

# Digitalization and Industrie 4.0 by PROFINET

Xaver Schmidt, PI Industrie 4.0 Project Group





## Grain Management

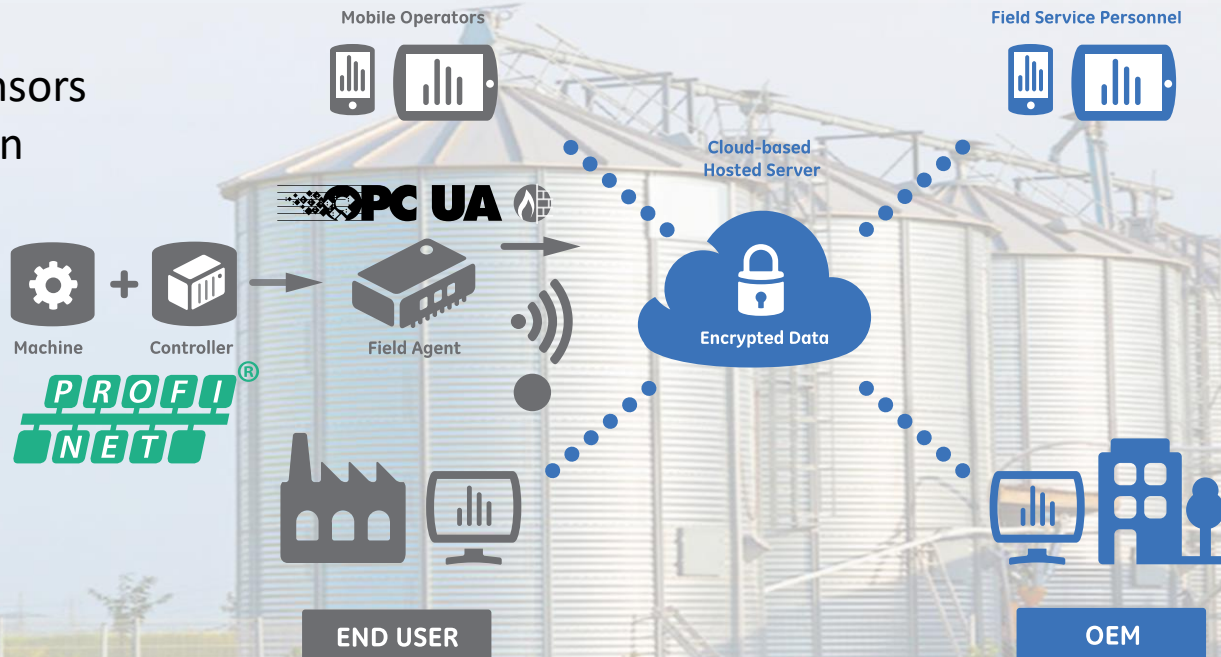
- Temperature & moisture sensors collect data from stored grain

