



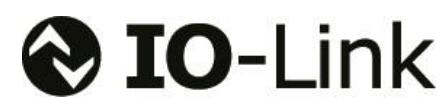
How PROFINET Works: A Beginner's Guide



Nelly Aylon



Hunter Harrington



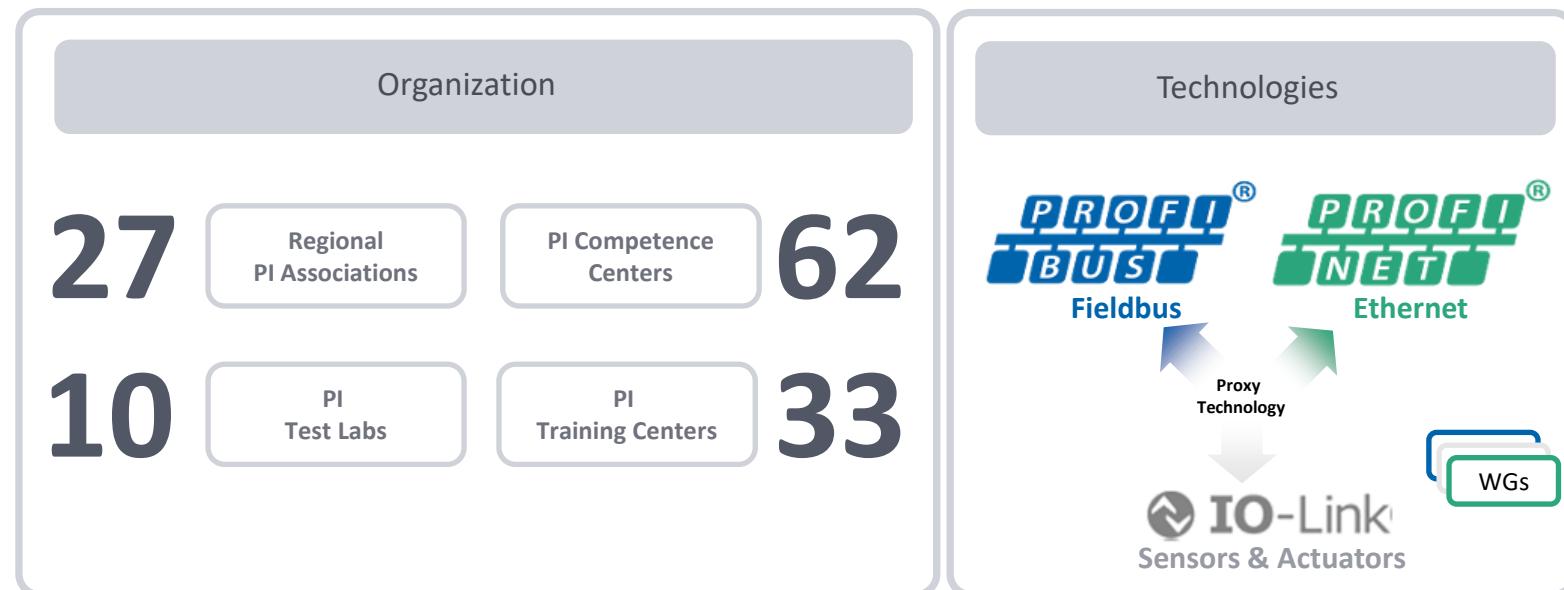


PROFIBUS & PROFINET International (PI)



- International creator, maintainer, and promoter of open, industrial communication standards PROFINET and PROFIBUS
- Founded 1989

PI= PROFIBUS & PROFINET International





PI North America

- North American Regional PI Association
- Founded in 1994 as PROFIBUS Trade Organization
- Non-profit and member-supported



Support in North America:

	PICC	PITC	PITL
PROFI Interface Center	✓	✓	✓
JCOM Automation	✓	✓	
Phoenix Contact Software	✓		
HMS	✓		

PICC = PI Competence Center
PITC = PI Training Center
PITL = PI Test Lab



Sponsors



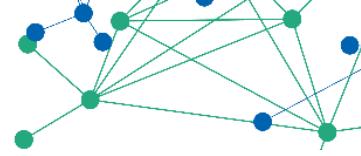
SIEMENS



 **gridconnect**

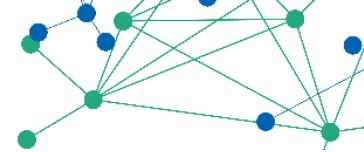
optimize!
softing





How PROFINET Works





Networking Knowledge

- Full-duplex vs half-duplex communication: cellphone vs walkie talkie
- Full-duplex transmission: Data can be transmitted in both directions at the same time.



- Half-duplex transmission: Data can be transmitted in both directions, but not at the same time.





Networking Knowledge

- TCP/IP and UDP/IP: Transport protocols used for sending data packets over the Internet Protocol

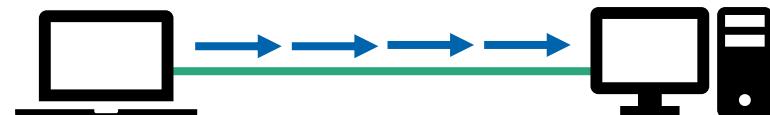
- TCP: Transmission Control Protocol

- Connection-oriented protocol
- Provides error control and flow control
- Built for reliability



- UDP: User Datagram Protocol

- Connectionless protocol
- Simpler transport control protocol
- Built for speed



IP = Internet Protocol





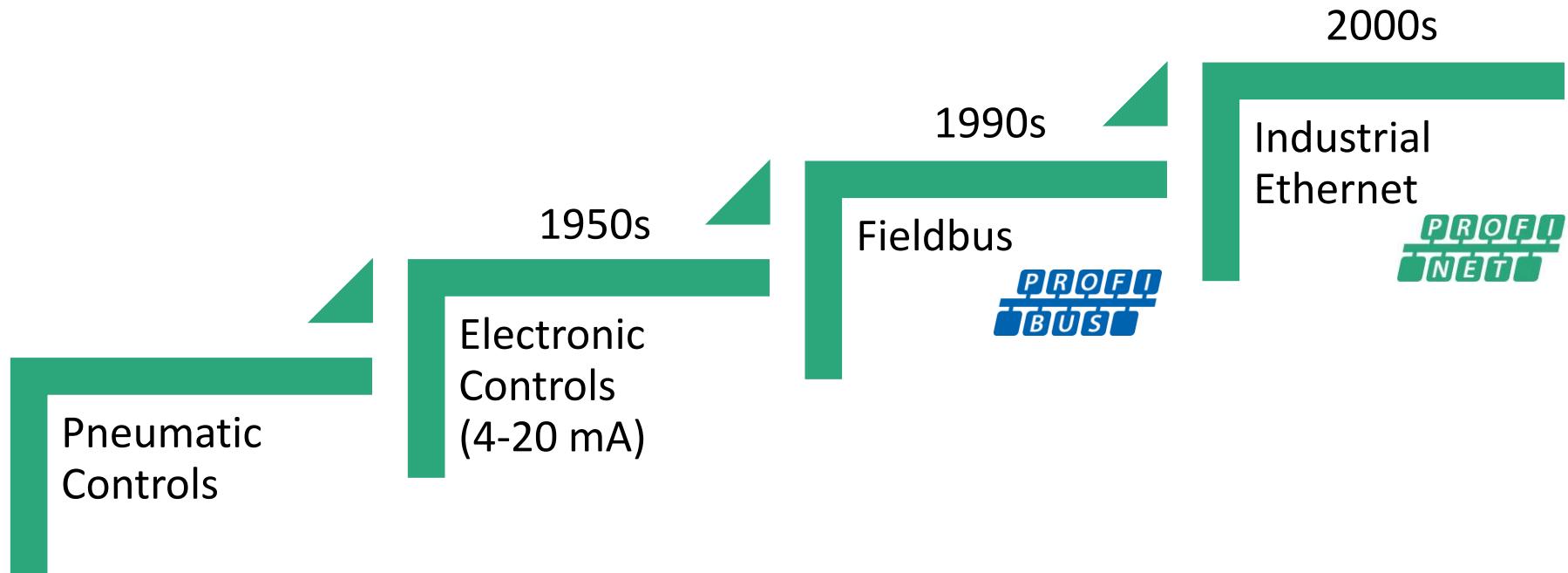
Industrial Automation Challenges

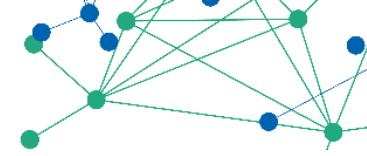
- Rough environmental conditions
- Complex plant-specific topologies and configurations
- High-performance applications (speed and determinism)
- Costly downtime
- Extensive number of connections (100,000+)





The Evolution of Controls in Manufacturing





First Automated Controls



Pneumatic Controls

- Pneumatic pressure controls: Move pressurized or compressed air "signals" from a controller to a device through copper or plastic tubes.
- Challenges:
 - Expensive
 - Signal quality compromised by external environmental changes (i.e. vibration, temperature)
 - Loud systems





Electronic Controls (4-20 mA)

Motivations:

