Discussion, not lecture
The Organization
- Global support

Breadth of Application Coverage
- Factory (discrete), process, and motion

Depth of features
- Determinism, diagnostics, PROFIenergy, PROFIsafe, I-Device, Shared Device, wireless, etc.

Leadership
- Pioneered safety and many other Industrial Ethernet aspects

Resources
The Organization: PROFINET

PI worldwide:
- 27 Regional PI Associations (RPA)
- 1,487 Members

PI Technical Support:
- 53 PI Competence Centers (PICC)
- 28 PI Training Centers (PITC)
- 10 PI Test Laboratories (PITL)

Certified

www.us.profinet.com
## The Organizations

<table>
<thead>
<tr>
<th></th>
<th>PI</th>
<th>ODVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional Associations</td>
<td>27</td>
<td>4</td>
</tr>
<tr>
<td>Members</td>
<td>1,487</td>
<td>300</td>
</tr>
<tr>
<td>Training centers</td>
<td>28</td>
<td>1</td>
</tr>
<tr>
<td>Test labs</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Competence Centers</td>
<td>53</td>
<td>0</td>
</tr>
</tbody>
</table>

- Broad international support matters if
  - You ship products globally
  - You ship machines globally
  - You build plants globally
- PI certification of PICCs, PITCs, & PITLs
- Quality of Service agreements with PI
- Audited by PI
<table>
<thead>
<tr>
<th>Activities</th>
<th>PI</th>
<th>ODVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newsletter subscribers</td>
<td>130,000</td>
<td>no</td>
</tr>
<tr>
<td>Member Newsletter</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Twitter accounts</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>YouTube channels</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Facebook pages</td>
<td>3+</td>
<td>0</td>
</tr>
<tr>
<td>LinkedIn groups</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Webinars</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Blog</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Training Classes*</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Certified Training Classes*</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Certified Engineers*</td>
<td>1,000</td>
<td>0</td>
</tr>
</tbody>
</table>

*US Only
The Organizations: Cooperation

**PI**
- Works with NAMUR for process
- Works with AIDA for automotive
- Started Wireless Cooperation with FF and HART
- Launched FDI (Field Device Integration) with FF, HART, OPC, FDT
- Incubated IO-Link
- Absorbed Interbus

**ODVA**
- Some relationships with SERCOS and Modbus
PI markets

Process
- Oil and gas
- Water/wastewater
- Pharma

Factory
- Automotive
- Logistics
- Other discrete manufacturing
It’s all about the data

IoT
IIoT
Industrial Internet
Industry 4.0
The road to IIoT

Evolution NOT Revolution
Breadth of Application Coverage

- Factory – both
- Process – both, but…
  - Non-intrinsically safe instruments, EIP has more
  - Intrinsically safe, both rely on PROFIBUS PA (or Foundation Fieldbus)
  - PROFINET uses proxies to integrate others
- Motion
  - PI has had PROFIdrive for decades
    - First for PROFIBUS, then PROFINET
  - ODVA has CIPmotion and SERCOS III
<table>
<thead>
<tr>
<th>Technology</th>
<th>PROFINET</th>
<th>EtherNet/IP</th>
<th>Modbus TCP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Communication Model</strong></td>
<td>Provider-Consumer</td>
<td>Provider-Consumer</td>
<td>Client-Server</td>
</tr>
<tr>
<td><strong>Real-time Protocol Options</strong></td>
<td>IEEE 802.3 (Layer 2) primary, UDP/IP option, TCP/IP option</td>
<td>UDP/IP (Layer 4)</td>
<td>TCP/IP (Layer 4)</td>
</tr>
<tr>
<td><strong>Jitter with IO</strong></td>
<td>++ (low)</td>
<td>- (high)</td>
<td>-- (higher)</td>
</tr>
<tr>
<td><strong>Protocol Standard</strong></td>
<td>IEC 61158</td>
<td>IEC 61158</td>
<td>IEC 61158</td>
</tr>
<tr>
<td><strong>Transmission Type</strong></td>
<td>Unicast primary, Multicast optional</td>
<td>Multicast primary, Limited Unicast</td>
<td>Unicast only</td>
</tr>
<tr>
<td><strong>Device Names</strong></td>
<td>Mandatory</td>
<td>Optional</td>
<td>Optional</td>
</tr>
<tr>
<td><strong>COTS switch possible?</strong></td>
<td>Yes</td>
<td>Not recommended</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Switch requirements</strong></td>
<td>100Mbit/s or faster, full duplex for IO traffic</td>
<td>Full Duplex IGMP Snooping, One IGMP Query, Wire speed For IO traffic</td>
<td>No special requirements</td>
</tr>
<tr>
<td><strong>IP Address Assignment</strong></td>
<td>Automatic w/ PN DCP DHCP optional</td>
<td>DHCP and Managed</td>
<td>DHCP and Managed</td>
</tr>
</tbody>
</table>
PROFINET in Process

