obstacles etc.
  - Application: Performance vs resource usage, e.g.: high-res (speed >>) vs low-res obstacle detection (speed <<)

- Functional Safety applications and Packet Delay Variation over wireless networks
  - A trade-off between performance and uninterrupted machine operation

Adaptive Manufacturing & Wireless Communication

Conclusion

Wireless communication in industrial automation is required to facilitate trends like Adaptive Manufacturing – and brings new challenges to tackle.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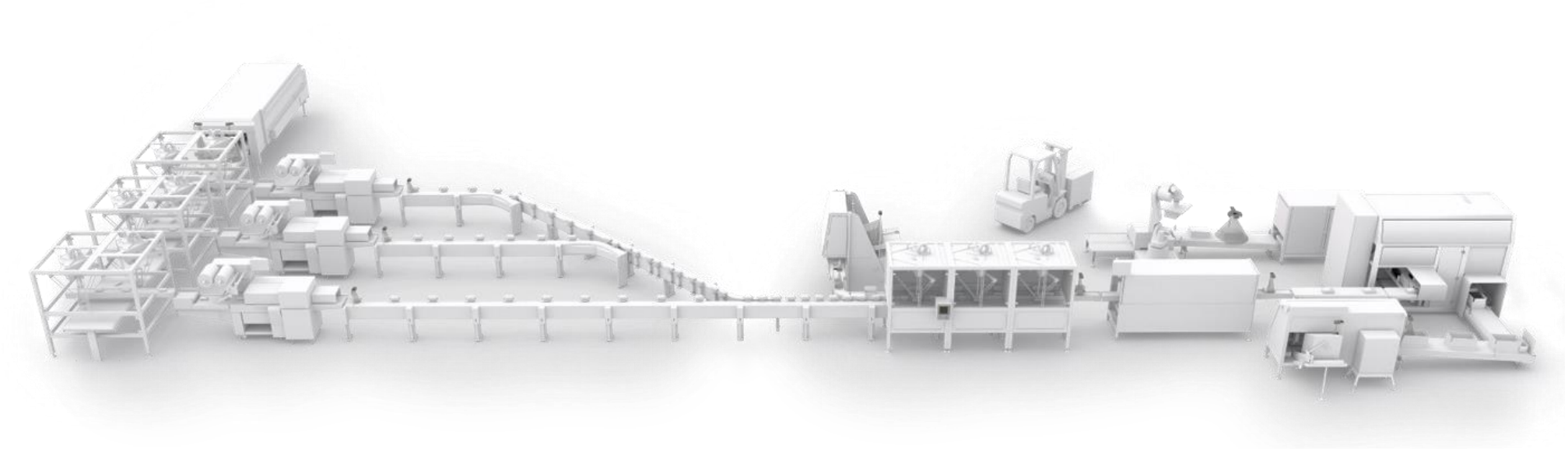
Q&A

Adaptive Manufacturing

The need for wireless communication



- Individual modules, e.g., bottle unscrambler, filler, capper, labeller, packaging
- Modules may be exchanged for cleaning or added/removed to adjust throughput.
- Processing steps may require transport of goods to/from different processing cells

→ AGVs with wireless connectivity in the adaptive manufacturing process.

Trends: Adaptive Manufacturing
Examples

Bottle labelling

- Top and bottom track for capping (top) and (rotary) labelling (bottom)
- Bottle & label size adjustable on the fly
- Modular track system

Cartoning

- Vision-guided robots, loading cartons on..
- ..Independently controlled shuttles
- Different carton sizes, batch-size one packaging

Filling/capping/labelling

- Adapting to different caps, containers, labels and cartons
- Designed for frequent and quick changeover

These examples and more: https://www.br-automation.com/en/technologies/adaptive-manufacturing/adaptive-applications/

OPC UA FX
Background

“OPC UA is not a protocol!

Instead it is a collection of technologies to ensure a secure exchange of standardized information from the sensor to the cloud (and back).” [1]

- **OPC UA** → Open Platform Communication Unified Architecture
- Specification parts for **Field eXchange (FX)** are defined by the **Field Level Communication (FLC)** working group of the OPC Foundation
- Formerly also referred as **OPC UA over TSN**
- Communication based on **OPC UA PubSub** and **TSN** technologies