- Low-cost
- Easy to use
- Not subject to major signal line losses

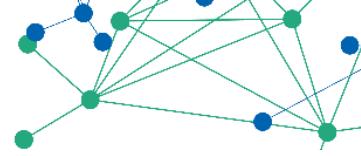
Challenges:

- Individual cables and wires ←
- Slow troubleshooting
- Prone to unwanted noise interference

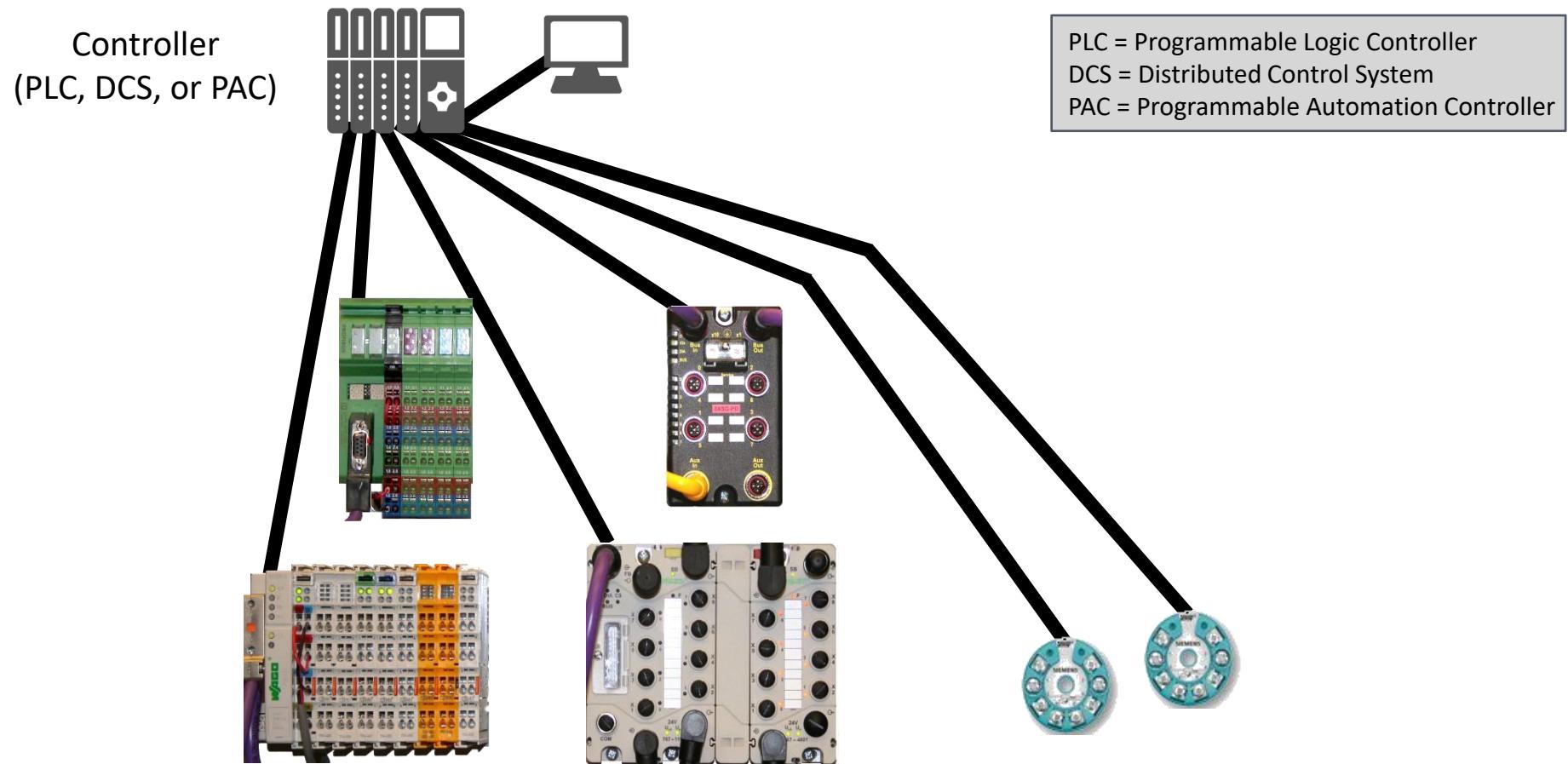


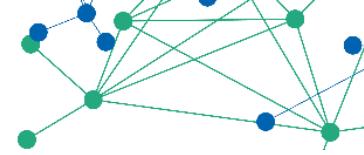
Electronic Controls (4-20 mA)





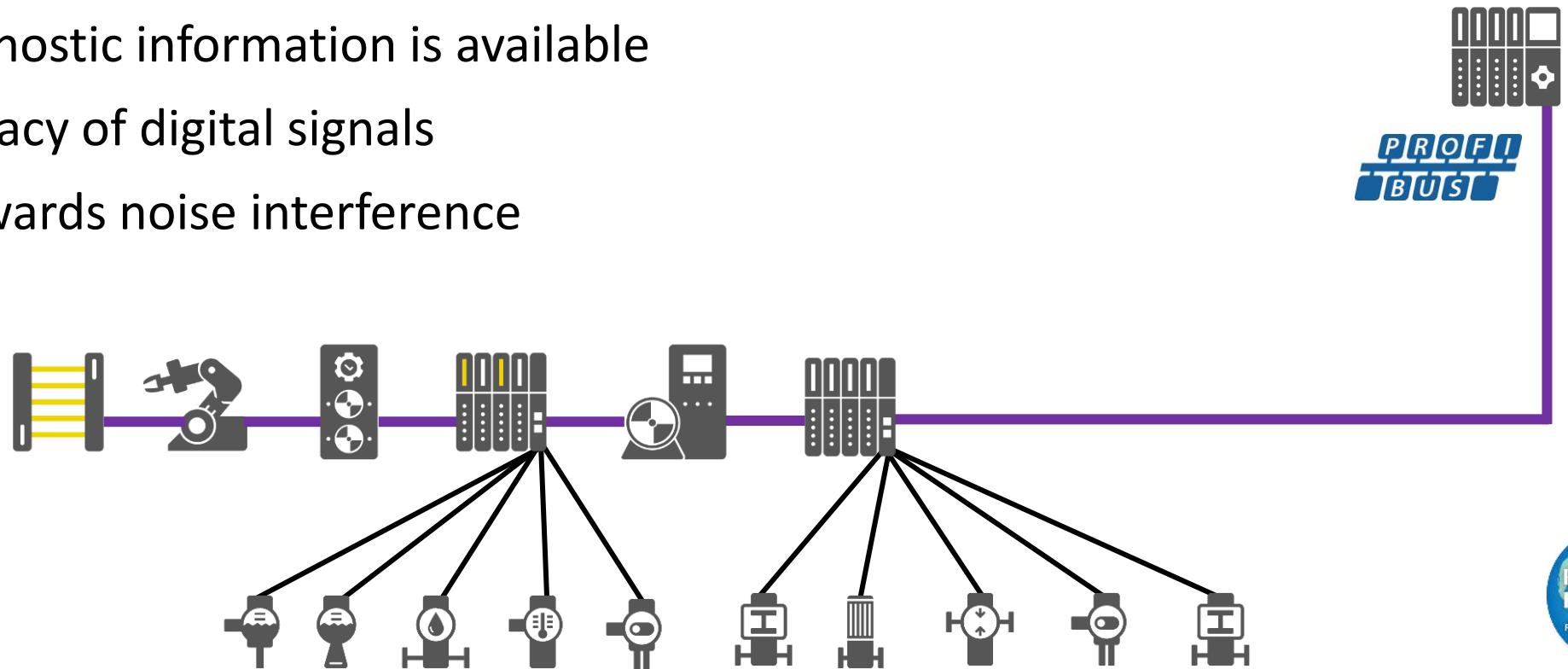
Direct Wired System





Value Proposition: Fieldbuses

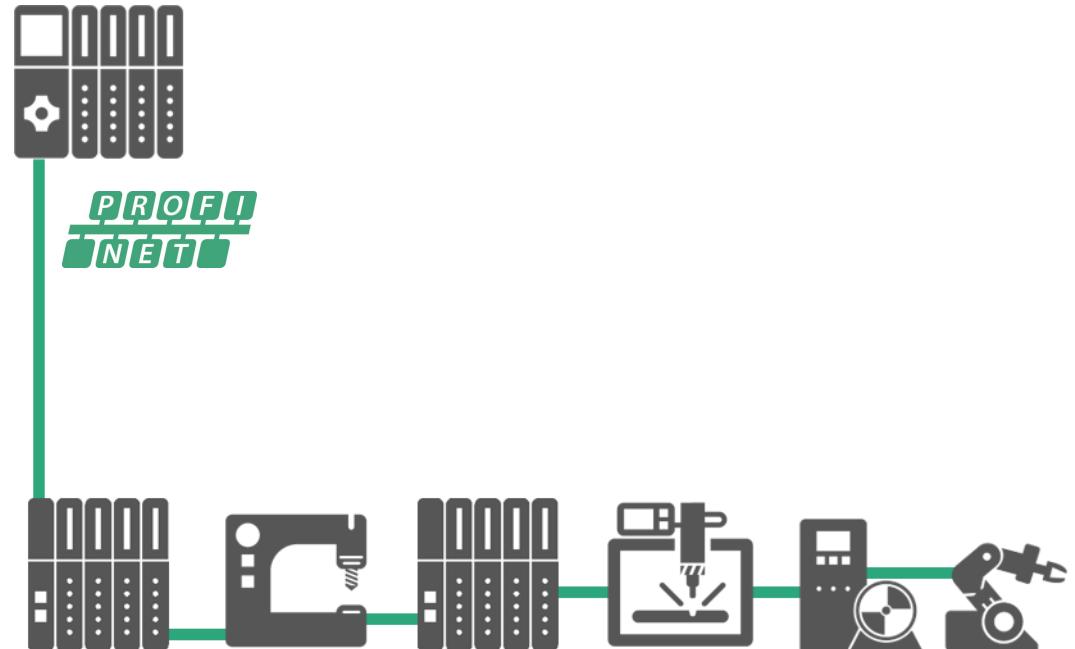
- Wire and cable reduction ←
- Physical layer: RS-485
- Large amounts of information (digital signals)
- Network diagnostic information is available
- Greater accuracy of digital signals
- Resilience towards noise interference





