Control System Design using PROFIBUS and PROFINET

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Outline of the presentation

- Overview of networked control systems and PROFIBUS & PROFINET technology.
- Control and monitoring systems – what are the main design requirements?
- Maintenance and diagnostic considerations.
- Intelligence down to the actuator/sensor level
- Bringing the information up to the higher levels.
- Training for system designers.

Benefits of networked systems

- The advantages of networked control and monitoring systems are very well known:
  - Significant reduction in the amount of wiring and connections.
  - More extensive data to and from devices, i.e. diagnostic information, device parameters etc.
  - Centralised commissioning of devices.
  - Device management and maintenance facilities.
  - Greater flexibility in system layout and design.
  - Ease of future expansion and modification.

PROFIBUS

- PROFIBUS International celebrates its 20th year this year.
- PROFIBUS is by a large margin the most widely used fieldbus technology.
- PROFIBUS has solutions for a wide range of industries and applications areas
  - Manufacturing, Materials handling;
  - Process, water & sewage treatment, oil & gas;
  - High-speed multi-axis servos and robotics;
  - High integrity and Functional safety systems;
  - And more.

Application areas


Car manufacture

Pipelines

Bottling Plants

- Manufacturing Automation
  - Car manufacturing
  - Bottling systems
  - Storage systems
- Building Automation
  - Traffic automation
  - Heating, air-conditioning
- Process Automation
  - Water and sewage treatment
  - Chemical and petrochemical plants
  - Paper and textile industries
- Power industry and power distribution
  - Power plants
  - Switchgear
- Functional safety systems
- High reliability systems
- Redundancy.

Brewing industry

Paper and Printing Industry

Food Industry

Precious metals recovery

Water Treatment and sewage

Building Automation

Polymer production and Storage

PROFIBUS

- PROFIBUS is truly an "open" system:
  - Supported by over 300 manufacturers;
  - With over 3000 devices;
  - Allowing true multi-vendor systems to be simply constructed using best of breed devices;
  - Extensive support available:
    - Excellent documentation and practical guides;
    - Worldwide network of Competency Centres;
    - Wide range of accredited training available;
    - Certified installers, engineers;
    - Certified products and components;
    - Commissioning and test tools widely available.

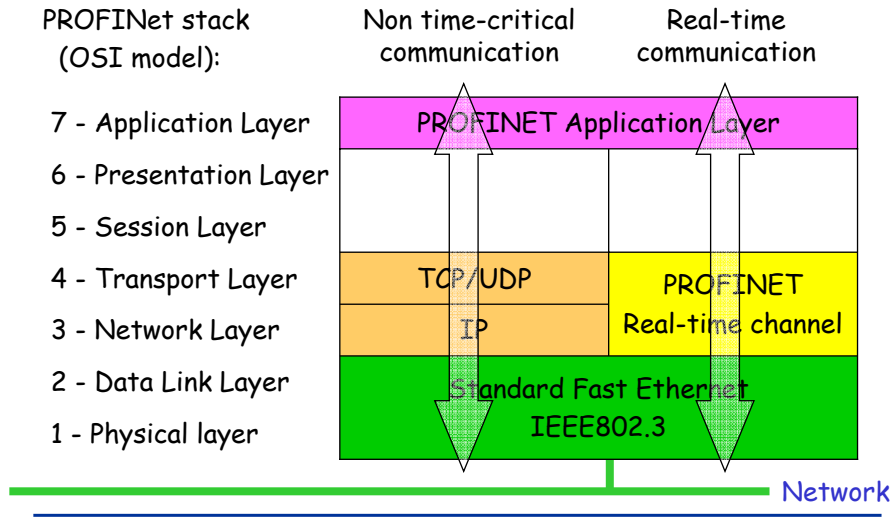
The PROFIBUS family

- **PROFIBUS DP** - Decentralised Periphery
  - Low cost, high speed, simple communications for general applications.
- **PROFIBUS PA** - Process Automation
  - Developed specifically for the process industry, very cost effective two-wire connection carrying both power and data. Particularly cost effective for hazardous environments
- **PROFINET** – Industrial Ethernet
  - Implements real-time control and monitoring over standard Ethernet.
  - Offers integration between different fieldbus technologies.

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,
  - 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.

