# PROFINET – AN INTEGRATED AUTOMATION CONCEPT BASED ON ETHERNET

H. Kleines, J.Sarkadi, F.Suxdorf, K.Zwoll, Forschungszentrum Jülich, Jülich, Germany

*Abstract*

The PROFInet architecture defined by the PROFIBUS user organisation is more than a communication standard. It defines a vendor-independent engineering model covering plant-wide automation. With regard to communication it is based on DCOM, thus using TCP/IP and Ethernet. Its component-based approach goes beyond OPC's tag-based approach. Functionally PROFInet extends the configuration and diagnostic features of PROFIBUS, employing established IT standards like XML. PROFInet is evaluated in Forschungszentrum Jülich for future application in neutron scattering experiments.

## INTRODUCTION

Industrial automation equipment, especially PLCs, fieldbus systems and decentral periphery, is well established in the infrastructure of research institutions, especially for access systems, vacuum systems, etc. [1]. Beyond the scope of pure infrastructure systems, PLCs are increasingly becoming central components of experiment control systems, replacing VME- or PC-based real-time systems [2],[3]. Main reasons are

- low prices induced by mass market,
- robustness
- long term availability and support from manufacturer
- powerful development environment
- high degree of scalability
- professionality (connectors, conformance to standards,…)

Today, in FZ Juelich all new and advanced experiment control systems are heavily PLC-based [3], as illustrated by the architecture of the control system of a small angle neutron scattering experiment shown in Fig 1. Control systems in neutron scattering experiments cover the accurate movement of a diverse range of mechanical parts, vacuum systems and sample environment (pressure, temperature, etc.).

As shown in Fig. 1, process communication of physics experiment control systems in Jülich typically is based on PROFIBUS, the most widely accepted fieldbus technology. This covers communication between PLCs and supervisory computers, as well as communication between central PLCs and decentral process equipment responsible for individual subsystems.

In industrial automation the increasing processing power of peripheral devices results in a strong trend to distributed systems. Thus hierarchical configurations with central process stations controlling peripheral slaves are being replaced by configurations with autonomous systems communicating according to their technological requirements. This is supported by the trend to component based automation [4]. It aims at the reduction of engineering costs by implementing reusable components, applicable to different automation systems. An important aspect is an homogenous communication infrastructure. Here Ethernet and TCP/IP, being well established in office applications, are becoming more popular also in automation systems. One major obstacle for the introduction of Ethernet to automation system is the lack of appropriate application protocols. Here proprietary solutions are dominant. The only widely accepted application protocol is OPC (OLE for Process Control), which has been designed for vendor-independent access of process variables by a supervisory computer. Of course this limited functionality is not sufficient for integrated automation solutions.

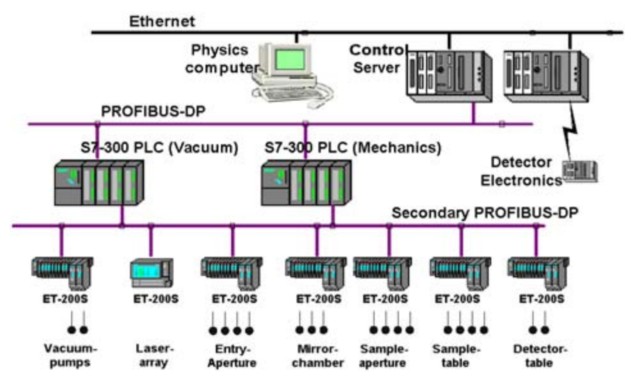


Figure 1: Control system architecture of the neutron scattering experiment KWS3.

PROFInet [5] is a new open standard defined by the PNO (PROFIBUS user organisation) for distributed automation based on Ethernet. It provides a uniform approach on engineering, data transfer and diagnosis. The transparent integration of PROFIBUS DP systems and the component-based model make it a promising new candidate for physics experiment control, especially in neutron scattering.

## OVERVIEW OF PROFINET

The PROFInet concept supports the structuring of an automation system into autonomous subsystems called technological modules. Technological modules comprise all mechanics, electronics and software to perform a specific task. PROFInet uses an object oriented approach by modelling each technological module as a component. The external behaviour of a component is described by interface variables. Components can be reused for different automation systems.