Value Proposition: Industrial Ethernet

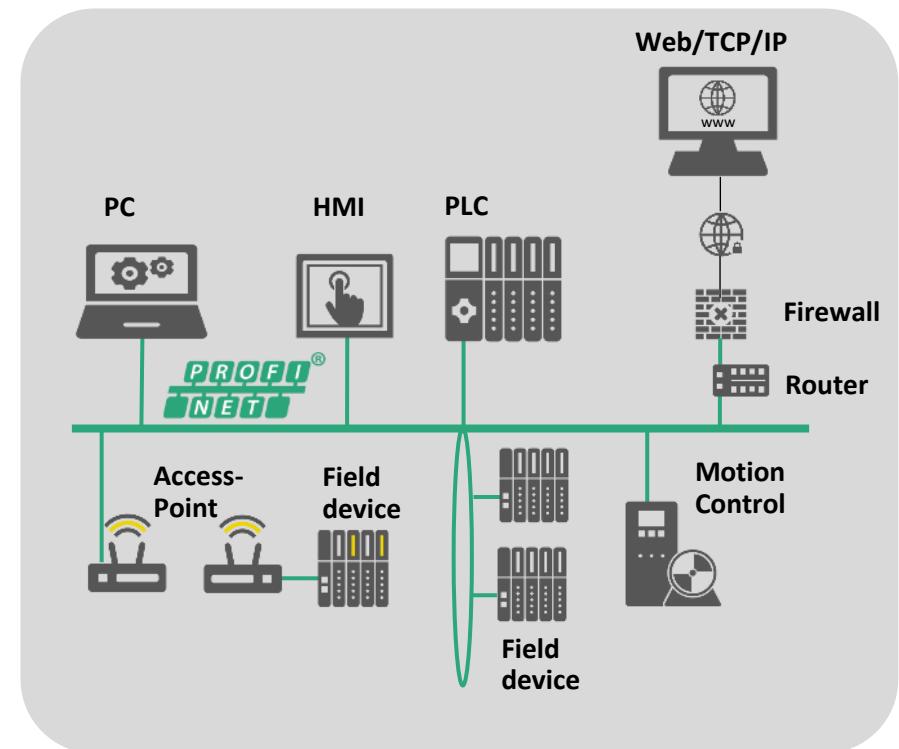
- Savings in wiring and installation costs by using distributed IO mechanisms
- Physical layer: Ethernet
- 100 Mbps, full-duplex
- Flexible topology
- High bandwidth
- Large message size
- Extensive address space





What is PROFINET?

- Communication protocol designed to exchange data between controllers and devices
 - Controllers: PLCs, DCSs, PACs...
 - Devices: IO blocks, vision systems, RFID readers, drives, process instruments...
- Open Industrial Ethernet standard (IEC 61158)
 - Physical Layer: Industrial Ethernet
 - Allows coexistence with other Ethernet protocols
- PROFINET exchanges IO data with the appropriate **speed and determinism**
 - Real-time performance



PLC = Programmable Logic Controller
 DCS = Distributed Control System
 PAC = Programmable Automation Controller

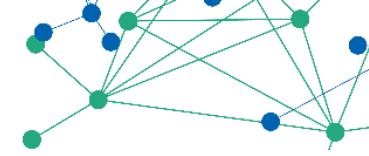


Common Industrial Ethernet Questions



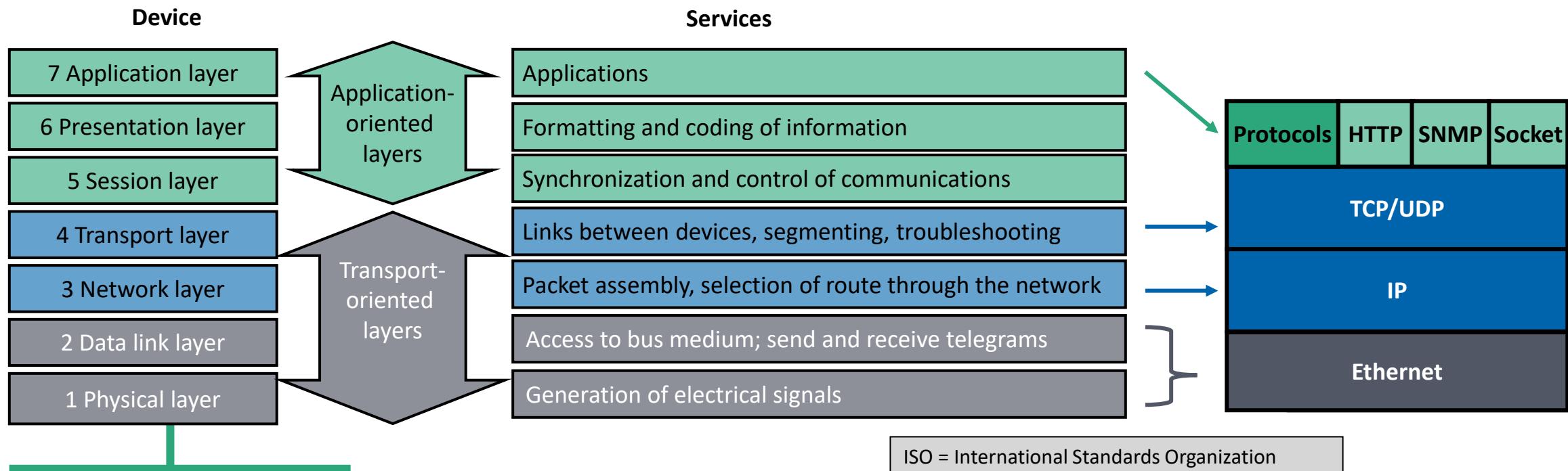
- Industrial automation applications require determinism, so...
 - Is Ethernet deterministic?
 - Can an Ethernet protocol be deterministic?
 - How does PROFINET achieve determinism?





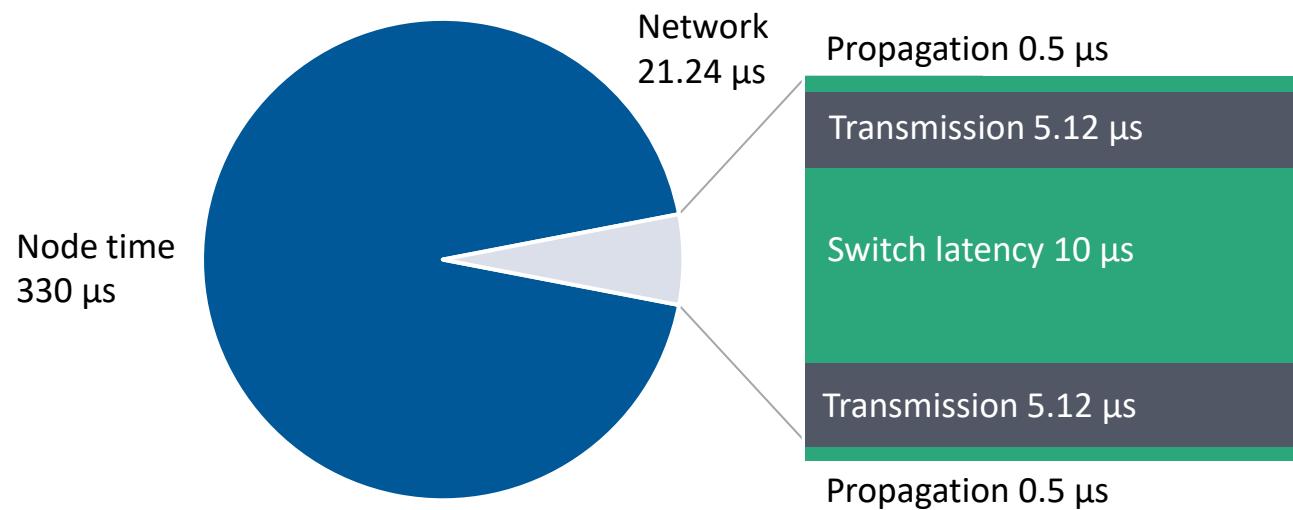
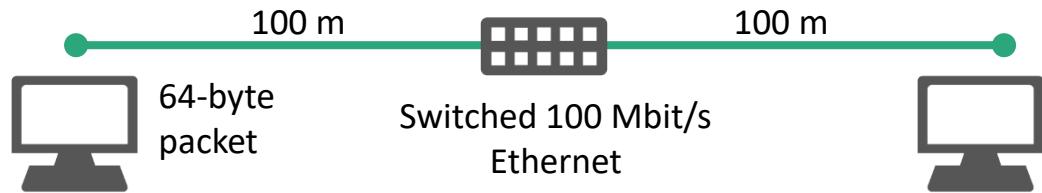
The ISO/OSI Model