## Hazard Monitoring

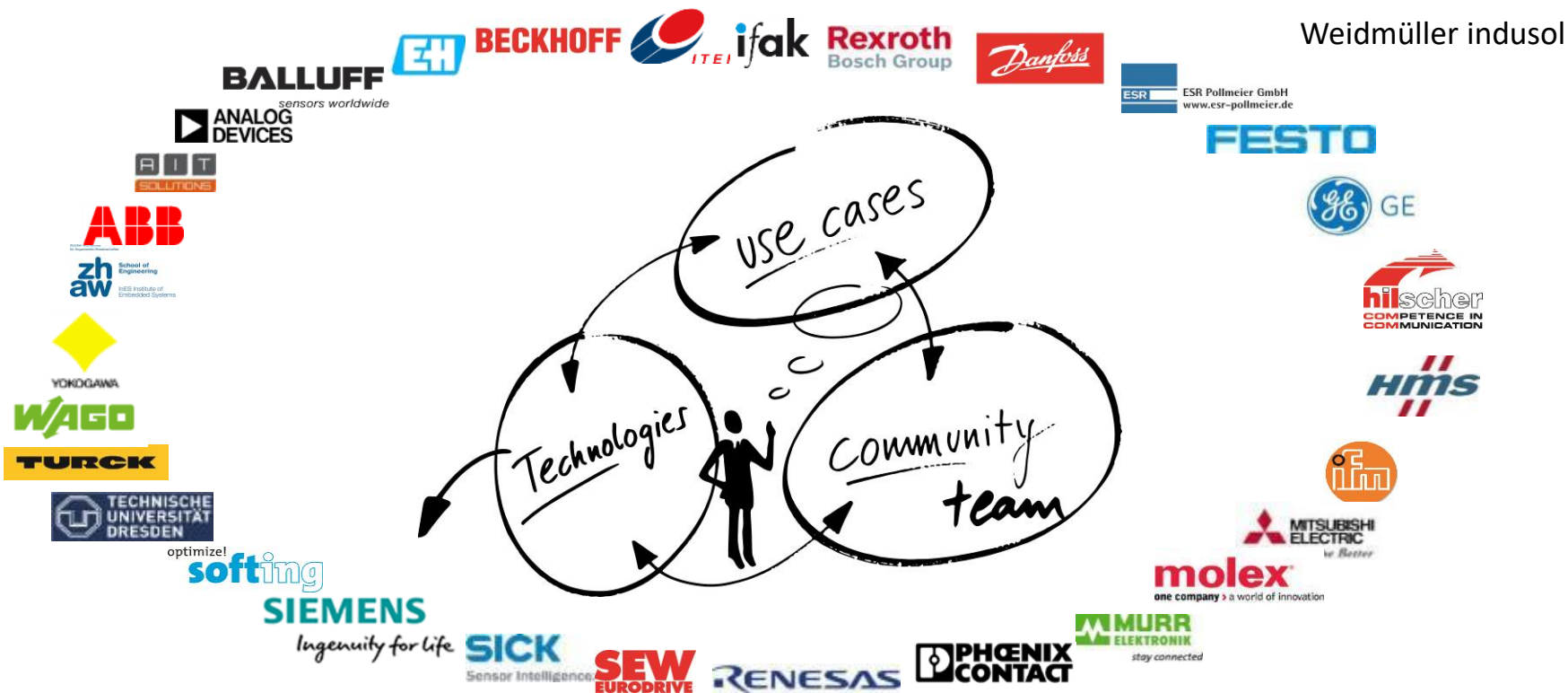
- Temperature & motion sensors monitor grain elevators

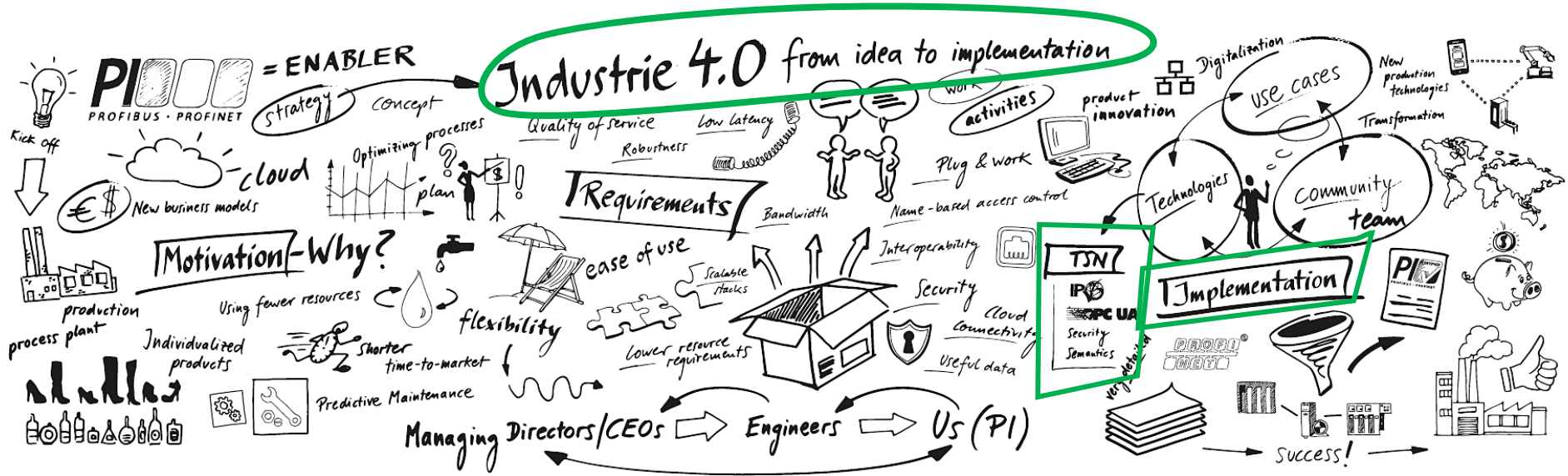
## Why PROFINET?

- Uptime and Real time!



