PROFINET vs. EtherNet/IP

You can download this presentation from us.profinet.com/cbp/

Carl Henning
PI North America
While I strive for accuracy in describing EtherNet/IP, I’m not an EtherNet/IP expert.

Information in this presentation is drawn from public sources like organization websites.

Consider this as Carl’s opinion of the comparison.
The Organization
  - Global support

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

Depth of features
  - Determinism, diagnostics, PROFIenergy, PROFI safe, 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)

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
The Organizations: Activities

<table>
<thead>
<tr>
<th>Activity</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
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

www.us.profinet.com
## Competitive comparison: discrete IO

<table>
<thead>
<tr>
<th>Technology</th>
<th>PROFINET</th>
<th>EtherNet/IP</th>
<th>Modbus TCP</th>
</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 (Layer 4) 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>Device Names</td>
<td>Mandatory</td>
<td>Optional</td>
<td>Optional</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>
Resources

- Marketing flyer: PROFINET
- System description: PROFINET
- Guidelines
  - Design
  - Install
  - Commission
- Web-based training
- MinutePROFINET
- PROFINET IO Video
- PROFINET Certified Network Engineer class

www.us.profinet.com
PROFINET in Process

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>Media (Network) Redundancy</td>
<td><strong>Yes</strong> SP, RSP, PN MRP, bumpless IRT, vendor specific</td>
<td><strong>Yes</strong> SP, RSP, DLR, vendor specific</td>
<td><strong>Yes</strong> SP, RSP, vendor specific</td>
</tr>
<tr>
<td>Bumpless Redundancy</td>
<td><strong>Yes</strong></td>
<td><strong>No</strong></td>
<td><strong>No</strong></td>
</tr>
<tr>
<td>Controller Redundancy</td>
<td><strong>Yes</strong></td>
<td><strong>Not on EtherNet/IP, Only with additional ODVA networks and hardware</strong></td>
<td><strong>No</strong></td>
</tr>
<tr>
<td>Device Redundancy</td>
<td><strong>Yes</strong></td>
<td><strong>No</strong></td>
<td><strong>No</strong></td>
</tr>
<tr>
<td>PROFINET for PA (Process Automation)</td>
<td><strong>Yes</strong></td>
<td><strong>No</strong></td>
<td><strong>No</strong></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>
System description: PROFINET
PROFINET in Process Automation webinar
White paper
MinutePROFINET

Compared to discrete/factory automation, process automation:
- cycle times ~ 100 ms
- 100% uptime required
- production runs 24/7
- upwards of 100,000 I/O signals
Resources: PROFIBUS PA

- **Marketing Flyer: PROFIBUS for Process Automation**
- **System Description: PROFIBUS Technology and Application**
- **Video series - PROFIBUS Dialogues**
  - Standardization
  - Explosion Prevention
  - Life Cycle Management
  - Device Diagnostics/Condition Monitoring
- **Webinar series**
  - Part 1
  - Part 2
  - Part 3
  - Part 4
Standard Ethernet devices can be connected at any point in the network
No closed real-time domain
### Competitive comparison: motion control

**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>Architecture</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>
Marketing Flyer: Drives & PROFIdrive
PROFIdrive System Description
PROFIdrive webcast
PROFIdrive Slide set
White paper
MinutePROFINET Performance 3
MinutePROFINET Performance 4
PROFIblog: PROFIdrive
Speed, determinism

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

- Configuration
- Real-time Layer 2 (RT)
- High Speed IO
- Deterministic
- Bandwidth Reservation (IRT)

IRT channel
Standard channel
Cycle 1

PROFINET
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:

- **UNWELCOME DELAYS**

![Diagram showing TCP/IP Suite and Ethernet delays](image)
Ethernet doesn’t cause delays

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

Scheduling
- IRT channel
- Standard channel
- IRT channel
- Standard channel
- IRT channel

Cycle 1 → Cycle 2 → Cycle n

e.g. 1 ms position controller clock cycle

Synchro-

ization

Isochronous (IRT) Data

IRT-Data

Real-time (RT) Data

RT - Data

Open standard communication

TCP/IP-Data

31.25μsec

Real-Time

Scheduling

Bandwidth

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
IEEE1588
Boundary Clock

PROFINET
Transparent Clock*

*part IEEE 1588 V2, approved March 2008

- Issue of cascading time control loops
- Extension of start-up time
- Used by EtherNet/IP CIPSync