- Each communication procedure is divided into logical components which are linked via defined interfaces



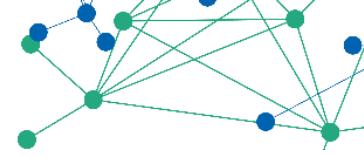


Message Delay

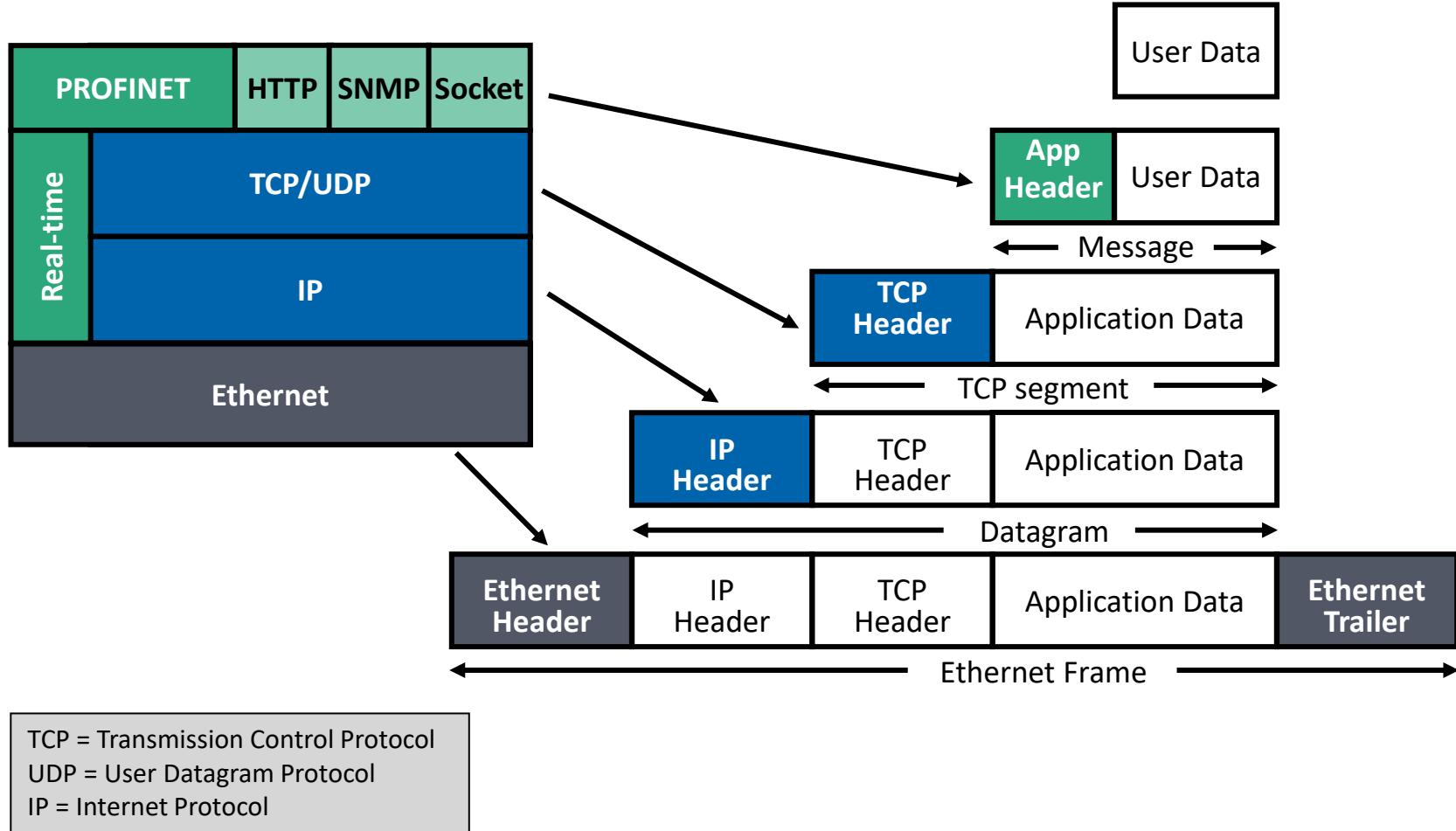


Source: University of Michigan, *Industrial Ethernet Book*,
[“Performance Metrics for Industrial Ethernet”](#)