# A strong community drives the standard







	Status Technology	Procedure	Goal
IPv6	Many detailed functions in Standard	Development of concept with customers incl. IT	Auto addressing naming
OPC UA	Parallel communication Integrated Solutions available	Clarify market expectations	Cooperation with OPCF
Security	Diverse requirements Many solutions	Selection based on requirements / Use Cases	Integration of necessary security features
Semantics	eClass, Automation ML,...	Selection of most important definition	Integration of existing Features in Standard
TSN	Many options in Standard	Mapping of PN to TSN	Benefit from technology advancements of Standard-Ethernet-Technology



As usual, these topics has to fit!



## Design Constraints

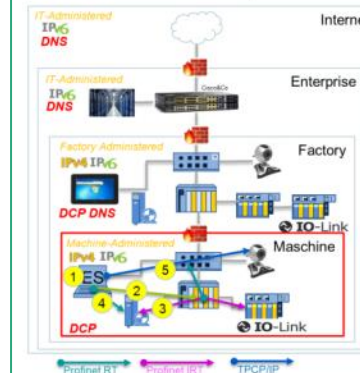
- Reduced complexity for the end customer in comparison to IPV4
- Don't increase memory footprint dramatically to support chips with embedded RAM&ROM.
- Increased cyber security in comparison to IPV4 under consideration of complexity and footprint



## Some IPV6 relevant features

Feature	Possible usage
Global Unicast Address	From Internet/Enterprise/Factory to device in machine
Link Local Address	Profinet and non Profinet devices in machine
Unique Local Address	From Enterprise/Factory to device in machine
Neighbor Discovery	In all use cases. Replacement of ARP
Stateless Autoconfig	Profinet and non Profinet devices in machine
DHCPv6	Non Profinet devices in machine
DNSv6	From Internet/Enterprise/Factory to device in machine
NAT46/64	Migration Scenarios

## Use-Case Example: Profinet in Machine



1. Topology setup in ES
  - Default NoS
  - IPv6 address not needed
2. Name assignment
  - Setup of Device Names by ES or IOC
  - Device creates link local address
3. AR Establishment from IOC
  - Get local IPV6 address with DCP Identify
  - AR Connect at local IPV6 address
4. Supervisor access from ES
  - DCP Identify with NoS or...
  - DCP-Set new IPV6 address
5. IP access to Non-Profinet Devices
  - DNS V6?



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OPC Team Kickoff

- Prio 1: Assetmanagement, Diagnosis
- Coordination with IO-Link

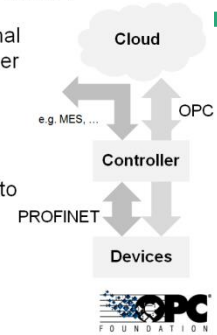
VDMA

- Companion Standards
- Mapping of the PI-Profiles

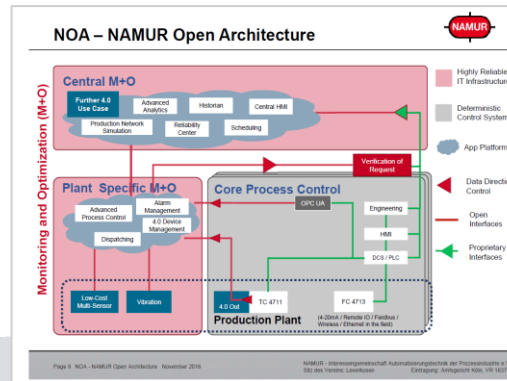
NOA NAMUR Open Architecture

- Similar requirement

- PROFIBUS & PROFINET International and OPC Foundation agreed to further extend their collaboration
- The power to run deterministic real time data and open IT traffic in the same network will be the foundation to make Industrie 4.0 happen



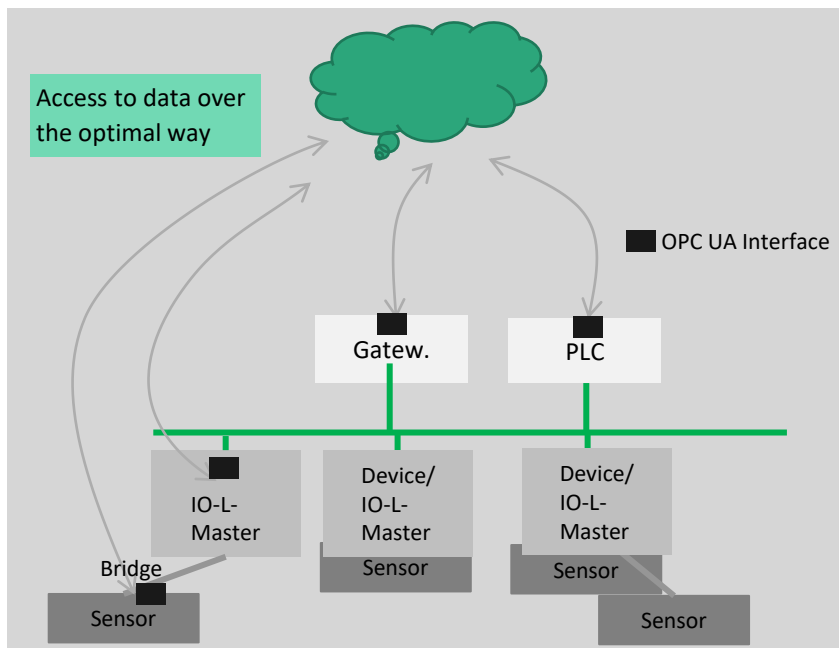
SPS/IPC/Drives 2015  
OPC Press Conference 24.11.2015