- Only one control loop between Master clock and Slave clock
- Usable in switched networks
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
- PROFIenergy
- PROFIsecure
- 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.)*
Logical model provides quick error localization

Diagnostic information is structured hierarchically

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

Network diagnosis:
IP-Address, Ping Location, Statistic

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

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

SNMP = Simple Network Management Protocol
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.
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.
## IT Standards f/PROFINET Network Diagnostics

### Benefit

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Protocol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard tools for reading statistics and diagnostics</td>
<td>SNMP</td>
<td>Simple Network Management Protocol for network diagnostics</td>
</tr>
<tr>
<td>Web access to devices for configuration / diagnostics</td>
<td>HTTP</td>
<td>Hyper Text Transfer Protocol for Web services and browsing</td>
</tr>
</tbody>
</table>

How does it work...

www.us.profinet.com
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 | LLDP | Link Layer Discovery Protocol, IEEE 802.1AB
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 - Empty -</td>
</tr>
<tr>
<td>Port 2 I/O 2 – Port 2 – IO Device</td>
</tr>
<tr>
<td>Port 3 I/O 3 – Port 1 – IO Device</td>
</tr>
<tr>
<td>Port 4 PLC – Port 1 – IO Controller</td>
</tr>
<tr>
<td>Port 5 I/O 1 – Port 2 – IO Device</td>
</tr>
<tr>
<td>… ...</td>
</tr>
</tbody>
</table>

Diagram of a network layout with annotations for ports and devices connected through LLDP.
- 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
How to replace a PROFINET device which has failed without using an 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
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

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

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

I/O 1
I/O 2
I/O 3
I/O 4

Switch

P1
P2
P3
P4
P5

LLDP

LLDP Alias Name “Switch.P4”
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>
<thead>
<tr>
<th>Technology</th>
<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,</td>
<td>(DHCP, bootP, DHCP option 82, SNMP loop holes, vendor specific,</td>
<td>(limited to IT tools, SNMP loop holes, vendor specific, no built</td>
</tr>
<tr>
<td></td>
<td>comprehensive diagnostics)</td>
<td>limited network diagnostics, special switches very likely)</td>
<td>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>(can find IP or naming issues)</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>
</tbody>
</table>
Resources

- PROFINET Diagnostics Video
- PROFINET Diagnostics for PROFINET Webinar
Depth of Features

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

Stage 1: Definition of maintenance interface

Enterprise Resource Planning

MES

PAM Controller & Field Devices

Production Quality Maintenance Inventory

MES

Interface defined in IEC62264

Interface defined by PROFINET

Enterprise Resource Planning

Manufacturing Execution System

Plant Asset Management

White paper: MES and PROFINET
Depth of Features

- Speed, determinism
- Diagnostics
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- I-Device
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- 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
  - IEC 62390
  - Data types
  - Diagnosis
  - Models

"Common Profiles"
- I&M Functions
- Redundancy
- Time Stamp
- PROFIsafe

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

**PA Devices**
- Water/waste water
- intellig. Pumps
- SEMI
- Remote I/O for PA
- Laboratory Devices
- Robot/NC
- Encoder
- PROFI drive
- Fluid Power

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

**PROFINET IO**
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>

*PROFINET, EtherNet/IP, and Modbus TCP are protocols used in industrial automation.*
PROFlenergy Resources

- PROFlenergy flyer
- Video: What does PROFlenergy mean?
- MinutePROFINET: What is PROFlenergy
- White Paper: “The PROFlenergy Profile”
- White Paper: “Get Energy Costs under Control”
- White Paper: “Assessing PROFlenergy’s potential”
- Blog Report with videos: “PROFlenergy”

www.us.profinet.com
Depth of Features

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

- Marketing Flyer: PROFIsafe
- System Description: PROFIsafe Technology and Application
- PROFItelevision: Safety with PROFINET
- Application Story: KUKA Reduces Machine Safety Components
- PROFIsafe webinar
- Safety, the Movie
- www.profisafe.net
Depth of Features

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

www.us.profinet.com
PROFINET over wireless backbones

- 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
Competitive Comparison: wireless

- PROFINET – designed in, safety included
- EtherNet/IP – multicasting complicates
Resources

- **Industrial Wireless Networking** Webinar
- **Four kinds of wireless** blog post
- **PROFINET Certified Network Engineer** class

More App stories

- **Disney Toy Story Midway Mania**
- **Disney Radiator Springs Racers**
- **Swedish Tower**
- **Steel Industry**

![Disney Toy Story Midway Mania](image1)