Engineering Station / OS

DCS/AS

Diagnosis & Commissioning

PROFINET

Positioners
PN/PA link
Drives
Motor starter

PROFINUS DP
RS 485iS
max. 1.5Mbit/s in Ex

ET 200iSP
Classic I/O & HART

PROFINUS PA 31.25kbit/s

Positioners
Level
Temperature
Flow
Pressure

Transparent access to diagnostic and commissioning data
## Competitive comparison: process

<table>
<thead>
<tr>
<th>Technology</th>
<th>PROFINET</th>
<th>EtherNet/IP</th>
<th>Modbus TCP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Media (Network) Redundancy</strong></td>
<td>Yes: SP, RSP, PN MRP, bumpless IRT, vendor specific</td>
<td>Yes: SP, RSP, DLR, vendor specific</td>
<td>Yes: SP, RSP, vendor specific</td>
</tr>
<tr>
<td><strong>Bumpless Redundancy</strong></td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Controller Redundancy</strong></td>
<td>Yes</td>
<td>Not on EtherNet/IP, Only with additional ODVA networks and hardware</td>
<td>No</td>
</tr>
<tr>
<td><strong>Device Redundancy</strong></td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>PROFINET for PA (Process Automation)</strong></td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Fieldbus Integration</strong></td>
<td>Many, including non PI networks (PROFIBUS, Interbus, ASI, DeviceNet, Foundation Fieldbus, Modbus, Hart, etc.)</td>
<td>CompoNet, DeviceNet, ControlNet, Modbus TCP</td>
<td>Modbus</td>
</tr>
</tbody>
</table>
Standard Ethernet devices can be connected at any point in the network
No closed real-time domain
**Competitive comparison: motion**

**Motion control comparison:** Modbus TCP is left out of this table as they do not support motion control.

<table>
<thead>
<tr>
<th>Technology</th>
<th>PROFINET</th>
<th>EtherNet/IP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Architecture</strong></td>
<td>Open System (simultaneous TCP)</td>
<td>Open System (simultaneous TCP)</td>
</tr>
<tr>
<td>IEEE 802.3 compliant</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Deterministic</td>
<td>Yes, Transparent clock &lt; 1μs jitter calculated jitter</td>
<td>No, Boundary clocks Accumulating jitter</td>
</tr>
<tr>
<td>Synchronized Peer-to-Peer</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>TCP/IP traffic</td>
<td>Yes</td>
<td>Yes, with caution</td>
</tr>
<tr>
<td>Throughput</td>
<td>150 Axes/1ms, 35 Axes/250μs</td>
<td>30 Axes/1ms</td>
</tr>
<tr>
<td>IEEE 1588</td>
<td>IEEE 1588v2 Built into PROFINET chips</td>
<td>IEEE 1588 Special switches needed</td>
</tr>
<tr>
<td>Automatic Timing Calculation</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
Depth of Features

- Speed, determinism
- Diagnostics
- Vertical
- PROFIenergy
- PROFIsafe
- I-Device
- Shared Device
- Wireless
- More
- Security (common problem and solution)
5 steps to determinism

1. Configuration
2. Real-time
3. Layer 2 (RT)
4. High Speed IO
5. Deterministic (IRT)

IRT channel
Standard channel
Cycle 1

PROFINET
HTTP SNM...
TCP/UDP
IP
Ethernet

IRT = Isochronous Real-time
DFP = Dynamic Frame Packing

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PROFINET and TCP/IP

PROFINET uses TCP/IP where it makes sense:
- Diagnostics
- Non time critical data
- Communicating with higher level IT systems

PROFINET real-time coexists with TCP/IP without restrictions

PROFINET DOES NOT USE STANDARD TCP/IP
Why not use TCP/IP for real-time?

Because it’s not fast enough and it’s not deterministic enough.

Here’s why:
Ethernet doesn’t cause delays

Node A

Switched
100Mbps Ethernet

Node B

64-byte packet

Node time
330

100m

100m

Transmission
5.12

Bandwidth
TCP/IP

31.25μsec

Scheduling

Real-Time

Node A

Node B

Switch latency
10

Transmission
5.12

Propagation
0.5

Transmission
5.12

Propagation
0.5

All times in μs

Source: University of Michigan, Industrial Ethernet Book, “Performance Metrics for Industrial Ethernet”
The device determines which path the telegram takes

**PROFINET RT (Real Time)**

- The device determines which path the telegram takes.

---

**Ethernet Frame**

- InterFrame Gap 12 Byte
- Preamble 7 Byte
- Sync 1 Byte
- MAC 6 Byte
- VLAN 2 Byte
- EtherType 2 Byte
- Frame ID 2 Byte
- Data 40*…1440 Bytes
- Cycle Counter 2 Byte
- Data Status 1 Byte
- Trans Status 1 Byte
- FCS 4 Byte

**Ethertype (type of protocol):**
- Ethertype (PN): 0x8892
- Ethertype (IP): 0x0800
- EtherType (ARP): 0x0806
- EtherType (IPV6): 0x86DD

---

**IEEE EtherType**

- IEEE EtherType 0x0800
- IEEE EtherType 0x8892

**TCP / UDP**

**IP**

**Real-time**

---

**TCP/IP**

- 31.25µsec
- Scheduling
- Bandwidth
- Real-Time
- TCP/IP

---

www.us.profinet.com
When you try to use all layers...