**VDMA represents the broad manufacturer industry**  
VDMA has 3200 member companies

- Agricultural Machinery
- Air Conditioning and Ventilation
- Air Pollution Control
- Air-handling Technology
- Building Control and Management
- Cleaning Systems
- Compressors, Vcompressed Air and Vacuum Technology
- Construction Equipment and Building Material Machines
- Drying Technology
- Electrical Automation
- Electronics, Micro and Nano Technologies
- Engine Systems for Power and Heat Generation
- Engines and Systems
- Fire Fighting Equipment
- Fluid Power
- Food Processing Machinery and Packaging Machinery
- Foundry Machinery
- Gas Welding
- Hydro Power
- Integrated Assembly Solutions
- Large Industrial Plant Manufacturing
- Lifts and Escalators
- Machine Tools and Manufacturing Systems
- Machine Vision
- Materials Handling and Intralogistics
- Measuring and Testing Technology
- Metallurgical Plants and Rolling Mills
- Metallurgy
- Micro Technologies
- Mining
- Plastics and Rubber Machinery
- Power Systems
- Power Transmission Engineering
- Precision Tools
- Printing and Paper Technology
- Process Plant and Equipment
- Productronic
- Pumps + Systems
- Refrigeration and Heat Pump Technology
- Robotics
- Robotics + Automation
- Security Systems
- Software
- Surface Treatment Technology
- Textile Care, Fabric and Leather Technology
- Textile Machinery
- Textile Turbines and Power Plants
- Thermo Process Technology
- Valves
- Waste Treatment and Recycling
- Wind Energy
- Woodworking Machinery





**PROFINET enables the best suitable access to data without restrictions**



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## Task group in the security WG

- Experts
- Engaged Ongoing

## First step

- Use Cases / Requirements

## Then concept/spec

- Security measures



### Achievements

- Group consolidated
- Feature List
- Use Cases
- Security concept in progress
- Technical concepts

### Measures (in discussion)

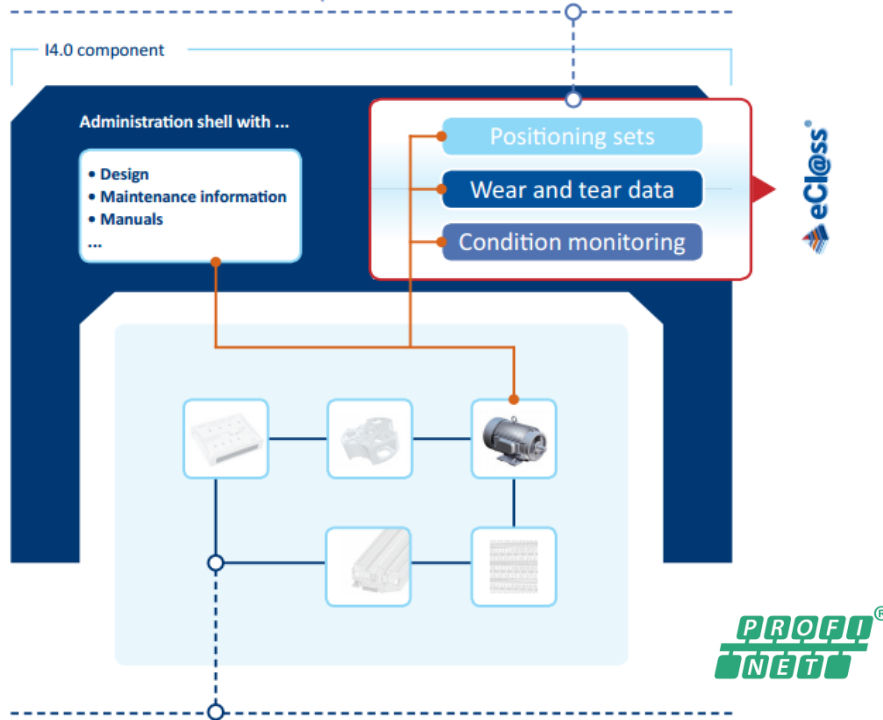
- Network Access Control
- Data integrity MAC (message authentication code)
- Encryption
- Authorization
- Security Information & Event Management