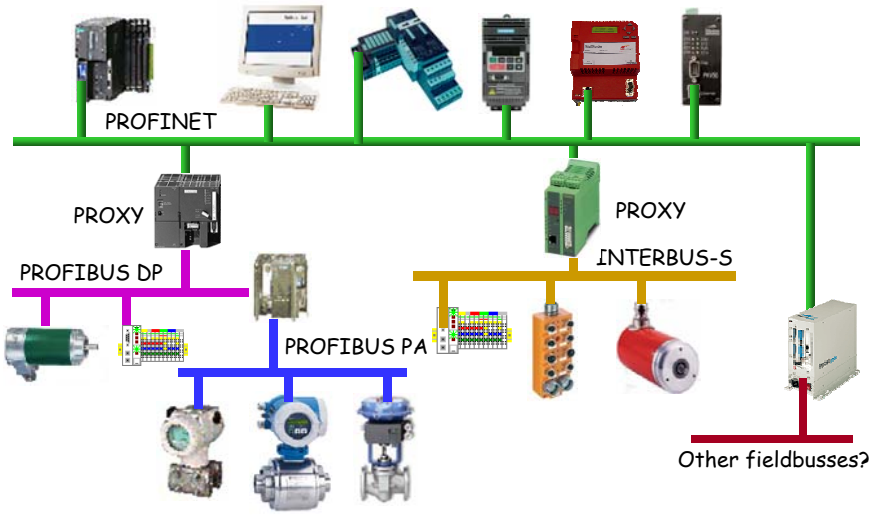
PROFINET



PROFINET

- 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.

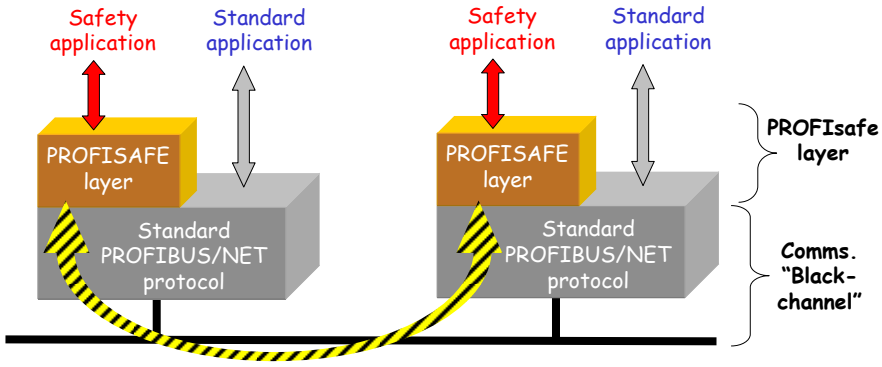
Integration with Fieldbus



Functional Safety with PROFIBUS/NET

- PROFIBUS and PROFINET both offer safety oriented communication that allows for integrating safety oriented components.
- A second 'safety fieldbus' is not necessary.
- PROFIsafe V2 can be used in certified safety systems according to EN954 cat-4 or IEC61158 SIL3.

Functional Safety with PROFIBUS/NET

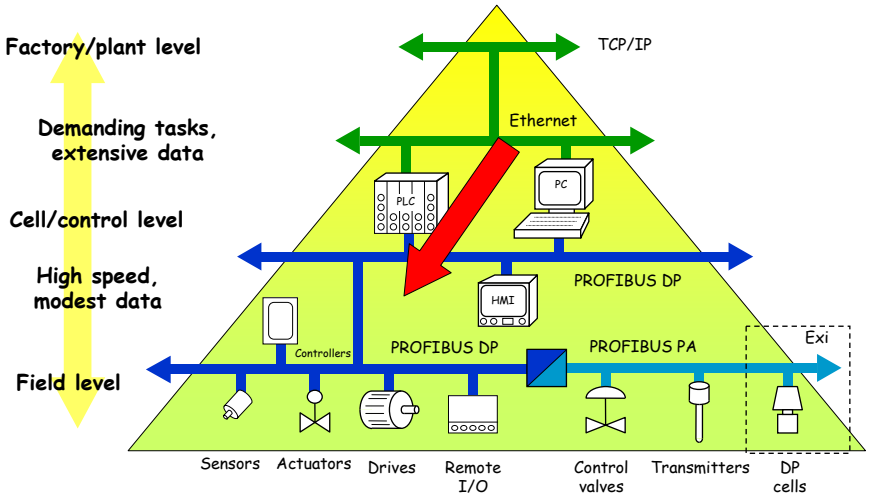


- PROFIsafe V2 provides functional safety for both PROFIBUS and PROFINET systems.