PROFINET is the enabling factor to achieve speed and determinism
When you try to use all layers...

PROFINET is the enabling factor to achieve speed and determinism.

Bandwidth Reservation for PROFINET IRT

- Communication system scheduling
  - Exact cycle synchronization
  - Separate time domains for Real-time and non-Real-time

IRT = Isochronous Real Time

![Diagram showing IRT channel and standard channel scheduling](image)

- Cycle 1
- Cycle 2
- Cycle n

e.g. 1 ms position controller clock cycle

<table>
<thead>
<tr>
<th>Synchronization</th>
<th>Isochronous (IRT) Data</th>
<th>Real-time (RT) Data</th>
<th>Open standard communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRT-Data</td>
<td>TCP/IP-Data</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

31.25 µsec Scheduling
Bandwidth
Real-Time TCP/IP
Every IRT device knows, when data arrives and where to send it

<table>
<thead>
<tr>
<th>Switch schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rec. port</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3*)</td>
</tr>
<tr>
<td>4*)</td>
</tr>
</tbody>
</table>

*) 100% free for TCP/IP

Switch must be IRT-aware
**Functional principle of synchronization**

- **IEEE 1588**
  - **Boundary Clock**
  - Master Clock → Boundary Clock → Boundary Clock → Slave Clock
  - Slave Port → Sync Ctrl.
  - Master Port → Local Time
  - Issue of cascading time control loops
  - Extension of start-up time
  - Used by EtherNet/IP CIPSync

- **PROFINET**
  - **Transparent Clock**
  - Master Clock → Transparent Clock → Transparent Clock → Slave Clock
  - Forwarding of Sync Message
  - Sync Ctrl. → Local Time
  - Only one control loop between Master clock and Slave clock
  - Usable in switched networks

---

*part IEEE 1588 V2, approved March 2008*
31.25 microsecond cycle

Scalable down to 31.25 µs!
PROFINET achieves industry requirements for speed and determinism using standard Ethernet by using these 5 steps:

1. Using TCP/IP where appropriate
2. Skipping it when necessary
3. Reserving bandwidth for higher performance
4. Scheduling traffic to ensure motion control needs
5. Fast Forwarding, Dynamic Frame Packing, and Fragmentation to achieve 31.25µsecond cycle times
Depth of Features

- Speed, determinism
- Diagnostics
- Vertical
- PROFlenergy
- PROFlsafe
- I-Device
- Shared Device
- Wireless
- More
- Security (common problem and solution)
Ethernet based systems can provide diagnostics on the Transport oriented layers (lower level) as well as Application based diagnostics (higher level). Picking the right protocol is important if you want a complete set of diagnostic capabilities.

Application Layer Diagnostics (For Example: PROFINET)
Provides PROFINET device specific diagnostics (module unplugged, wire break, IO status, Data records, etc.)

Transport Oriented Layers Diagnostics (For Example: SNMP, HTTP, LLDP)
Provides information about TCP, UDP, IP, Ethernet (link down, bandwidth, statistics, connections, etc.)
Device Diagnostic Information

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

Station: Failure in Device (e.g. Valve Station 2)

Slot: Failure in Module (e.g. Analog Input Slot 3)

Channel: Failure in Channel (e.g. Cable Break in Channel 2)

Network diagnosis:
IP-Address, Ping Location, Statistic

SNMP = Simple Network Management Protocol

Station name >>> Slot >>> Channel >> Channel type > Error information
Examples of Diagnostic Information

- The device monitors the Output Channels in order to discover a wire break (no current is flowing although the output is set to ‘1’)

- An analog Input has a range of 0..10V. An input voltage of 12V is detected and reported as overvoltage.

→ Diagnostic Information is not only "PROFINET related", but also helps in the application.
1. Diagnostics in the PLC
   - IO Device sends diagnostic to the IO Controller
   - Reaction to the failure directly in the PLC

2. Diagnostics to PC and HMI
   - IO Supervisor reads diagnostics directly from IO Devices
   - Visualization of failures on HMI / PC system
   - Diagnostics information stored and archived for analysis

Diagnostic information is there where it is needed
**Diagnostics and Switches**

- Network is operating normally
- The switch passes the PROFINET Diagnostic from the IO Device to the IO Controller
- The switch could be optionally configured as a PROFINET IO device

---

**Network Failure!**

- Switch is configured as a PROFINET IO Device (GSD)
- Switch reports Network failure as PROFINET Diagnostic to the IO Controller (1)
- Additional SNMP channel for Standard Information (2) – more later

---

[Left Diagram]

- IO Controller
  - DIgnostic Error
  - IO Device 1
  - IO Device 2

[Right Diagram]

- IO Controller
  - 1
  - Device Unreachable!
  - IO Device 3
  - IO Device 1
  - IO Device 2

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Ethernet based systems can provide diagnostics on the Transport oriented layers (lower level) as well as Application based diagnostics (higher level). Picking the right protocol is important if you want a complete set of diagnostic capabilities.