Protocol	RTC	Remarks / Threat / Measures	Short name	Name	Remark	
Ownership	PROFINET					
Standard	XXXX					
Description	XXXX					
Category	Process					
Attack vectors	Spoofing	An attacker pretends to be a valid PROFINET participant and sends RTC messages		NAC	Network Access Control	
	Tampering	An attacker tampers RTC messages between two PROFINET participants		MAC	Message Authentication Code	Message signing
	Reputation	%	RTC messages are being sent by technical systems (software). Malfunction of the software is not regarded as a security issue	EN	Message Encryption	
	Information disclosure	An attacker eavesdrops to RTC messages learning the receipt or details on the operation		PS	PROFINET Security Tester	Robust devices
	Denial of services	An attacker sends a tremendous number of RTC messages flooding the input handler of the address(es).		Vendor	Vendor's responsibility for secure implementation	
		An attacker sends certain (corrupted) RTC messages which influences the addressee(s) in way to stop servicing in the proper way		FWL	Firewall	
	Execution of privileges	%	HAUT	Human Authentication		
			DAUT	Device Authentication		
			AUTR	Authorization		
			LOG	Logging features		





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Schematic diagram of an administration shell; source: eCl@ss data base

- Standardized data is a requirement for standardized models
- Must be possible to map real time world to administration shell
- Values from real time systems build the basis for information in administration shell

**The collaboration of eCl@ss and PI enables consistent data models**



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TSN consists of **several IEEE Standards**.

For example:

- Enhanced synchronization behavior (IEEE 802.1ASbt)
- Suspending (Preemption) of long frames (IEEE 802.1Qbu)
- Enhancements for scheduled traffic (IEEE 802.1Qbv)
- Path control and bandwidth reservation (IEEE 802.1Qca)
- Seamless redundancy (IEEE 802.1CB)
- Stream reservation (IEEE 802.1Qcc)
- ...

Functions

Synchronization

Low Latency

Robustness

High Availability

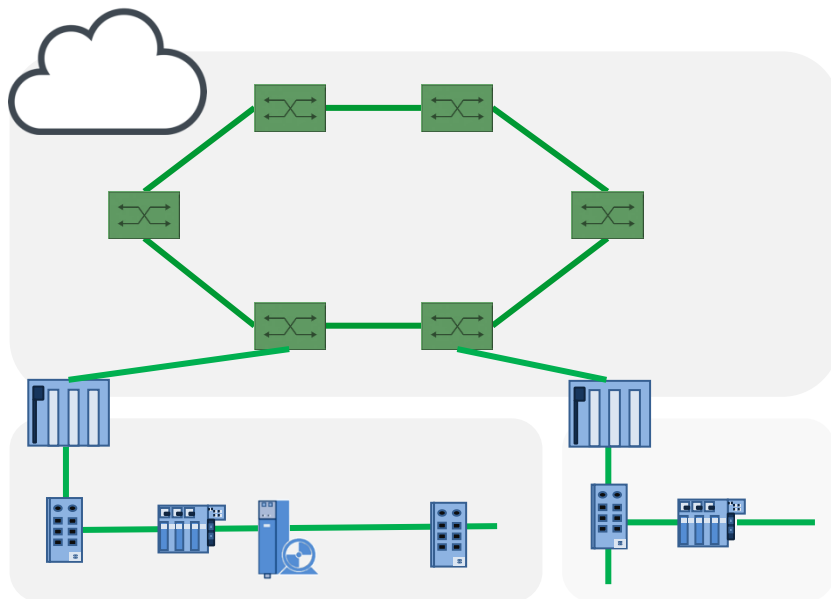
→ IEEE defines a „building set“, which can be used by higher level communication protocols (also partly)