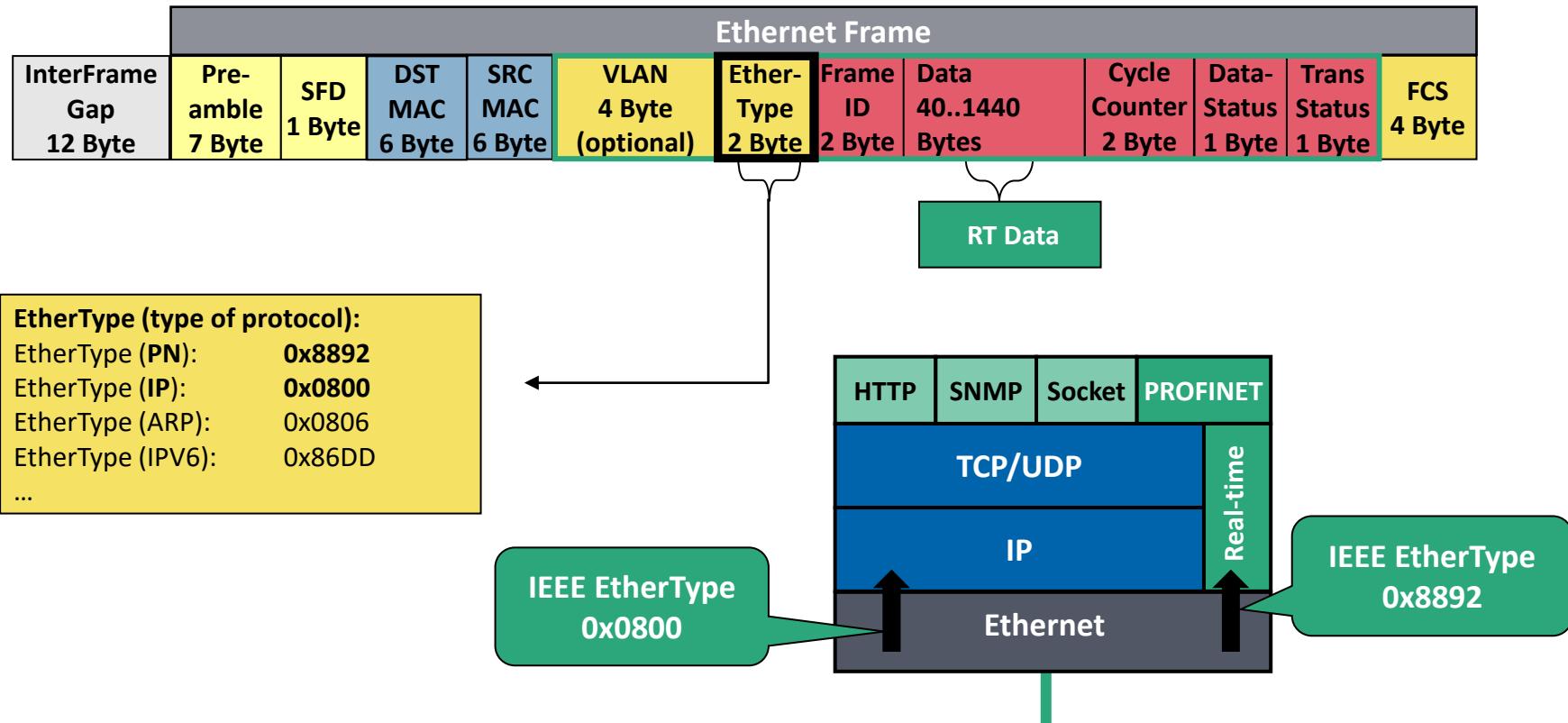


Encapsulation



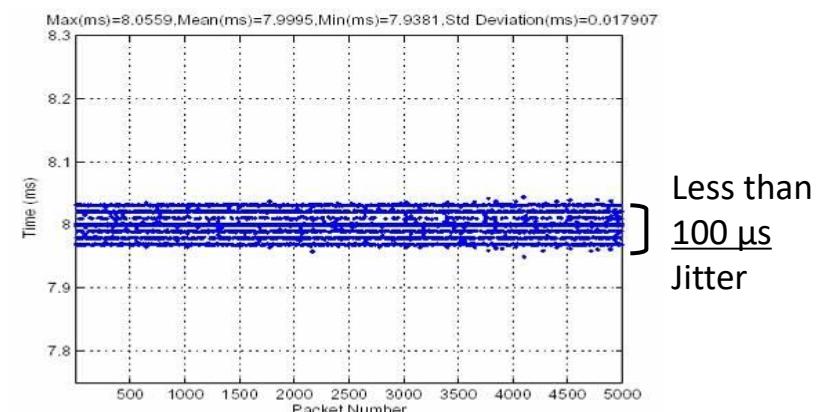
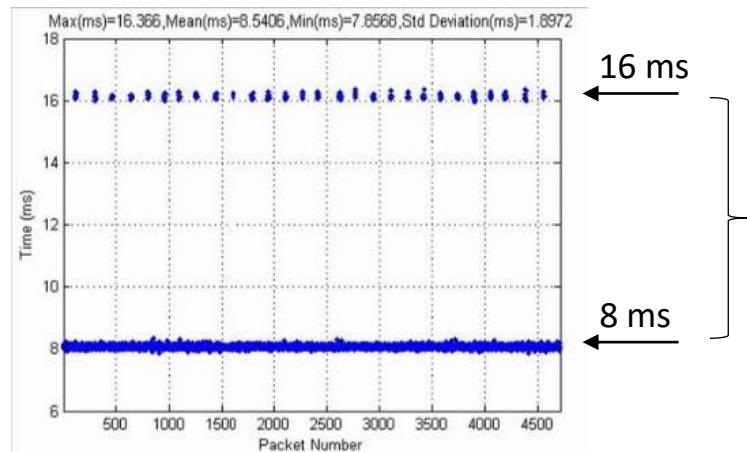
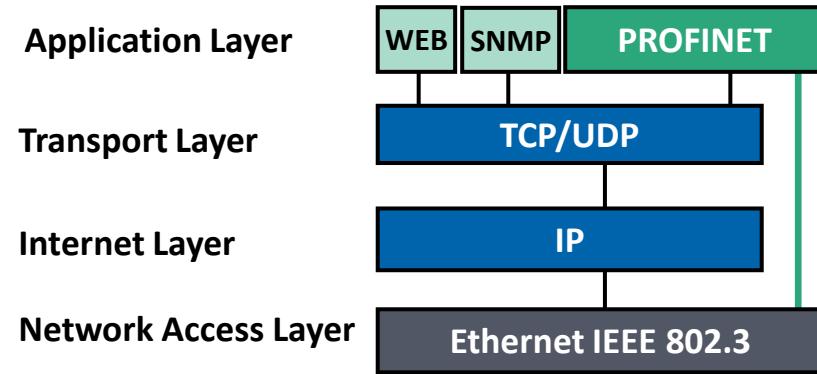
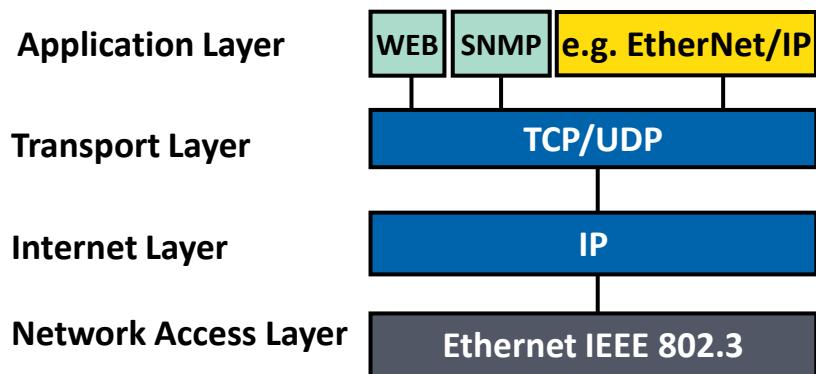


PROFINET EtherType





PROFINET Real-time and Jitter



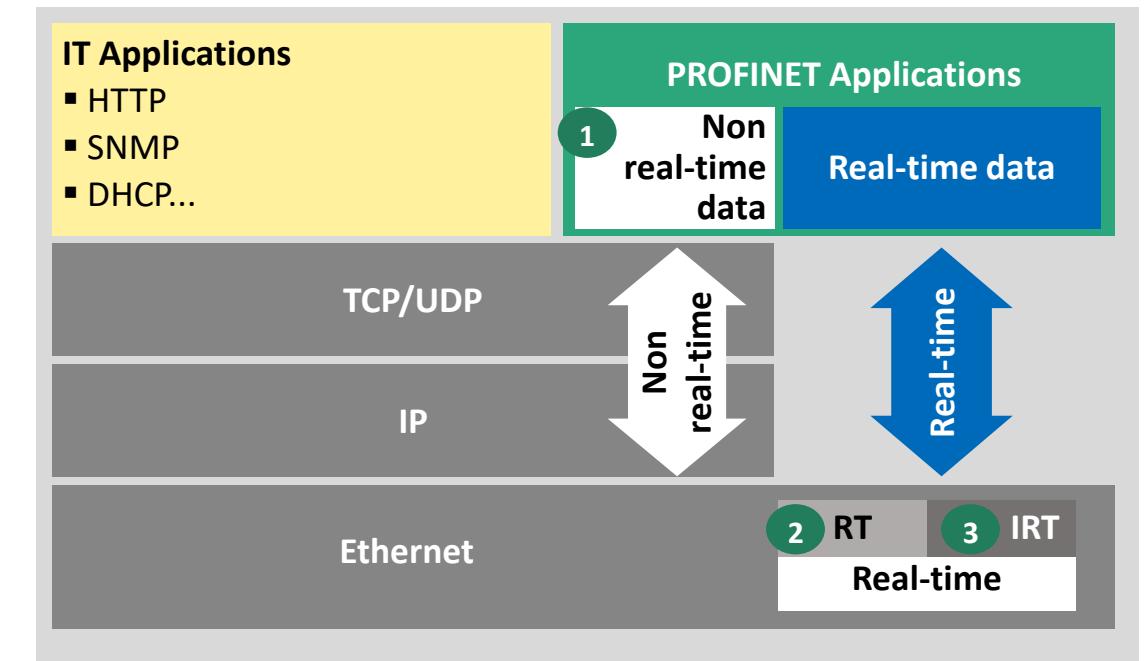
Source: University of Michigan, *Industrial Ethernet Book*, “[Performance Metrics for Industrial Ethernet](#)”



PROFINET Communication Channels



- TCP/IP or UDP/IP
- PROFINET RT
- PROFINET IRT



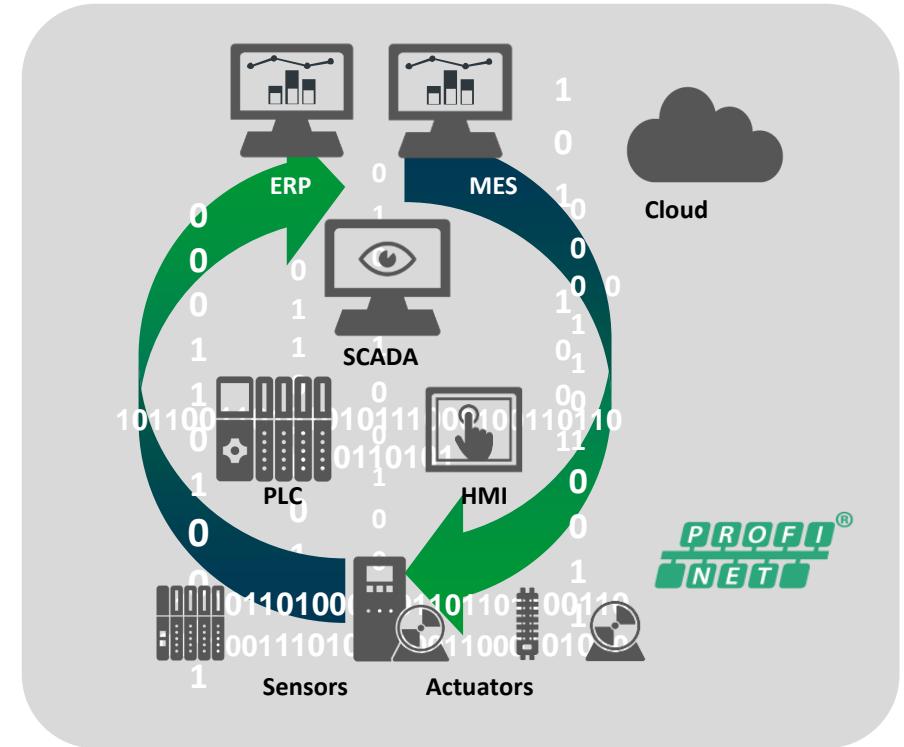
PROFINET RT = PROFINET real-time

PROFINET IRT = PROFINET isochronous real-time





- Future proof due to use of IEEE-standards
 - Standard unmodified Ethernet
- Parallel operation of various Ethernet protocols, such as:
 - OPC UA, HTTP, SNMP, MQTT...
- Vertical integration
 - PROFINET supports well known network structuring using Routers and Bridges
 - Web servers in PROFINET devices
 - Remote diagnostic information





PROFINET Application Examples



- Automotive
- Conveying Systems
- Assembly Machine and Textile Industry
- Shipbuilding
- Infrastructure Traffic and Railway