ISO/OSI Model: Where Diagnostics fit in

- **Layer 1**: Ethernet
- **Layer 2**: IP
- **Layer 3**: Layer 4
- **Layer 7**: Application

**Application Layer Diagnostics** (For Example: PROFINET)
- Provides PROFINET device specific diagnostics (module unplugged, wire break, etc.)

**Transport Oriented Layers Diagnostics** (For Example: SNMP, HTTP, LLDP)
- Provides information about TCP, UDP, IP, Ethernet (link down, bandwidth, statistics, connections, etc.)
### Benefit | Protocol | Description
--- | --- | ---
Standard tools for reading statistics and diagnostics | SNMP | Simple Network Management Protocol for network diagnostics
Web access to devices for configuration / diagnostics | HTTP | Hyper Text Transfer Protocol for Web services and browsing
Network Diagnostics Using **SNMP**

- **PROFINET uses SNMP**
  - PROFINET uses standard MIBs (Management Information Base MIB-II, LLDP Discovery MIB)
  - This MIB-II contains information about device name, IP address, location, status and statistics (examples include CRC errors, port status, bandwidth utilization, …)
Network diagnostics using HTTP

Easy access over the web (local or remote)
IO Controllers, IO Devices, proxies or switches can have web diagnostics implemented

Simple access
Regardless of location, even wireless
No engineering tool needed
### Benefit Protocol Description

Mapping the network topology and simple device replacement

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Protocol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mapping the network topology and simple device replacement</td>
<td>LLDP</td>
<td>Link Layer Discovery Protocol, IEEE 802.1AB</td>
</tr>
</tbody>
</table>

**How does it work...**

IT Standards for PROFINET Network Diagnostics
The Link Layer Discovery Protocol (LLDP) is a vendor-independent protocol and independent of the network structure.

Via LLDP, connected devices specify their identity and properties to their neighbors cyclically every few seconds. Ports, names, transmission rates, etc.

The information is stored in a local table (LLDP Discovery MIB).

Benefits of using LLDP include...

...topology information can later be read out with SNMP from the LLDP Discovery MIB

...simple device replacement can be achieved.

Example LLDP Table:

<table>
<thead>
<tr>
<th>Discovery MIB - Switch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port 1</td>
</tr>
<tr>
<td>Port 2</td>
</tr>
<tr>
<td>Port 3</td>
</tr>
<tr>
<td>Port 4</td>
</tr>
<tr>
<td>Port 5</td>
</tr>
<tr>
<td>...</td>
</tr>
</tbody>
</table>

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Use of standard Ethernet mechanisms
- LLDP
- SNMP

Topology diagnostics for devices
- Same modeling of Ports as I/O channels

Standard and topology view (offline / online)

Maintenance information

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How to replace a PROFINET device which has failed without a engineering tool?

- Devices with memory card
  - Transfer memory card to keep existing device name

- Devices without memory card
  - Using the PROFINET simple device replacement feature

Our Phoenix Contact Device failed and does not have a memory card. We need to replace it with a new device with “empty” device settings.
Simple Device Replacement

1. Device “I/O 3” fails
2. Device is replaced with new MAC address and empty name
3. Devices exchange LLDP
4. The neighbor sends a LLDP alias name to new device
5. Controller finds new device using DCP and LLDP alias name
6. Device addressed with DCP “Set name” from controller
7. IO Controller starts device and system is back online

Hello I am the switch! You are connected to my port 4! “Switch.P4”

Found you “Switch.P4”! Let me set your device name again to “I/O 3”!
Simple Device Replacement

- Siemens Wireless Access Point (WAP)
- Siemens Switch
- Siemens Safety Controller
- Siemens ET200S IO, IO-Link Master, PROFIsafe
- IO-Link Proximity sensor
- Power Supply
- HMI
- IO-Link Proxy
- Turck IO
- Phoenix Contact IO
- Illuminated Push Buttons
- Balluff IP67 IO
- www.us.profinet.com
Setting up PROFINET Simple Device Replacement in Engineering Tool
Use of Ethernet diagnostic tools

Network analysis with standard tools

- Debugging during development w/
  - Ethernet Sniffer
  - Wireshark – www.wireshark.org
  - PROFINET decoding is built in
  - Color filter available

Device Link and traffic detection with LEDs

- LED Display
- Simple connection test without configuration

DCP (Discovery and Configuration Protocol)
Connect Request
Parameterization
Real-Time I/O
## Competitive comparison: diagnostics