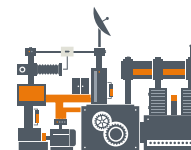
We use TSN for the

1. Field level
2. Plant level
3. Cloud connection

optimal and  
feasible in practice



**Plant level**

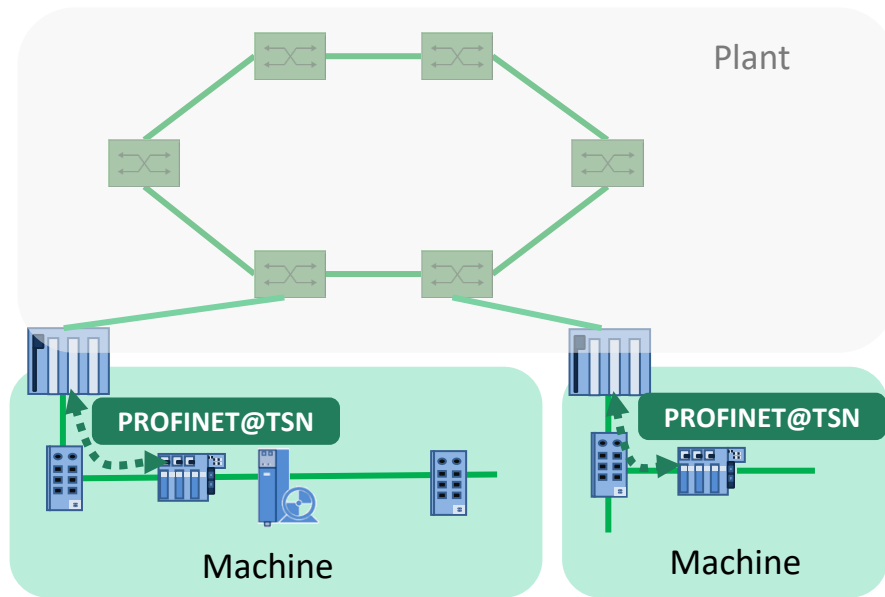


**Field level**



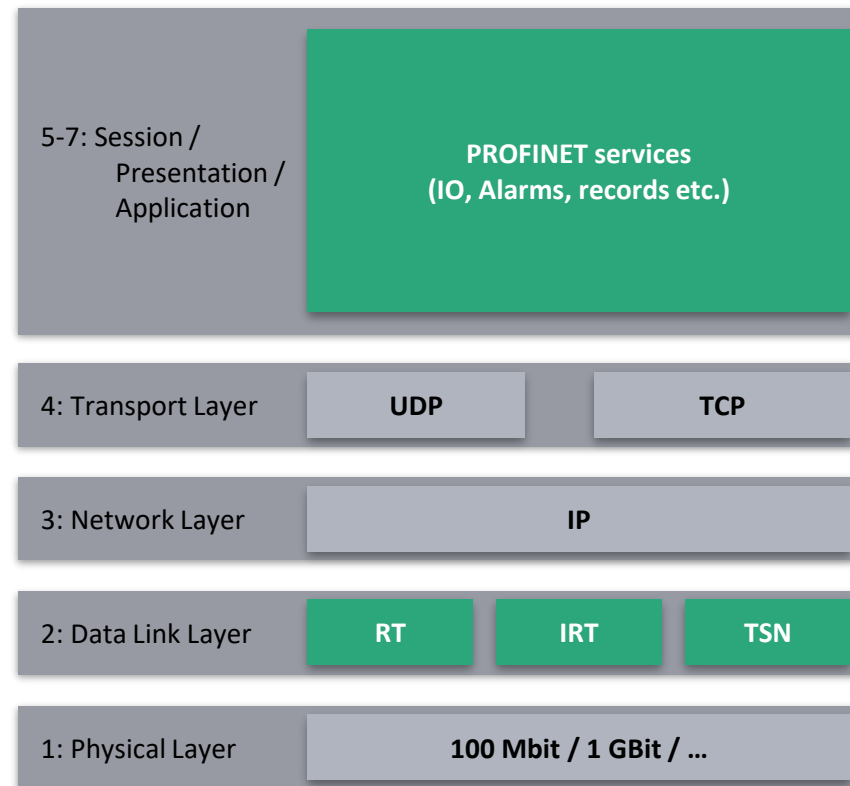


- Continuity in the user view
  - Same services
  - Same engineering
- Standard Ethernet technology
  - Wide-ranging chip supply
  - GBit / IEEE continued development
- High determinism
  - Integrated synchronicity
- Extremely rugged
  - Even with heavy TCP/IP traffic





- Proven PROFINET services
  - Configuration, parameterization, diagnostics
  - Profiles: PROFIsafe, PROFIdrive, PROFIenergy, etc.
- Easy TSN network configuration
  - Topology configuration only in isochronous mode
  - Network engineering integrated in PROFINET
- Uniform mechanism
  - For isochronous and non-isochronous applications
  - Flexible topologies, no "island formation"
- Flexibility on the physical layer
- Scalable and easy to integrate PROFINET stacks



