Overview and Applications of PROFINET

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What exactly is PROFINET?

- PROFINET is an open Industrial Ethernet standard developed by the PROFIBUS Organisation.

- PROFINET
  - is completely standard Ethernet (IEEE802.3).
  - operates at 100Mbit/s over twisted-pair copper or fibre-optic cables,
  - makes use of TCP/IP and other IT standards for non-real-time communications (i.e. configuration and parameters).
  - Provides a “real-time” channel for time-critical communications (i.e. process data)

- PROFINET is NOT PROFIBUS over Ethernet!

- However, PROFINET is well thought out to incorporate the requirements of modern systems based on the lessons learned from PROFIBUS.
PROFINET Scope and Application Areas

- Network Engineering and Maintenance
- Component Based Automation
- Integration with Fieldbus
- Deterministic real-time operation
- Wireless
- Safety and Security
- WEB integration
- Asset Management
- Manufacture materials handling storage
- Motion Control
- Process Control

Decentralized Peripherals

Intelligent Automation
PROFINET IO

• PROFINET IO provides decentralised peripherals using Ethernet connection and the PROFINET communication protocol.

• PROFINET IO uses Real-Time and Non Real-Time communications.

• PROFINET makes use of relevant TCP/IP protocols for setup, configuration and maintenance functions:
  - DHCP – Dynamic Host Configuration Protocol,
  - DNS – Domain Name Service,
  - SNMP – Simple Network Management Protocol,
  - ARP – Address Resolution Protocol,
  - HTTP – Web page access, and lots more!
PROFINET stack (OSI model):

7 - Application Layer
6 - Presentation Layer
5 - Session Layer
4 - Transport Layer
3 - Network Layer
2 - Data Link Layer
1 - Physical layer

Non time-critical communication

Real-time communication

PROFINET Application Layer
TCP/UDP
IP
PROFINET Real-time channel
Standard Fast Ethernet
IEEE802.3

Network
PROFIBUS OSI Model

OSI model:

- Application (7)
- Layers (3) to (6) not used in fieldbus systems
- Data Link (2)
- Physical (1)

FMS

- Fieldbus Message Specification

DP

- DP cyclic functions (DPV0)
  - also DPV1, DPV2 extensions

PA

- Fieldbus Data Link (FDL)

- RS485 / Fibre-Optic

- MBP (IEC61158-2)
PROFINET IO

- The TCP/IP channel is used for non-time critical tasks.
  - Downloading of configuration, parameters,
  - Diagnostics,
  - Device management information, etc.
- The Real-Time channel is used for time-critical data:
  - Cyclic process data,
  - Alarms and critical messages,
  - Communication monitoring.
- The PROFINET application layer protocol is defined in the International Fieldbus standard IEC61158 (type 10).
PROFINET Devices

- **IO-Controller (PLC)**
  - Equivalent to a PROFIBUS master Class-I
  - Configuration
  - Process data
  - Alarms

- **Field Device (IO-Device)**
  - Equivalent to a PROFIBUS slave

- **PROFINET Supervisor (Engineering tool)**
  - Equivalent to a PROFIBUS master Class-II
  - Diagnostics
  - Status
  - Parameters

- Ethernet
PROFINET I/O

• The PROFINET IO device model is similar to that used in PROFIBUS.
• Based on a slots with plug-in modules.
• However the base module has a PROFINET interface rather than PROFIBUS
PROFINET IO

- Many features that have been developed for PROFIBUS devices have been directly incorporated into PROFINET:
  - Standardised module and channel-related diagnostics,
  - Alarm and status information,
  - Identification and Maintenance (I&M) functions,
  - Time stamping,
  - Highly deterministic process cycle timing (Isochronous),
  - Device description file (GSD) with configuration data for the device and available modules - PROFINET uses XML.
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Real-Time Operation

• What does “Real-Time” mean?
  - A real-time control system responds in a deterministic manner within a time which is short compared to the plant response time.
  - i.e. it depends on the application!

• Standard communications (IT)
  - requires a response in the order of ~100ms.

• Factory automation
  - requires a response time in the order of ~10ms.

• Motion control
  - requires a response time in the order of ~1ms with a jitter <1μs.
Real-Time Operation

- PROFINET makes use of:
  - TCP/IP for standard communications, achieving response times reliably less than 100ms.
  - A Real-Time, RT, channel for I/O communications, achieving reliable cycle times < 10ms with <1ms jitter.
  - Isochronous Real-Time, IRT, channel for highly deterministic performance (e.g. servos robotics NC), achieving reliable cycle times < 1ms with <1μs jitter.
- RT and IRT communications are totally compatible with TCP/IP.
  - Since the information is transmitted as a standard Ethernet package.
Real-Time Operation

• PRIFINET IRT complies with IEEE 1588 - “Precision clock synchronization protocol for networked measurement and control systems”.

