Overview and Applications of PROFINET

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Outline of Presentation

- What exactly is PROFINET?
- Scope of PROFINET.
- PROFINET I/O.
- Real-time performance.
- Integration with fieldbus.
- Component Based Automation.
- Safety and Security.
- Industry acceptance and applications.
- Practical Demonstration of PROFINET IO
What exactly is PROFINET?

- PROFINET is an open Industrial Ethernet standard developed by the PROFINET Organisation.
- PROFINET
  - is completely standard Ethernet (IEEE802.3).
  - operates at 100Mbit/s over twisted-pair copper or fibre-optic cables,
  - exclusively uses switches and full duplex operation to completely eliminate collisions,
  - makes use of TCP/IP, XML and other IT standards.
  - is “real-time” and deterministic,
- PROFINET is well thought out to incorporate all the requirements of automation and control systems.
PROFINET Scope

- Network Engineering and Maintenance
- Component Based Automation
- Decentralized Periphery
- Integration with Fieldbus
- Deterministic real-time operation
- WEB integration
- Safety and Security
- Asset Management
- Manufacture materials handling storage
- Motion Control
- Process Control
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:
  - DHCP - Dynamic Host Configuration Protocol,
  - DNS - Domain Name Service,
  - SNMP - Simple Network Management Protocol,
  - ARP - Address Resolution Protocol,
  - ICMP - Internet Control Message Protocol, etc
PROFINET stack (OSI model):

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

Network

Non time-critical communication

Real-time communication

Standard Fast Ethernet

IEEE802.3

TCP/UDP

PROFINET Real-time channel

PROFINET Application Layer
PROFINET IO

• The Standard 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 IO devices

IO-Controller
E.g. PLC running application program
- Configuration
- Control/monitoring
- Alarms

PROFINET Supervisor
E.g. PC or laptop running engineering tool application
- Diagnosis
- Status/Control
- Parameters

Ethernet

IO-Device
E.g. Field device with inputs/outputs
• The PROFINET IO device model is similar to that used in PROFIBUS.
• Based on a slots with plug-in modules.
• Each slot can have sub slots.
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,
  - Device description file (GSD) with configuration data for the device and available modules - PROFINET uses XML.
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- Manufacture
- Materials handing
- Storage
- Motion
- Control
- Process
- Control

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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
  - 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 < 100ms.
  - A Real-Time, RT, channel for I/O communications, achieving cycle times < 10ms with <1ms jitter.
  - Isochronous Real-Time, IRT, channel for highly deterministic performance (drives and servos), achieving cycle times < 1ms with <1µs jitter.
  - IRT uses communications based on IEEE802.1Q VLAN technology.

• RT and IRT communications are totally compatible with TCP/IP.
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.
  - Less than 1µs jitter.
Isochronous Real-Time Operation

Cycle 1
- IRT channel
- Non real-time channel
- IRT channel
- Non real-time channel
- IRT channel
- Non real-time channel

Cycle 2
- Sync
- IRT
- RT
- NRT
- Open channel i.e. TCP/IP

Cycle 3

Less than 1ms possible
Isochronous Real-Time Performance

IRT traffic

<1µs jitter

15% jitter

TCP/IP traffic

100% jitter

0 1ms 10ms 100ms Cycle time
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Integration with Fieldbus

- Approaching 20 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

PROXY

PROFIBUS PA

INTERBUS-S

Other fieldbusses?
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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 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:
   - Vendor A
   - Vendor B
   - Vendor C
   - Project program

2. Import components into library:
   - Fill
   - Close
   - Pack

3. Link components:
   - A1
   - A2
   - B
   - C

Bottom up development:

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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 EN954 cat 4 or IEC61158 SIL3.
• PROFIsafe V2 provides functional safety for both PROFIBUS and PROFINET systems.
• Suitable for use in SIL3 applications.
PROFINET Security

- Objectives of PROFINET Security
  - Fault-free operation and protection of industrial systems and production process
  - Protection against unauthorized access
  - Extended use of existing, open and field-tested IT security standards
- Protection for "automation cells" using security network components.
  - Real-time communication unaffected within the cell
  - Lower-level PROFIBUS/fieldbus links are also protected.
PROFINET Security

- PROFINET security modules provide cell protection against deliberate or accidental malicious access by employees or outsiders.
Industrial Acceptance and Applications

- The success of PROFIBUS as the number one fieldbus has come about mainly because it supports a wide range of applications and industries:
  - Solutions exist for:
    - Low cost distributed I/O,
    - Power supply over bus (two-wire connection),
    - Intrinsic Safety (explosion prevention),
    - High-Speed, highly deterministic control (motion control),
    - Redundancy (high availability systems),
    - Functional Safety (accident prevention),
    - Asset Management etc.
  - Approaching 3000 products from over 300 different vendors.
- The consequence is that approaching 20 million PROFIBUS devices have been installed.
PROFINET builds on the success of PROFIBUS and ensures a future for both.

PROFINET has been in development for over 6 years.

Over 100 PROFINET products are currently available from about 25 different companies.

Hundreds of applications have been reported from a wide range of industries and using a wide range of technologies including safety, wireless, CBA, motion control.
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 are reported to be:
- The integration of safety-related information,
- The simple integration of existing PROFIBUS and Interbus systems.
PROFINET Practical Demonstration
PROFINET Configuration

• PROFINET system configuration is based on similar concepts to PROFIBUS.
• Each device has a GSD file which describes its characteristics and capabilities.
• PROFINET GSD files are written in XML (eXtensible Mark-up Language) – often called GSDML files.
• GSDML Files contain information on:
  - Device identification,
  - Available modules,
  - Parameters and settings,
  - Diagnostic information
  - Different languages are supported within one file.
Configuration

- Configuration of a PROFINET IO system follows similar procedures to PROFIBUS; i.e.
  - Install GSDML file into catalogue of configuration tool,
  - Select device and place on bus,
  - Allocate the IP address,
  - Add modules,
  - Set device and module parameters.
- However many configuration tools also provide on-line functionality to:
  - Download configuration data to devices,
  - Set IP addresses and device names,
  - Test connectivity and provide device diagnostics.
Demonstration

- We will configure two PROFINET IO devices to be controlled by a simple IO Controller running on a laptop.
The Automation Systems Centre

• The Automation Systems Centre at Manchester Metropolitan University is the UK’s PROFIBUS International Competence Centre.

• We provide training and support for PROFIBUS, Industrial Ethernet (including PROFINET), Actuator-Sensor Interface (AS-i) and Open PLC programming (IEC61131-3)
Contact Information

- Further information can be obtained from:
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