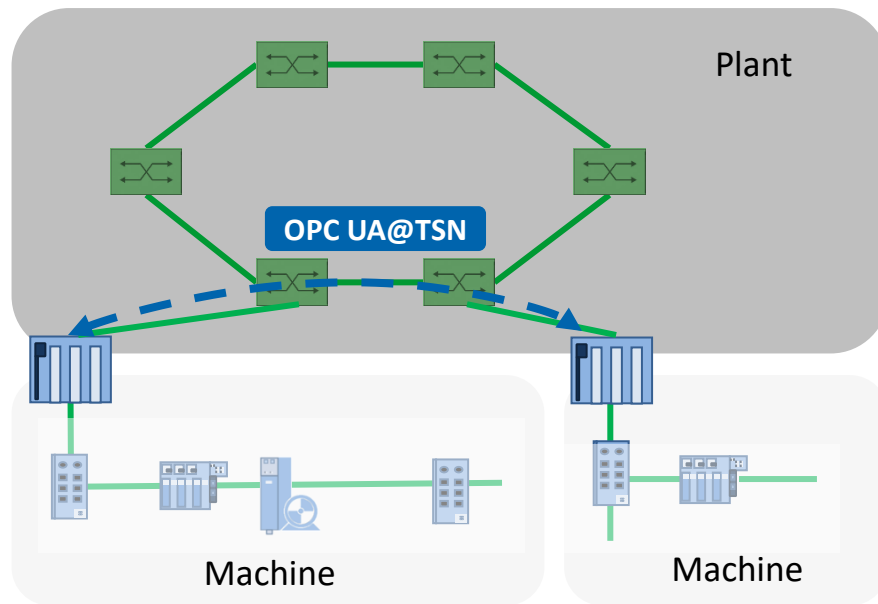


## ■ OPC UA

- For horizontal controller / controller communication
- Cross-vendor interoperability