<table>
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<th>PROFINET</th>
<th>EtherNet/IP</th>
<th>Modbus TCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Management</td>
<td>(DCP, DHCP option, SNMP, LLDP, topology, options, naming concept, comprehensive diagnostics)</td>
<td>(DHCP, bootP, DHCP option 82, SNMP loop holes, vendor specific, limited network diagnostics, special switches very likely)</td>
<td>(limited to IT tools, SNMP loop holes, vendor specific, no built in network functions)</td>
</tr>
<tr>
<td>Comprehensive Diagnostics</td>
<td>Yes, Application and Network</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Diagnostics IO Status</td>
<td>Yes</td>
<td>No, IO only</td>
<td>No</td>
</tr>
<tr>
<td>Diagnostics Network Browser (can find IP or naming issues)</td>
<td>Yes, returns all PROFINET Devices and information</td>
<td>Limited to IT or vendor tools no common tool</td>
<td>Limited to IT or vendor tools no common tool</td>
</tr>
<tr>
<td>Diagnostics Topology</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>SNMP loop holes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Resources

- PROFINET Diagnostics Video
- PROFINET Diagnostics for PROFINET Webinar

www.us.profinet.com
Depth of Features

- Speed, determinism
- Diagnostics
- Vertical
  - PROFlenergy
  - PROFIsafe
  - I-Device
  - Shared Device
  - Wireless
  - More
- Security (common problem and solution)
How do I move information vertically

Stage 1: Definition of maintenance interface

ERP

MES

Interface defined in IEC62264

Interface defined by PROFINET

PAM

Controller & Field Devices

Enterprise Resource Planning

Manufacturing Execution System

Plant Asset Management

White paper: MES and PROFINET

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Depth of Features

- Speed, determinism
- Diagnostics
- Vertical
- PROFIenergy
- PROFIsafe
- I-Device
- Shared Device
- Wireless
- More
- Security (common problem and solution)
Agreement within a device family on how to use the PROFIBUS / PROFINET data by adding data structures, cyclic / acyclic services, behavior, parameterization, diagnosis, integration, etc.
Application Profiles

"Best Practice Patterns"

Profile Guidelines

- Cooperation with other organizations e.g. OPC, DriveCom, VDMA, OpenPLC, etc.
- Training (UML, Safety, Models, etc.)
- Tools

"Common Profiles"

- I&M Functions
- Redundancy
- Time Stamp
- PROFIsafe

PA Devices
- Water/waste water
- intellig. Pumps
- SEMI
- Remote I/O for PA
- Laboratory Devices

Robot /NC
- Encoder
- PROFI drive
- Fluid Power

FF, IEC 61804

SEMI

Interbus, CAN, etc.

Ident (Barcode, RFID)
- Weighing & Dosage
- Low Voltage Switchgear
- IO-Link
- Trains
- PROFI energy

PROFINET IO

PROFIBUS • PROFINET
NORTH AMERICA

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PROFlenergy Use Cases

- Switch off during short breaks
- Switch off during long breaks
- Switch off during unplanned breaks
- Reading of measured data
  - Provides a means of reducing or shutting off power when demand will be exceeded
## Competitive comparison

<table>
<thead>
<tr>
<th>Energy Management</th>
<th>PROFINET</th>
<th>EtherNet/IP</th>
<th>Modbus TCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production Pause savings</td>
<td>Yes</td>
<td>New</td>
<td>No</td>
</tr>
<tr>
<td>Data organization</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
Depth of Features

- Speed, determinism
- Diagnostics
- Vertical
- PROFIenergy
- PROFIsafe
- I-Device
- Shared Device
- Wireless
- More
- Security (common problem and solution)
PROFIsafe: How it works

PROFIsafe provides correct transmission of messages

“Black Channel”: ASICs, Links, Cables, etc. are not safety relevant

Non safety critical functions, like e.g. diagnosis

"PROFIsafe": Parts of the safety critical communications systems: Addressing, Watch Dog Timers, Sequencing, Signature, etc.

Safety relevant, but not part of the PROFIsafe-Profiles: Safety I/O and the Safety Control Systems
## Competitive comparison

<table>
<thead>
<tr>
<th>System</th>
<th>PROFINET</th>
<th>EtherNet/IP</th>
<th>Modbus TCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional Safety</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Safety for discrete, process, and motion</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Integrates AS-i Safety</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

www.us.profinet.com
Depth of Features

- Speed, determinism
- Diagnostics
- Vertical
- PROFIenergy
- PROFIsecure
- I-Device
- Shared Device
- Wireless
- More
- Security (common problem and solution)
How do I integrate controllers?

An IO controller can also be an IO device with IO controller functionality on the same interface.