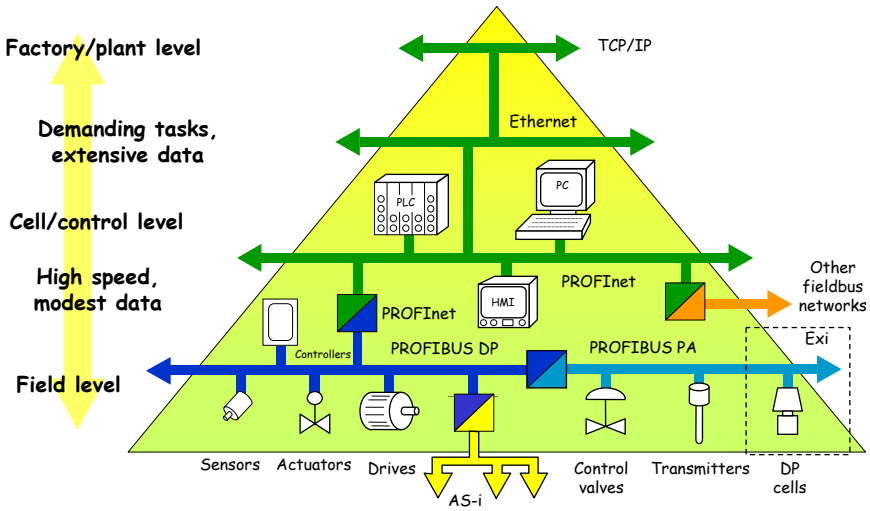
Control system requirements

- System designers need to meet several requirements:
  - Low cost
    - Should be whole life cycle, not just procurement costs.
  - Capability
    - Solution should deal with all requirements: Simple/complex tasks. High-speed/low speed, control/monitoring and safety, normal/explosive environments, etc.
  - Simplicity
    - One simple solution for everything?
  - Maintainability
    - Built-in diagnostics down to the device level, brought up to the top level.
    - Ability to deal with failures and replacement of devices without shutting the plant down.

Trends in Control System Architecture



The PROFIBUS family



AS-i for low level devices

- PROFIBUS is applicable to a wide range of applications. But, it is not cost effective at the very lowest level.
- Devices such as proximity sensors, on/off pneumatic actuators or even panel lamps and switches which cost less than £50 each cannot justify a PROFIUS interface.
- The Actuator/Sensor Interface (AS-i) is designed to be cost effective at the lowest level and costs much less to implement.

AS-i for low level devices

- AS-i, in its basic form, connects up to 31 devices to a controlling master or fieldbus gateway.
- Each device can incorporate up to 4 digital inputs and 4 digital outputs.
- AS-i connectivity can be integrated into devices at very low cost, making it suitable for simple, single-channel on-off devices.

AS-i for low level devices

- AS-i integrates very easily with PROFIBUS, PROFINET and other fieldbus technologies.
- Gateways are available from many manufacturers allowing simple integration of AS-i sub-networks.
- AS-i devices can incorporate in-built diagnostics that can warn of simple peripheral errors.
- These diagnostics can easily be relayed on to the higher levels.
- Further, device parameters can aid remote commissioning and testing of sensors and actuators, just like PROFIBUS and PROFINET.

Maintenance issues

- Device faults can be broken down into "Communication" or "Peripheral" faults.

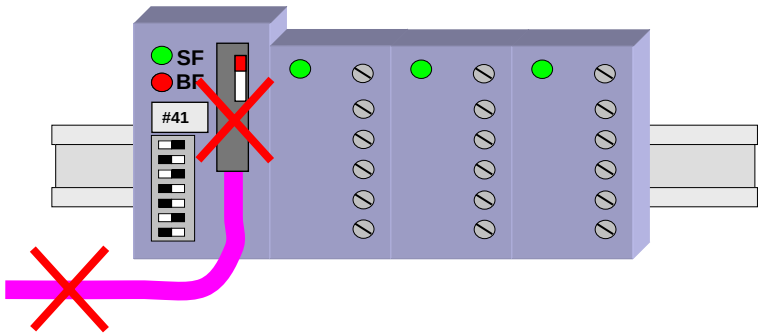
Communication faults ⟷ Peripheral faults

- Faults that disrupt network communications.
- E.g. network wiring errors, interference pickup, reflections etc.
- These are "bus-faults".

- Concerned with the sensor or actuator (i.e. IO).
- E.g. sensor wire break, loss of output power, sticking valve etc.
- Network communications are OK – not "bus faults".

Communication Faults

- Mainly caused by poor network wiring or layout or cable/connector deterioration.
- Can be permanent or intermittent.

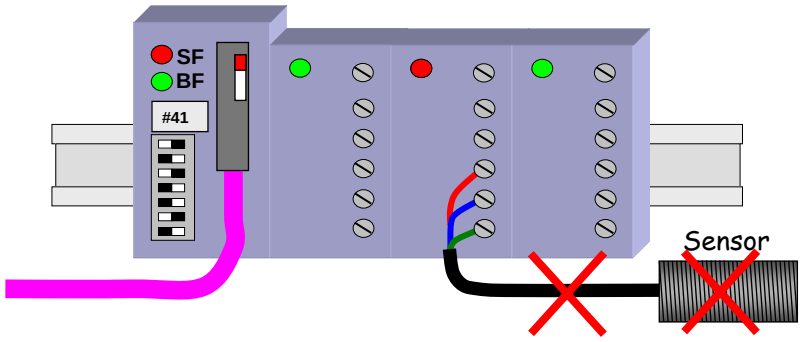


Communication faults

- Communication faults require specialist tools.
- Communication errors do not always produce loss of control. This is because PROFIBUS is very robust to errors that can corrupt data.
- Quite often users are blissfully unaware that their system has communication errors because PROFIBUS robustness and fault tolerance can hide these faults.
- Only when the rate of data corruption reaches a critical threshold will the fault become visible.