![Steel Industry](image2)
Depth of Features

- Speed, determinism
- Diagnostics
- Vertical
- PROFlenergy
- PROFI safe
- 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
- PROFlenergy
- PROFIsafe
- I-Device
- Shared Device
- Wireless
- More
- Security (common problem and solution)
PI and ODVA have security documents
Both rely on protecting the network itself
Automation World/Belden webinar
Control Engineering: Were you just hacked?
www.isssource.com
www.SCADAhacker.com
Eric Byres’ blog
“Protecting ICSs from Electronic Threats”
Part 1
Part 2
Part 3
us-cert.gov/control_systems
MacAfee
PROFINET Security Guideline
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; now they also advocate them

PI was first with redundant media, controllers, and devices
Wrapping Up
PROFINET IS COFFEE
Not PROFIBUS wrapped in TCP/IP

Designed for industry from start

Fast

Robust

Deterministic
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 $\uparrow$
  - New training
- So…start with the 100% solution
PROFINET
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
How fast?

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

How repeatable?

- TCP/IP: seconds
- Process instruments: 10's of milliseconds
- Factory IO: <1 millisecond
- Motion control: <1 microsecond
- High speed IO, motion: 31.25 microseconds (called “jitter”)

Industrial Scalable Complete Open Fast Flexible Easy Ethernet
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

Industrial
Scalable
Complete
Open
Fast
Flexible
Easy
Ethernet
Simple Device Replacement
Easy configuration
Automatic topology
Automatic timing calculations
Ethernet (Standard Unmodified)

- Standard Unmodified Ethernet
  - Conforms to IEEE802.3
- Media includes
  - Copper
  - Fiber
  - Wireless
- Uses standard Ethernet switches*
# 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
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<th>PROFINET</th>
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<th>Modbus TCP</th>
</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>
## Industrial Ethernet Functionality

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<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 (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>
</tbody>
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<tbody>
<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 (PROFInergy)</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>
<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>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>
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</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 from the PROFINET configuration / engineering tool)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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)
- PROFINET versus EtherNet/IP (2/24/15)
Resources: PROFINEWS App

First PROFINET Test Lab in China

China has its first PROFINET Test Lab. Here's PI Chairman Karsten Schneider presenting Mr. Ouyang Jinsong, Director of ITEC, with the Accreditation Certificate at the recent PI-China Conference.

SPS/IPC/Drives Follow Up

PROFINES Editor Geoff Hodgkinson fills in the background to our Ethernet in the Field story published during the Fair. It's all about railways, signalling and cables.

Choosing an Industrial Ethernet

How do you choose an automation networking protocol? PI North America's Michael Bowne offers his 7 steps to success and says "This guide is here to help!"
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 [...]
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
<table>
<thead>
<tr>
<th>City</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles</td>
<td>Feb 3</td>
</tr>
<tr>
<td>Dallas</td>
<td>Feb 19</td>
</tr>
<tr>
<td>Atlanta</td>
<td>Mar 4</td>
</tr>
<tr>
<td>Houston</td>
<td>Mar 19</td>
</tr>
<tr>
<td>Richmond</td>
<td>Apr 2</td>
</tr>
<tr>
<td>St. Louis</td>
<td>Apr 16</td>
</tr>
<tr>
<td>Newark</td>
<td>Apr 28</td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>May 14</td>
</tr>
<tr>
<td>Minneapolis</td>
<td>June 4</td>
</tr>
<tr>
<td>Denver</td>
<td>June</td>
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<tr>
<td>Chicago</td>
<td>Aug</td>
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<tr>
<td>Tampa</td>
<td>Oct</td>
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<tr>
<td>Detroit</td>
<td>Oct</td>
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<tr>
<td>Louisville</td>
<td>Nov</td>
</tr>
<tr>
<td>Raleigh</td>
<td>Nov</td>
</tr>
<tr>
<td>Seattle</td>
<td>Dec</td>
</tr>
</tbody>
</table>

For the latest schedule and to register visit [www.us.profinet.com](http://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 Catching the Process Fieldbus
Order PROFIBUS Pocket Guide
Order The New Rapid Way to PROFIBUS DP
Order Industrial Communication with PROFINET
Resources: Social Media

- PROFIBlog
- Facebook
- YouTube
- LinkedIn
- Twitter
- PROFItelersion
- MinutePROFINET
- ThePROFIblogger

www.us.profinet.com
Resources: People

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Marsha Bryant, Administrator

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John Swindall, PROFIBUS Systems Engineer