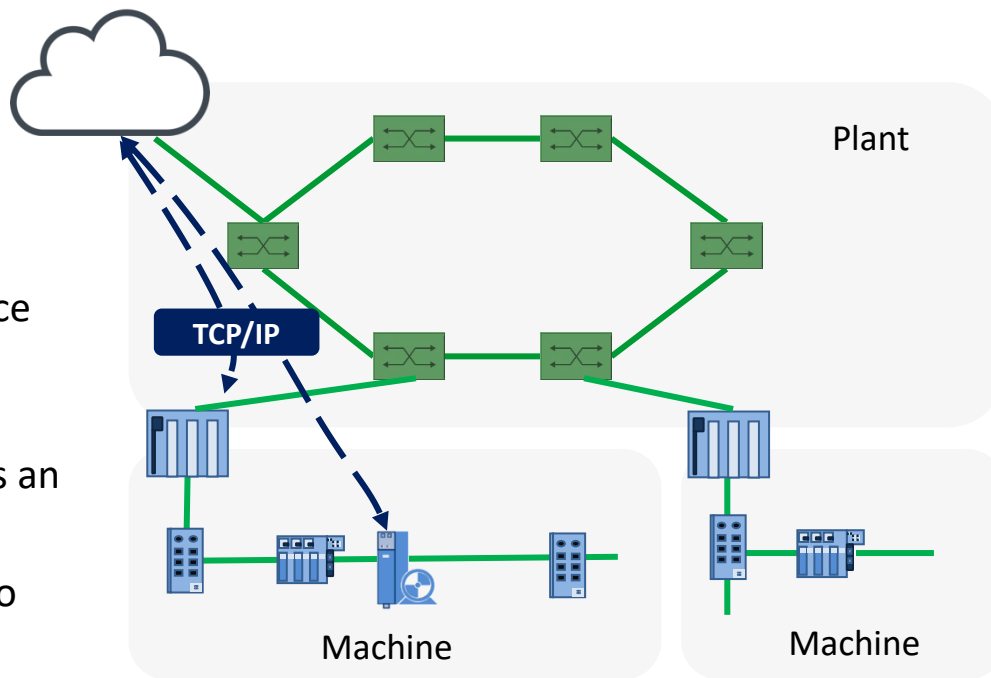
## ■ Procedure

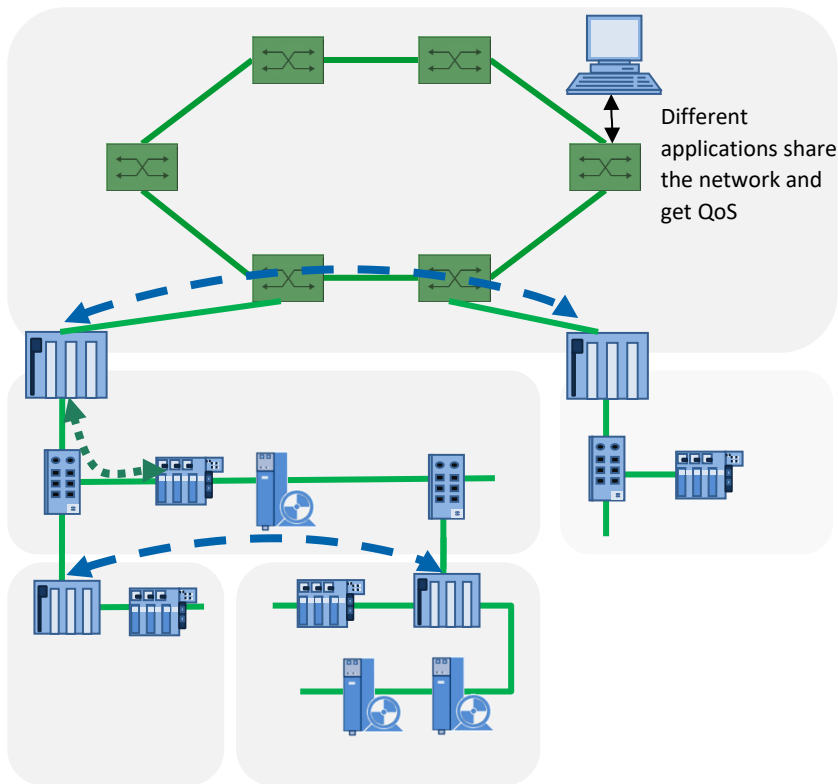
1. Client/Server (TCP/IP)
2. Pub/Sub (UDP)
3. Real time with TSN





- Industry 4.0 leads to increased TCP/IP communication
- Examples
  - From the device to the cloud
  - SCADA, MES
  - Quality data, predictive maintenance
  - Asset management, etc.
- Convergence with TCP/IP is and remains an integral part of PROFINET architecture
- Greater bandwidth and resilience due to TSN mechanisms





## TSN technologies for network configuration:

- ▮ Stream Reservation protocols
- ▮ UNI interface: Plug&Work
- ▮ Central / Distributed

Not yet standardized (IEEE, IEC)

learn & adopt

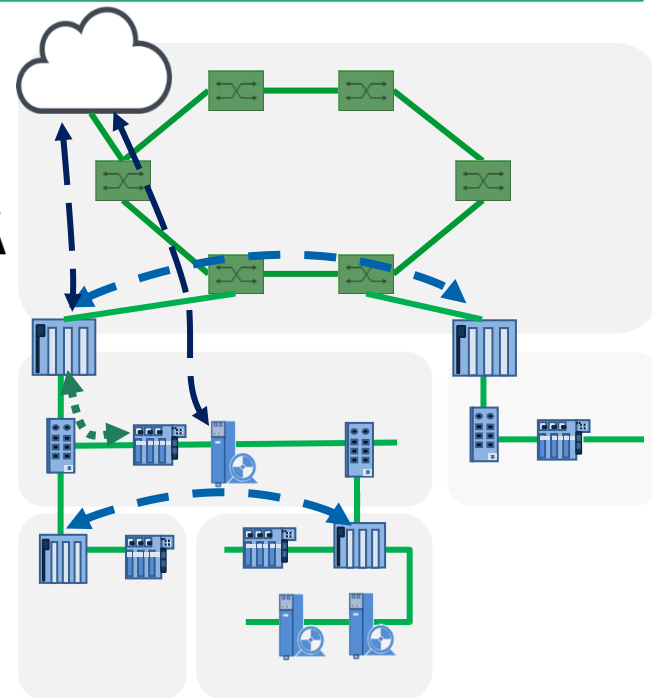
## Outlook:

### Use of PROFINET network infrastructure for additional TSN streams

- ▮ Continuity: PN@TSN for cyclic I/O data exchange (fieldbus)
- ▮ Also: Plug&Work
- ▮ Use of existing TSN device HW



- PROFINET and OPC UA form the basis for industrial communication for Industry 4.0
  - PROFINET = Fieldbus with tried and proven user view
  - OPC UA = M2M, M2Cloud, Device2Cloud
- Convergence with TCP/IP is important on all levels
- PROFINET and OPC UA will use TSN in the future
- TSN offers more
  - Bandwidth
  - Deterministic, ruggedness
  - Plug&Work networks
  - Standard chips



**The industry will still be talking about PROFINET tomorrow!**

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