• However this not always good enough!

• PROFINET extensions to IEEE 1588 provide better accuracy with:
  - Automatic determination and compensation of the network transmission time.
  - Resulting in less than 1µs jitter at 100Mbit/s.
Isochronous Real-Time Performance

- IRT traffic: <1μs jitter
- RT traffic: 15% jitter
- TCP/IP traffic: 100% jitter
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Integration with Fieldbus

- Over 30 million PROFIBUS devices are currently installed worldwide.
- This investment is protected with PROFINET for both manufacturers and end-users.
- PROFINET provides a transparent interface with PROFIBUS via a “Proxy”.
- The Proxy is a PROFINET IO device on one side and a PROFIBUS master on the other.
- PROFIBUS Configuration is integrated into the PROFINET configurator and is downloaded via Ethernet.
Integration with Fieldbus

PROFINET

PROXY

PROFIBUS DP

PROFIBUS PA

INTERBUS-S

PROXY

Other fieldbusses?
PROFINET Scope

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Component Based Automation

• Component Based Automation is a modular architecture for distributed control.
• Based upon an “object oriented approach” to distributed automation.
• Component Based Automation provides a scalable architecture for dealing with complex distributed control systems.
Component Based Automation

- Consider a manufacturing application consisting of a number of machines from different vendors.
- Each will incorporate a local control system to automate the machine.
- These intelligent machines must communicate in order to schedule and control production.
Component Based Automation

- The OEM develops the application software for their device.
- And creates an “application specific” component
- With an agreed standardised interface.
Component Based Automation

- Components can be exercised and tested by the machine vendor separately from the final application.
- Software components are then “wired” together to build the plant control system:
Component Based Automation

1. Create components
2. Import components into library
3. Link components

Bottom up development:

Component description
Vendor A
Vendor B
Vendor C

Project program

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Component Based Automation

- The component software connection is independent of the communication connections:
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Functional Safety with PROFINET

- PROFINET also offers safety oriented communication that allows for integrating safety oriented components.
- A second 'safety fieldbus' is not necessary.
- ProfiSafe V2 is certified according to IEC61158 Safety Integrity Level 3 (SIL3).
- ProfiSafe is a profile that can run over PROFIBUS or PROFINET.
• PROFIsafe V2 provides functional safety for both PROFIBUS and PROFINET systems.
• Suitable for use in SIL3 applications.
Industrial Acceptance and Applications

• PROFINET builds on the success of PROFIBUS and ensures a future for both.

• PROFINET has been in development for about 10 years.

• Take up of Industrial Ethernet has been slower than initially predicted.

• PROFIBUS is still growing exponentially - currently over 30 million devices installed.

• Over 2 million PROFINET devices are currently installed - currently growing at about 40% per year!
In 2004, AIDA, a consortium of the big four European automotive manufactures announced adoption of PROFINET as the industry standard.

The main reasons for this decision were reported to be:
- The integration of safety-related information,
- The simple integration of existing PROFIBUS and Interbus systems.
Some Myths about PROFINET

• PROFIBUS runs at up to 12Mbit/s, whereas PROFINET runs at 100Mbit/s. Therefore PROFINET is about 8 times faster than PROFIBUS. NOT TRUE!
  - PROFINET gives very similar performance to PROFIBUS.

• PROFINET will replace PROFIBUS in the next five years. NOT TRUE!
  - PROFINET will replace some PROFIBUS DP devices, but PROFIBUS PA will continue.
  - Both DP and PA will be supported for many years to come.
Some Myths about PROFINET

• PROFINET is not standard Ethernet
  NOT TRUE!
  - PROFINET always uses completely standard Ethernet. It just doesn’t always use TCP/IP protocols – only for not time critical communications.

• PROFINET systems can be maintained by out IT people.
  TRUE, BUT NOT A GOOD IDEA!
  - PROFINET is much more than just an IT network. Real time determinism, reliability, device diagnostics and security are all much more important than on IT systems.
PROFINET problems

• It is widely accepted that 90% of all PROFIBUS problems are caused by poor layout and installation.
• PROFINET will generally reduce these physical-layer problems because all Ethernet wiring is point-to-point (only two devices on a cable).
• However, it will not eliminate wiring problems.
  - We will still see problems with routing, interference pickup, grounding etc. etc.
• Software problems may be more common since the range of protocols used is very extensive.
• The problems associated with Industrial Ethernet systems are quite different to those in IT.
  - people with IT experience need additional training.