Factory Automation



- Oil & Gas & Energy Industries
- Power Generation
- Chemical and Medial Industries
- Mines und Metal
- Food & Beverage

Process Automation



- Printing Machinery
- Machines for Wood, Ceramics and Glass Production
- Plastics
- Packaging
- Wind Turbines

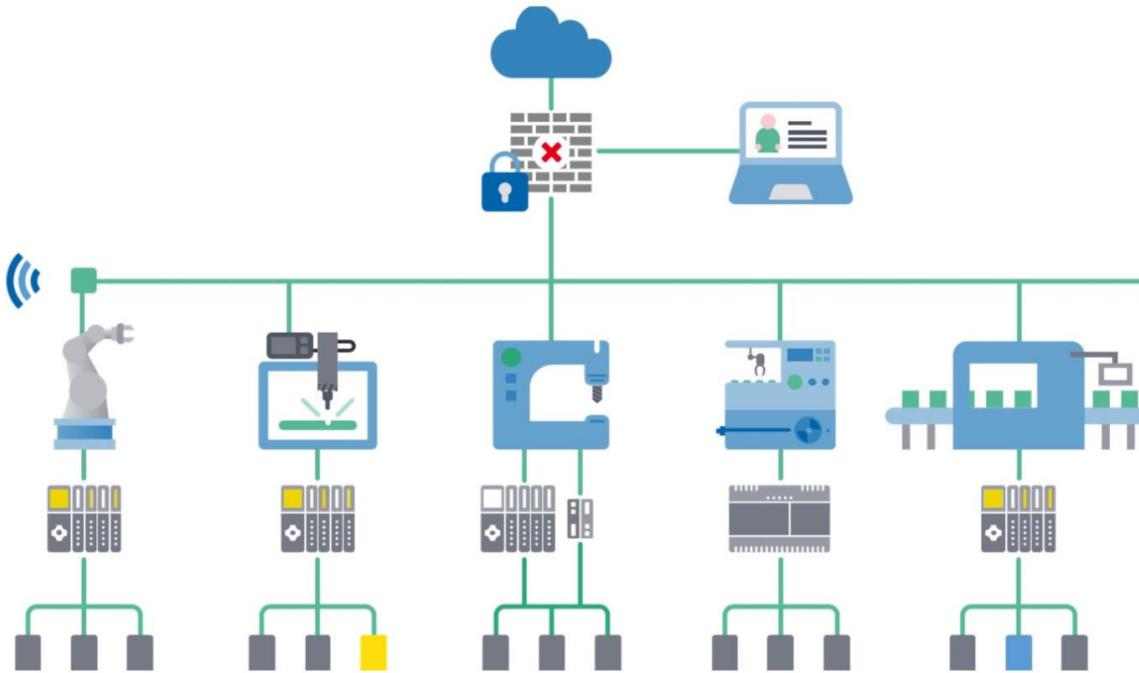
Motion Control

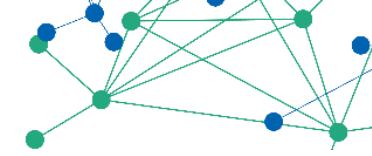




Common Questions

- Is PROFINET a protocol?
- Is PROFINET Ethernet?
- Does PROFINET use IP addresses?





PROFINET Network Design



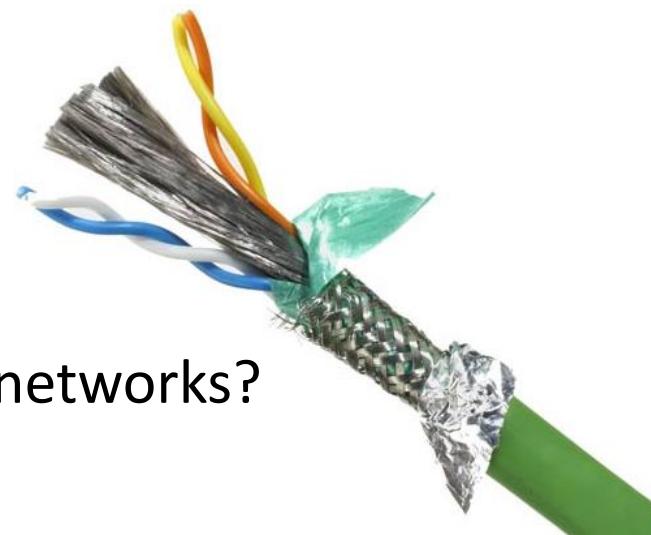


Cables for PROFINET

- Standard Ethernet cable options
 - Copper and fiber options
 - Requirement: 100 Mbps transmission speeds
- Industrial Ethernet cable: Ruggedized Ethernet cables, built for the factory floor
- PROFINET cables: Industrial Ethernet cables that often come with a green jacket, and comply with ruggedized specifications that have been standardized by PI

- Can you implement Cat 5, 5e, Cat 6, 6a, or Cat 7 cables in PROFINET networks?

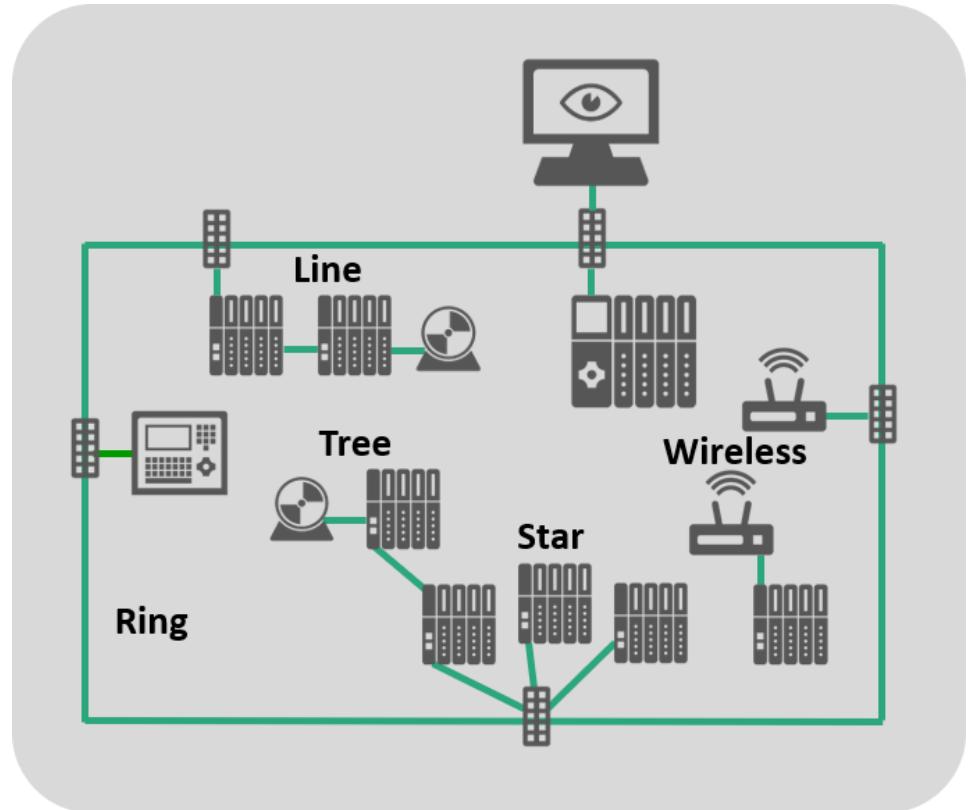
Yes, but you must check the specifications of each cable





Topology and Media Options

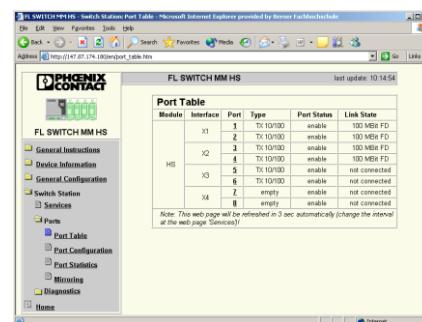
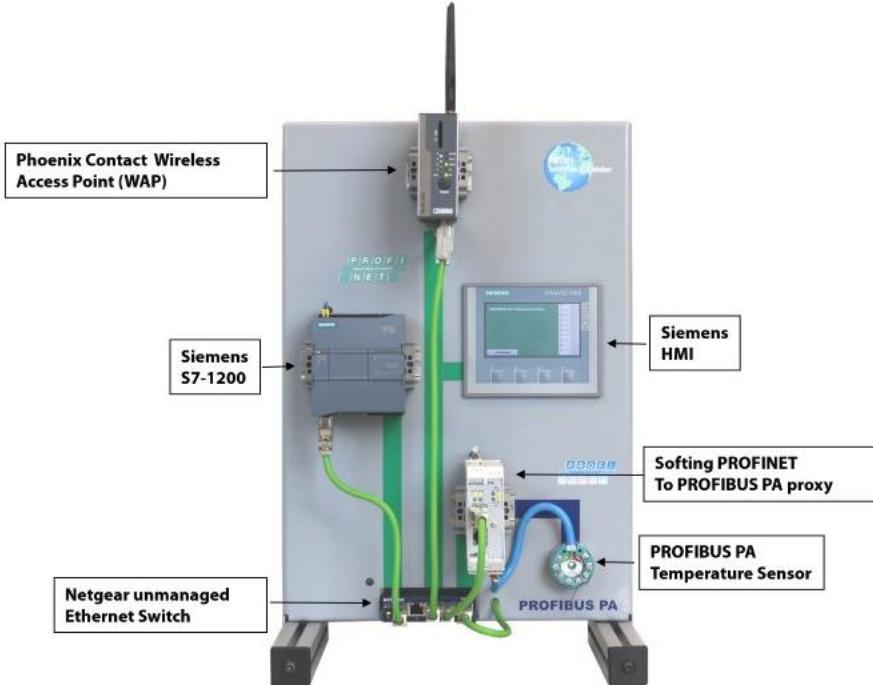
- Several plant topology options
 - Wired: Line, tree, star, and ring
 - Wireless topologies based on Wi-Fi and Bluetooth
- Physical layer: copper, fiber optics, or wireless
- Easy combination of different topologies