- Allow local controllers in a modular architecture to communicate to a higher level station (main controller).
- Familiar IO access, without TCP/IP telegrams or proprietary methods.
- Simple and familiar IO interfacing of CPUs.
- Interfacing of CPUs in different projects.
- Integration among different controllers (manufacturers).
- Transmission of cyclic data (RT, IRT).
Depth of Features

- Speed, determinism
- Diagnostics
- Vertical
- PROFIenergy
- PROFIsecure
- I-Device
- Shared Device
- Wireless
- More
- Security (common problem and solution)
PROFINET offers shared device functionality
- Two Controllers can access the same device
- Flexible assignment of modules to different controllers

Shared device results in reduced costs, simplified architectures, can save on cabinet space, allowing optimized solutions
Depth of Features

- Speed, determinism
- Diagnostics
- Vertical
- PROFIenergy
- PROFIsafe
- I-Device
- Shared Device
- Wireless
- More
- Security (common problem and solution)
Wireless

- Long distance (RTU)
  - Long distances
  - Water/wastewater and oil patch applications
  - No standards

- Process Instruments
  - Short distances, battery powered, mesh
    - WirelessHART, ISA 100.11a

- Discrete Sensors and Actuators
  - Short distances, line-powered, mesh
  - Standards still evolving

- Backbone
  - Medium distances
  - Long-established standards

RTU = Remote Terminal Unit

PROFIBUS & PROFINET gateways to WirelessHART
PI developed a standard
PROFINET uses this

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PROFINET runs over these standard wireless technologies:

- IEEE 802.11 (b,g,a,h,n,ac) – Wireless LAN
- IEEE 802.15.1 – Bluetooth

Wireless is part of the PROFINET specification

- Many vendors
- Some IO devices have wireless built in

PROFIsafe is safety-certified over wireless using PROFINET as the transport mechanism
PROFINET – designed in, safety included

EtherNet/IP – multicasting complicates
Depth of Features

- Speed, determinism
- Diagnostics
- Vertical
- PROFlenergy
- PROFIsafe
- I-Device
- Shared Device
- Wireless

More

Security (common problem and solution)
Bumpless Redundancy
Fast Start Up
iPar Server
Proxies
Unmanaged switches
Application Profiles for
  Lab, trains, pumps, SEMI, robots, …
Depth of Features

- Speed, determinism
- Diagnostics
- Vertical
- PROFIenergy
- PROFIsecure
- I-Device
- Shared Device
- Wireless
- More

Security (common problem and solution)
PI and ODVA have security documents. Both rely on protecting the network itself.
Leadership

- PI created
  - Functional safety over the network using the black channel approach
  - Energy management covering production pauses and data organization
- PI advocated 2-port switches in devices when ODVA said it was a bad idea
- PI was first with redundant media, controllers, and devices
Wrapping Up
What is PROFINET?

PROFINET IS COFFEE
Industrial

- Not PROFIBUS wrapped in TCP/IP
- Designed for industry from start
  - Fast
  - Robust
  - Deterministic

Industrial
Scalable
Complete
Open
Fast
Flexible
Easy
Ethernet
Scalable (Don’t Fence Me In)

- Don’t settle for an 80% solution
- Eventually you will need more
  - Motion Control
  - Process Instrument
  - Safety over the bus
  - Connectivity to a production system
- And that will require:
  - New bus
  - New software
  - New training
- So…start with the 100% solution

PROFINET

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Finished (stable)
- Spec at version 2.3 for 2 years
- Work on “objects” continues

All application areas
- Discrete, process, motion, high speed

Depth of features
- Diagnostics
  - PROFIBUS-like + IT protocols
- Functional safety
- Energy management
- Fast startup
- … many more
Created and maintained by PI; not by any one company
PI members participate in Working Groups and as reviewers
Membership not required to make products
No contract to sign
Industrial
Scalable
Complete
Open
Fast
Flexible
Easy
Ethernet

How fast?

- TCP/IP
  - seconds
- Process instruments
  - 100’s of milliseconds
- Factory IO
  - ~10 milliseconds
  - <1 millisecond
- Motion control
  - <1 millisecond
- High speed IO, motion
  - 31.25 microseconds

How repeatable?

- called “jitter”
  - covers this whole range

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Flexible

- Start with PROFINET
  - Virtually unlimited address space
  - Lots of bandwidth
  - Standard wireless
  - Future-proof leveraging of Ethernet
  - Connectivity upwards
  - Connectivity peer-to-peer
  - Connect directly to IO

- For specialized needs:
  - Unusual device: PROFIBUS to PROFINET
  - Intelligent sensor: IO-Link to PROFINET
  - Simple sensor: AS-i to PROFINET
  - Process instrument: PROFIBUS PA (or FF) to PROFINET
  - Wireless process instrument: WirelessHART to PROFINET
  - Wireless discrete sensor: PI WSAN to PROFINET
  - Legacy fieldbus: Proxy to PROFINET
  - Legacy instrument: HART to PROFINET
Easy Device Replacement
Easy configuration
Automatic topology
Automatic timing calculations