Peripheral faults

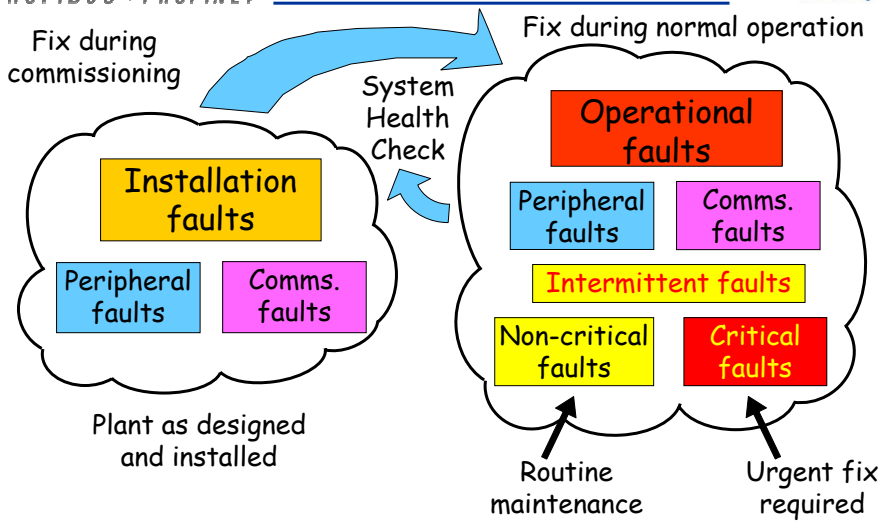
- Caused by sensor/actuator failure or wiring faults.
- Again faults can be intermittent.



Peripheral faults

- Peripheral faults can be located and diagnosed over the network.
- Modern intelligent devices incorporate extensive self-diagnostic features that can identify or highlight many peripheral faults.
- However, in our experience, system designers do not take advantage of these built-in diagnostics.
- The SCADA system can normally be easily set up to report and record these diagnostics at the top level. But often the lowest-cost implementation does not include this feature.

Fault categorisation



System Health Checking

- Health checking is an important part of the commissioning and maintenance strategy for your plant.
- The health check will help to find non-critical and intermittent faults that are not obvious.
- A health check should be carried out immediately after commissioning.
- The health check should be also repeated at intervals to check for faults that develop during plant operation.

Health checking

- Health checking is an essential feature of any networked system.
- However, the network must be designed and laid out to facilitate this.
- In our experience, the simple design rules that allow network health checking are often not implemented.
- System designers often forget about maintenance and fault finding.

Commissioning

- PROFIBUS and PROFINET technologies support extensive "parameters".
  - For example a modern drive may have up to 1000 parameters.
  - Even a simple process transmitter can incorporate hundreds of parameters.
- Parameters are options or settings on a device.
- Commissioning devices involves setting and adjusting these parameters to configure, calibrate and test the device.
- Parameters over the bus allows commissioning to be completed in a fraction of the traditional time.

Commissioning

- Unfortunately, system designers often procure devices and build systems without considering the implications of commissioning.
- Commissioning and maintenance "over the network" is an important consideration that can provide significant cost savings over the whole life cycle of the plant.
- The lowest cost device at purchasing may not be the lowest cost device over a ten year period.

System Design

- Many of the errors that can be seen in installations are traceable to fundamental decisions that are taken at the early stages of the project.
- For example:
  - use of inappropriate fieldbus for an application;
  - lack of awareness of maintenance and fault-finding facilities;
  - over-complex or inappropriate system architecture;
  - design decisions based on equipment purchasing cost rather than whole life-cycle costs.

Training

- Good quality PROFIBUS, PROFINET and AS-i training has been widely available for installers, maintenance technicians and engineers for many years.
- Unfortunately, key decision makers – managers, system designers and system integrators are quite often less well trained than others who are involved in the installation or maintenance.
- At the Automation Systems Centre at Manchester Metropolitan University we have responded to this need with a "Systems Designer course".
- This is a low-cost one-day add-on to our existing training programme.

Contact details

- A printable copy of this presentation can be downloaded from:

www.VerwerTraining.com

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Questions?