Switches for PROFINET

- Minimum requirements: 100 Mbps, full-duplex
- Switch type options:
 - **Unmanaged switches:** No configuration interface or options. They are inexpensive and easy to set up.
 - **Managed switches:** They provide extra features, powerful and built-in diagnostics.
 - **PROFINET switch:** PROFINET switches are managed switches that fulfill the minimum requirements, and also add PROFINET functionality. They act as a PROFINET device in the network.





PROFINET Configuration Basics



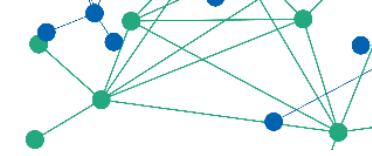


GSD file

- Description of device properties in the GSD
 - Pluggable modules (Number, Type)
 - Configuration data of the module (e.g. analog input)
 - Module parameters (e.g. 4..20mA)
 - Diagnostics information (e.g. wire break)
- The GSD is XML-based
- Where to find the GSD file?
 - Manufacturer's website or physically with the product

XML = eXtensible Markup Language
GSD = General Station Description
GSDML = GSD Markup Language





Addressing

- PROFINET devices will have a MAC address, IP address and a name (must be unique)
- Each PROFINET device and controller requires a device name for easy network management
- IP addresses
 - Use of IPV4 (32 bit address)
 - Class A, B, or C
 - Controller IP and subnet defines range of addresses for devices

No. of networks	Class	Address range	Network mask	Number of nodes per network
1	Class A	10.0.0.0 to 10.255.255.255	255.0.0.0	16.8 million
16	Class B	172.16.0.0 to 172.31.255.255	255.255.0.0	65534
256	Class C	192.168.0.0 to 192.168.255.255	255.255.255.0	254





Naming and Addressing Tips

- Make device names meaningful. It helps with management and diagnostics.
 - Ex. filler.jocy.cab1 or filler.192-168-1-8.jocy.cab1 or just filler
- Use of correct naming conventions is critical (a-z, 0-9, ., -)
- Label the devices with their name and IP (and MAC if not there, should be)
- Work with your IT department on the IP address ranges
- Most PROFINET devices get the IP from the controller
- Duplicate names and IP addresses are not permitted





Diagnostics in PROFINET Networks

- PROFINET device diagnostics are standardized
- Simple diagnostic setup
- Simple evaluation in engineering, PLC and HMI
- Independent of the used PLC

5.2.8.2 Coding of the field ChannelErrorType

This field shall be coded as data type Unsigned16 with the values according to Table 529, Table 530, and Table 531.

Table 529 – ChannelErrorType – range 1

Value (hexadecimal)	Meaning	Assigned text
0x0000	Reserved	Unknown error
0x0001	Short circuit	Short circuit
0x0002	Undervoltage	Undervoltage
0x0003	Oversupply	Oversupply
0x0004	Overload	Overload
0x0005	Overtemperature	Overtemperature
0x0006	Line break	Line break

Properties - 4 DO DC24V 2A HF - (R-/S2)

General Addresses Parameters

Parameter	Value
Outputs	
Group diagnostics	<input type="checkbox"/>
Diagnosis: No load voltage L+	<input checked="" type="checkbox"/>
Reaction to CPU-/Master-STOP	
Channel 0	
Diagnosis: Short circuit to G	<input checked="" type="checkbox"/>
Diagnosis: Short circuit to L+	<input checked="" type="checkbox"/>
Diagnosis: Wire break	<input checked="" type="checkbox"/>
Substitute value	
Channel 1	
Diagnosis: Short circuit to G	<input type="checkbox"/>
Diagnosis: Short circuit to L+	<input type="checkbox"/>
Diagnosis: Wire break	<input type="checkbox"/>
Substitute value	
Channel 2	

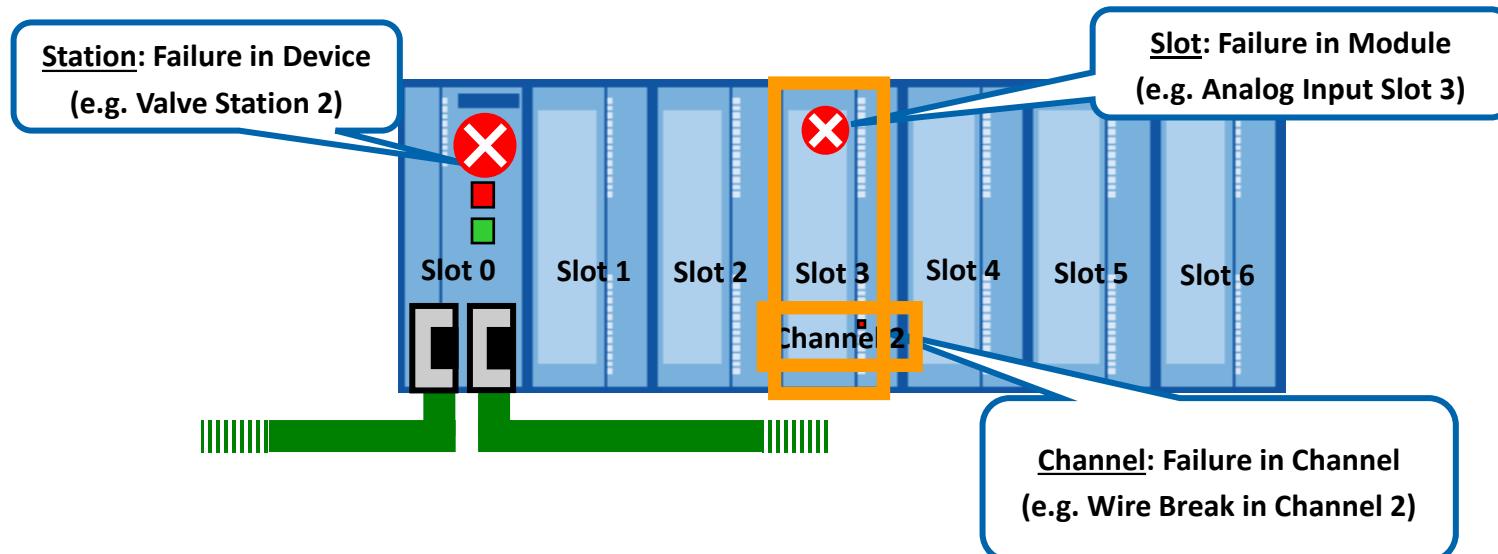




PROFINET Device Diagnostics Structure

- Logical model provides quick error localization
- Diagnostic information is structured hierarchically

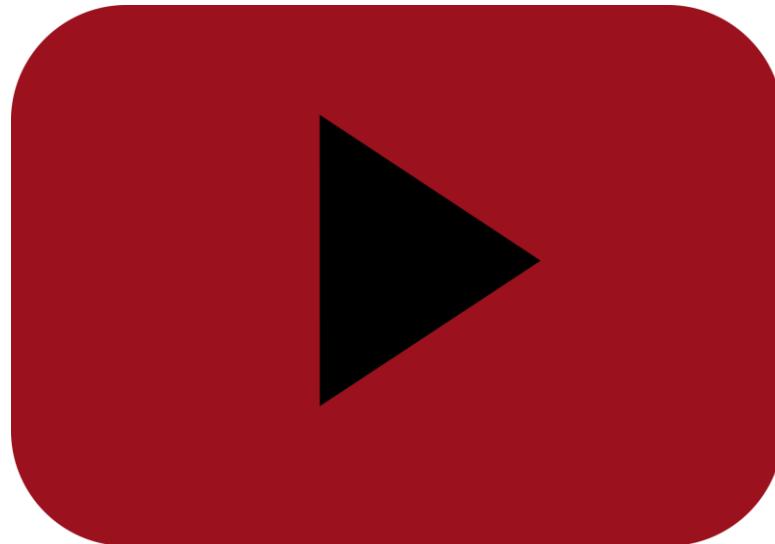
>>>> Station name >>> Slot >> Channel >> Channel type > Error information

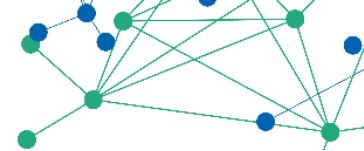


Diagnostic Information is not only “PROFINET related”, but also helps in the application