Industrial
Scalable
Complete
Open
Fast
Flexible
Easy
Ethernet
Ethernet (Standard Unmodified)

- Standard Unmodified Ethernet
  - Conforms to IEEE802.3
- Media includes
  - Copper
  - Fiber
  - Wireless
- Uses standard Ethernet switches*

Industrial
Scalable
Complete
Open
Fast
Flexible
Easy
Ethernet

www.us.profinet.com
Industrial Ethernet Capability Matrix
## Industrial Ethernet Functionality

<table>
<thead>
<tr>
<th>Technology</th>
<th>PROFINET</th>
<th>Ethernet/IP</th>
<th>Modbus TCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethernet IO</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Motion Control</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Peer-to-peer</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Process profile</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Safety</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Security Guideline</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Buses integrated</td>
<td>many*</td>
<td>DeviceNet ControlNet</td>
<td>Modbus</td>
</tr>
</tbody>
</table>

*Y = shipping  N = no plans known

*Available= PROFIBUS DP, PROFIBUS PA, Interbus, DeviceNet, Serial, Modbus, AS-i, HART, IO-Link, FF
Planned= CC-Link, more*

source: organization websites
## Industrial Ethernet Functionality

<table>
<thead>
<tr>
<th>Technology</th>
<th>PROFINET</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Communication Model</td>
<td>Provider-Consumer</td>
<td>Provider-Consumer</td>
<td>Client-Server</td>
</tr>
<tr>
<td>Real-time Protocol Options</td>
<td>IEEE 802.3 (Layer 2) primary, UDP/IP option, TCP/IP option</td>
<td>UDP/IP (Layer 4)</td>
<td>TCP/IP (Layer 4)</td>
</tr>
<tr>
<td>Jitter with IO</td>
<td>++ (low)</td>
<td>- (high)</td>
<td>-- (higher)</td>
</tr>
<tr>
<td>Protocol Standard</td>
<td>IEC 61158</td>
<td>IEC 61158</td>
<td>IEC 61158</td>
</tr>
<tr>
<td>Transmission Type</td>
<td>Unicast primary, Multicast optional</td>
<td>Multicast primary, Limited Unicast</td>
<td>Unicast only</td>
</tr>
<tr>
<td>COTS switch possible?</td>
<td>Yes</td>
<td>Not recommended</td>
<td>Yes</td>
</tr>
<tr>
<td>Switch requirements</td>
<td>100Mbit/s or faster, full duplex for IO traffic</td>
<td>Full Duplex IGMP Snooping, One IGMP Query, Wire speed For IO traffic</td>
<td>No special requirements</td>
</tr>
<tr>
<td>IP Address Assignment</td>
<td>Automatic w/ PN DCP DHCP optional</td>
<td>DHCP and Managed</td>
<td>DHCP and Managed</td>
</tr>
</tbody>
</table>

www.us.profinet.com
### Industrial Ethernet Functionality

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</tr>
</thead>
<tbody>
<tr>
<td>Device Names</td>
<td>Mandatory</td>
<td>Optional</td>
<td>Optional</td>
</tr>
<tr>
<td>Simple Device Replacement</td>
<td>Yes, no tools, support in all devices</td>
<td>No, DHCP Option 82 Managed, Need special switch/server with DHCP Option 82 support</td>
<td>No</td>
</tr>
<tr>
<td>Network Management</td>
<td>(DCP, DHCP option, SNMP, LLDP, topology, options, naming concept, comprehensive diagnostics)</td>
<td>(DHCP, bootP, DHCP option 82, SNMP loop holes, vendor specific, limited network diagnostics, special switches very likely)</td>
<td>(limited to IT tools, SNMP loop holes, vendor specific, no built in network functions)</td>
</tr>
<tr>
<td>Comprehensive Diagnostics</td>
<td>Yes, Application and Network</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Diagnostics IO Status</td>
<td>Yes</td>
<td>No, IO only</td>
<td>No</td>
</tr>
<tr>
<td>Diagnostics Network Browser</td>
<td>Yes, returns all PROFINET Devices and information</td>
<td>Limited to IT or vendor tools no common tool</td>
<td>Limited to IT or vendor tools no common tool</td>
</tr>
<tr>
<td>Technology</td>
<td>PROFINET</td>
<td>EtherNet/IP</td>
<td>Modbus TCP</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>-------------</td>
<td>-------------</td>
<td>------------</td>
</tr>
<tr>
<td>Diagnostics Topology</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>SNMP loop holes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Energy Management (PROFIenergy)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Safety</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Fast Start Up</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Wireless</td>
<td>Yes, IEEE 802.11 and Bluetooth</td>
<td>Yes, IEEE 802.11 (with caution when using multicast)</td>
<td>Yes</td>
</tr>
<tr>
<td>Performance</td>
<td>++</td>
<td>-</td>
<td>--</td>
</tr>
<tr>
<td>Automatic Timing Calculation</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Fieldbus Integration</td>
<td>Many, including non PI networks (PROFIBUS, Interbus, ASI, DeviceNet, Foundation Fieldbus, Modbus, Hart, etc.)</td>
<td>CompoNet, DeviceNet, ControlNet, Modbus TCP</td>
<td>Modbus</td>
</tr>
</tbody>
</table>
## Industrial Ethernet Functionality