[1] Statement of the OPC Foundation: https://opcfoundation.org/

OPC UA
Architecture

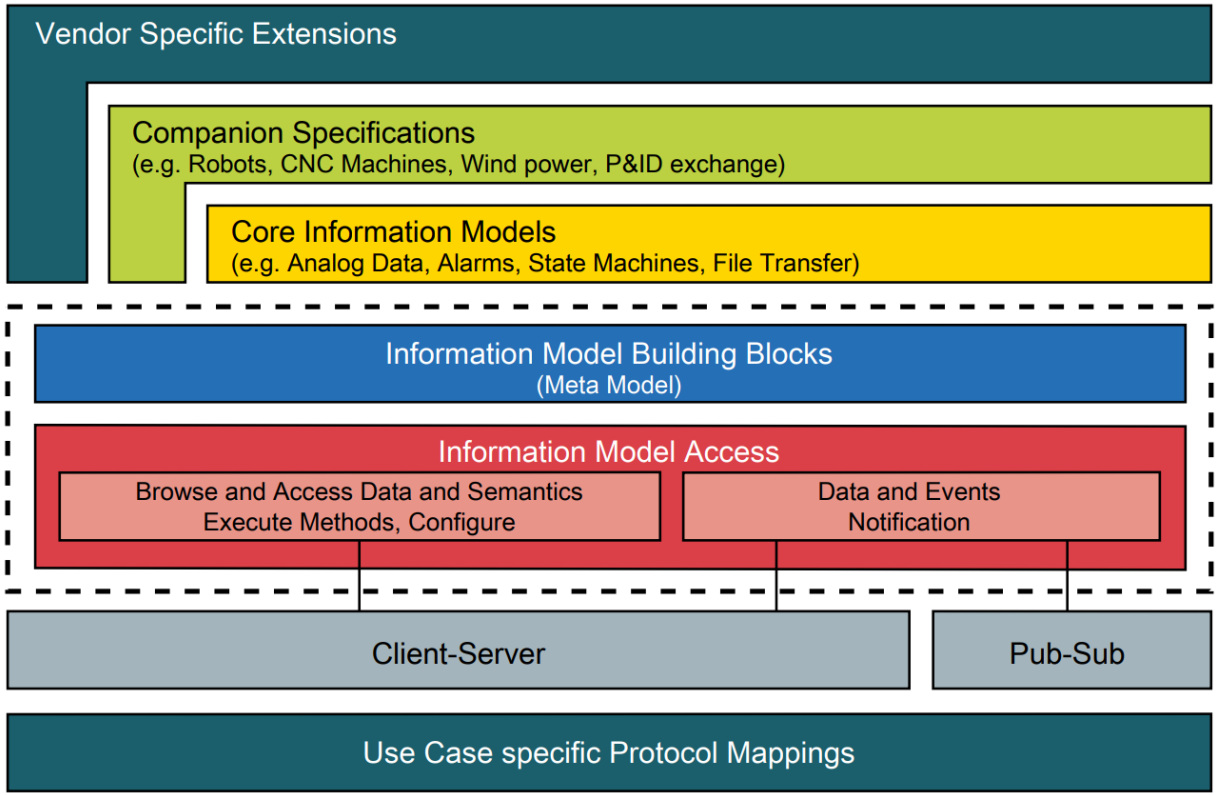
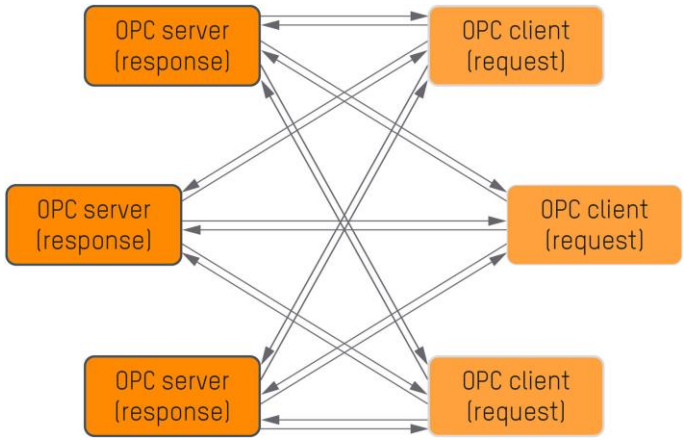
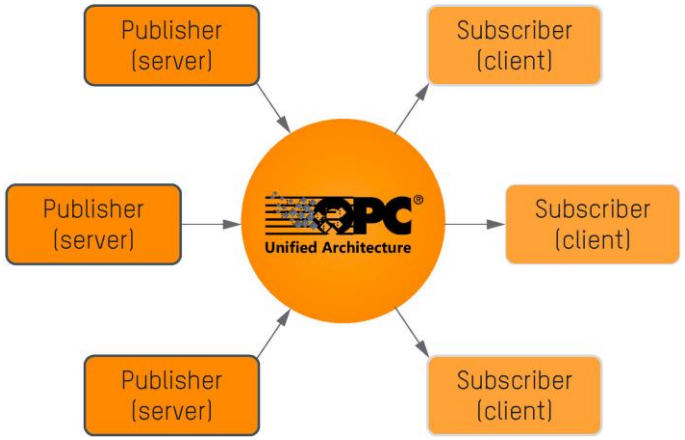


Figure taken from https://opcfoundation.org/about/opc-technologies/opc-ua/

OPC UA PubSub

Client/Server vs. PubSub





Client/Server

- **Semantic modelling** of information with standardized domain-specific information models and profiles
- **Connection-oriented** access of data and methods
- **One-to-one** communication pattern

Publish/Subscribe

- **Many-to-many** communication pattern
- **Broker-less** and **broker-based** communication service
- **Cyclic** and **change-based** transmission
- **Fixed** and **dynamic** message formats

Key Features

0ACST052.1 – industrial TSN Switch

- 4 ETH/TSN Ports + 1 ETH Port, 100/1000 MBit/s
- Fully non-blocking, deterministic, IEEE 802.1Q-compliant switch engine
- Configuration via OPC UA and NETCONF
- TSN Features
  - 802.1AS-2020 – time synchronization
  - 802.1Qav – credit-based shaper
  - 802.1Qbv – time-aware shaper
  - 802.1Qbu – pre-emption
  - 802.1Qci – ingress policing (future release)
- Security
- Tiny form factor
- Product released

Key Features

X20BC008T – Head station for modular IO system with OPC UA and TSN support

- OPC UA information model of IO system
- Deterministic communication @ 400µs
- Large slices portfolio available
- 2 ETH/TSN Ports, 100/1000 MBit/s
- Configuration via OPC UA and NETCONF
- Switch engine & TSN features = 0ACST052.1
- Security = 0ACST052.1
- Enhanced usability for stand-alone operation
- Product released