Configure a PROFINET Network





Certified Network Engineer Classes

PROFIBUS or PROFINET Certified Network Engineer class

- Full week training @ Johnson City, TN (also available on-site)
- Certification requires passing both a theoretical and practical exam
- Certified Network Engineers are listed at www.profibus.com
- [Register Online](#)





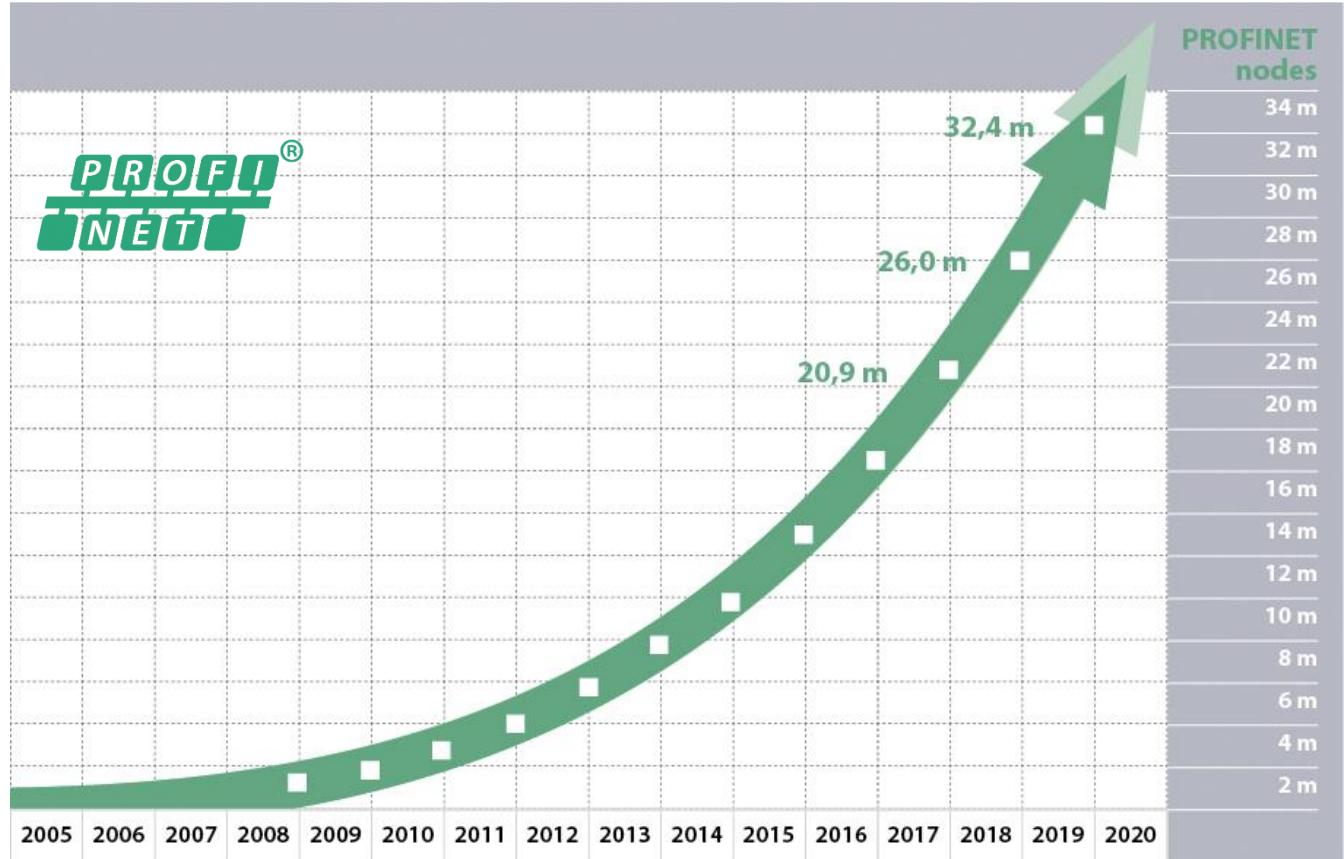
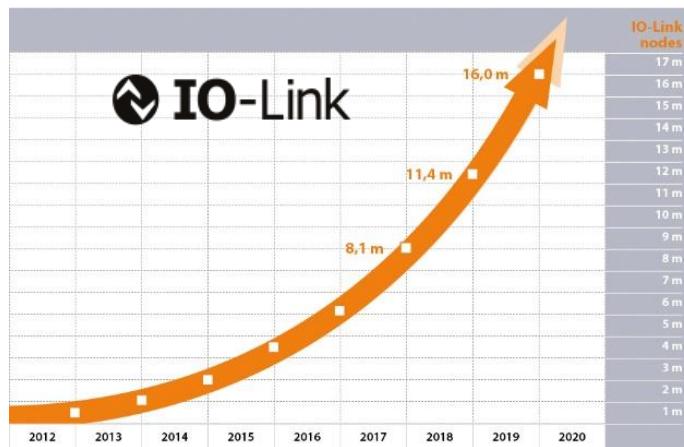
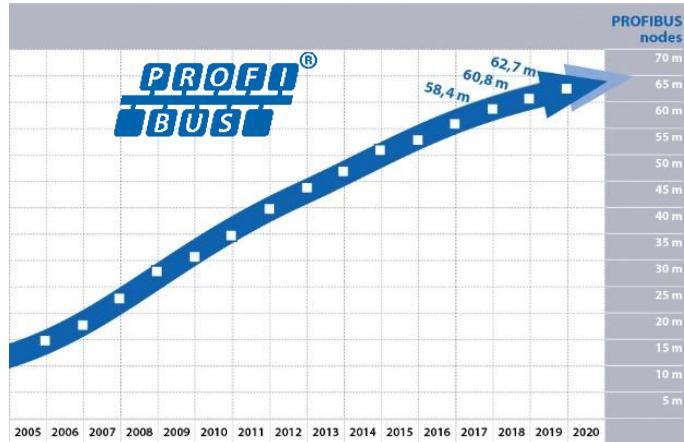
PROFINET Highlights

1. Flexible topology and media
2. User friendly interface
3. Device diagnostic and asset information
4. Support of motion control applications
5. IT integration: one system for all
6. *Options to implement scalable redundancy configurations*
7. *Energy management profile: PROFIdenergy*
8. *The integrated safety solution: PROFIsafe*
9. *IO-Link integration*
10. Huge organization and support





Industry Presence





Worldwide Support

 Canada PICC, PITC	 Netherlands RPA, PICC, PITC, PITL	 UK RPA, PICC, PITC	 Norway RPA, PICC, PITC	 Finland RPA	 Southern Africa RPA, PICC, PITC
 USA RPA, PICC, PITC, PITL	 Belgium PICC, PITC	 Ireland RPA, PICC, PITC	 Sweden RPA, PICC	 Denmark RPA	 India RPA, PICC
 Brazil RPA, PICC, PITC	 France RPA, PICC, PITC		 Turkey PICC	 China RPA, PICC, PITL	
 Chile RPA, PICC, PITC	 Germany RPA, PICC, PITC, PITL	 Argentina PICC, PITC	 Switzerland PICC, PITC	 Lebanon PICC	 South-East-Asia RPA
 Spain RPA, PICC, PITC	 Italy RPA, PICC, PITC	 Poland RPA, PICC, PITC	 Czech Rep. RPA, PICC, PITC, PITL	 Middle-East / UAE RPA, PICC	 Taiwan RPA
 Japan RPA, PICC, PITL	 Saudi Arabia PICC, PITC	 Australia/ New Zealand RPA, PICC, PITC			

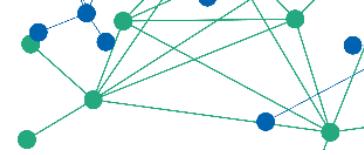
PI worldwide:

25 Regional PI Associations (RPA)

PI Technical Support:

59 PI Competence Centers (PICC)
32 PI Training Centers (PITC)
9 PI Test Laboratories (PITL)





Resources

- Our website: us.profinet.com
- Webinar: [Ethernet for Control Engineers](#)
- [PROFINET Technology Page](#)
- [PROFINET System Description](#)
- [PROFINET Intro Video](#)
- [PROFIBUS vs PROFINET Video](#)
- PROFINET Guidelines
 - [Design](#)
 - [Installation](#)
 - [Commissioning](#)
- [PROFINET Commander Software](#) (free version)



Resources



PI North America

16101 N 82nd Street, Suite 3B
Scottsdale, AZ 85260 USA

(480) 483-2456

www.us.profibus.com

Michael Bryant

Michael Bowne

Nelly Ayllon

Lynne Froehlich

Marsha Bryant

PROFI Interface Center

One Internet Plaza
Johnson City, TN 37604 USA

(423) 262-2576

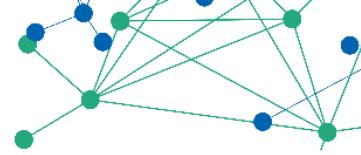
www.ProfilInterfaceCenter.com

Torsten Paulsen

Hunter Harrington

John Swindall





- Copy of the slide set and recording will be available @
<https://us.profinet.com/training/webinars/>

THANK YOU!