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</tr>
</thead>
<tbody>
<tr>
<td>Media (Network) Redundancy</td>
<td>Yes SP, RSP, PN MRP, bumpless IRT, vendor specific</td>
<td>Yes SP, RSP, DLR, vendor specific</td>
<td>Yes SP, RSP, vendor specific</td>
</tr>
<tr>
<td>Bumpless Redundancy</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Controller Redundancy</td>
<td>Yes</td>
<td>Not on EtherNet/IP, Only with additional ODVA networks and hardware</td>
<td>No</td>
</tr>
<tr>
<td>Device Redundancy</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Vertical Integration</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Devices can report maintenance information</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Peer to Peer communications</td>
<td>Yes with CBA, I-Device, PN/PN Couplers, TCP/UDP option for programmed communication</td>
<td>Yes only TCP/IP, programmed communication</td>
<td>Yes only TCP/IP, programmed communication</td>
</tr>
</tbody>
</table>
## Industrial Ethernet Functionality

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>PROFINET for PA</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>(Process Automation)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shared Device</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>iPar (optional parameter server)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>TCI – Tool Calling Interface</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>(allows vendor tools to be entered</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>from the PROFINET configuration /</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>engineering tool)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Phoenix Contact PROFINET Strengths

Organizational
- Active since beginning
  - Developing PROFINET
  - Continuing in Working Groups
- On Board of Directors of PI North America

Products
- Developed PROFINET ASIC
- PROFINET IO
- PROFINET controllers
- Ethernet switches that are PROFINET IO devices
- Redundancy of media and controllers
Competitive Resources from the PROFIblog

- Pegging the FUD Meter (8/27/07)
- The Fickle Finger of FUD* (10/30/07)
- FUD Dissection Part 1
- FUD Dissection Part 2
- Responding to FUD with FCN
- The Big Lie: SUE (12/17/08)
- The EtherNet/IP FUD-sicle – Melted Again (7/31/12)
Resources: PROFINEWS App
Welcome
November 10, 2014 | Written by Carl Henning

In only a few days the SPS/IPC/Drives Show will open its doors in Nuremberg. One highlight of this year’s booth will be a new manufacturing model that clearly demonstrates the technologies. The model was designed and built in a cooperative partnership with the TU Darmstadt and will include PROFINET products from many different vendors. For ex […]

PI Booth at SPS/IPC/Drives Show
November 10, 2014 | Written by Carl Henning

PI (PROFIBUS & PROFINET International) and 100 of its members will present devices and technologies on all aspects of PROFIBUS, PROFINET, and IO-Link at the SPS/IPC/Drives trade fair in Nuremberg, Germany. PI will be part of Europe’s leading exhibition for electrical automation at a new location in hall 2, stand 220 and 221. From November […]
Resources: Webinars

- Introduction to Ethernet for Control Engineers
- PROFINET
- Industrial Wireless
- Industrial Ethernet Diagnostics
- PROFIBUS in the Process Industries
- PROFIsafe
- PROFIenergy
- Completing a PROFINET Project

More
Resources: One-day training classes

PROFINET
Los Angeles, Feb 3
Dallas, Feb 19
Atlanta, Mar 4
Houston, Mar 19
Richmond, Apr 2
St. Louis, Apr 16
Newark, Apr 28
Pittsburgh, May 14

PROFINET
Denver, June
Minneapolis, June 4
Chicago, Aug
Tampa, Oct
Detroit, Oct
Louisville, Nov
Raleigh, Nov
Seattle, Dec

For the latest schedule and to register visit www.us.profinet.com
PROFIBUS or PROFINET Certified Network Engineer class
- Full week in Johnson City, TN
- Also available on-site
- Theoretical plus hands-on
- Certification requires passing both a theoretical and practical exam
- Certified Network Engineers are listed at www.profibus.com
- Details at certified.ProfiInterfaceCenter.com
- Register online
PROFINET Developer Workshop

- Provide background and knowledge to design and test a PROFINET product efficiently.
- How PROFINET can meet the specific application’s needs (ex. GSDML file development).
- Tailored to customer’s level of experience and education. Builds upon the PROFINET Certified Network Engineer curriculum.
- Hands-on experience and expert instruction on how to use the PROFINET test software suite.
- Small or large groups accommodated, both at the PIC or on the customer’s site.
Resources: Books

Order

Order

Order

Order
Resources: Social Media

- YouTube: PROFitelevision
- LinkedIn
- Twitter: MinutePROFINET
- YouTube: ThePROFIblogger
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Marsha Bryant, Administrator

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