In an engineering phase a specific automation system is formed by defining its components and the communication connections between their input and output variables. Component creation is done by configuring and programming a device in a conventional way with a vendor-specific tool, modelling it as PROFInet component and producing a vendor-independent XML description of this component.

The communication between components is defined by a vendor-independent PROFInet connection editor on an engineering station, that allows the import of the XML descriptions and definition of connections between component variables. The PROFInet connection editor supports download of component and connection configurations to the PROFInet devices.

During runtime all components autonomously exchange data according to their predefined connections without application interaction. Status of devices and connections can be monitored by the engineering station via the diagnostic interface of PROFInet.

It is expected that this consistent approach of PROFInet will reduce engineering costs drastically.

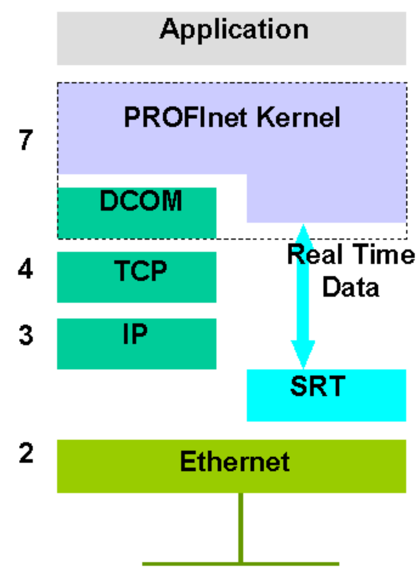


Figure 2: PROFInet protocol stack

Each PROInet devices is modelled as a standardized collection of COM objects. Some of these objects exist only during runtime. So all communication for engineering, runtime and diagnostics is based on the DCOM middleware on top of TCP/IP and Ethernet. For real time data an additional Soft Real Time (SRT) stack has been defined as shown in Fig. 2.

PROFInet defines a mechanism to integrate PROFIBUS subsystems via Proxies, that support a transparent communication with PROFIBUS devices via PROFInet. So existing fieldbus installations can easily be expanded with PROFInet, thus supporting PROFInet's acceptance.

## PROFINET TEST SYSTEM IN JÜLICH

Introduction of PROFInet in control systems for neutron scattering expeiments requires the PROFInet integration of S7-300 PLCs and PROFIBUS subsystems. We acquired the CP343-1 PN, a PROFInet controller for the S7-300, and the IE/PB link, a PROInet Proxy for PROFIBUS DP and build up the test installation shown in Fig. 3. On the PROFIBUS segment we used an intelligent ET200S system (with IM151/CPU). Generation of PROFInet components was directly supported by the STEP7 programming environment for S7 PLCs. On the engineering workstation we used the Siemens tool iMAP for interconnecting the components and download of connection data to the devices. Integration of standard DP slaves - like the "normal" ET200S - is still an open issue. Another focus of interest is the integration of application software developed in Jülich for supervisory computers. This requires the implementation of PROFInet on the supervisory computers. When these issues are solved, all components for the introduction of PROFInet to physics experiment control systems are available.

Future activities will concentrate on performance issues, especially with respect to the soft real time stack.

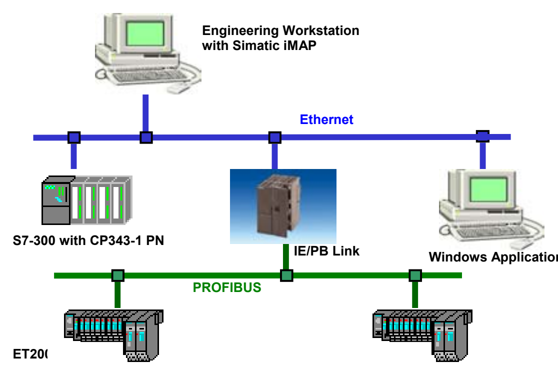


Figure 3: PROFInet Test System.

## CONCLUSIONS

PROFInet is an extremely powerful system, that goes far beyond existing Ethernet-based communication concepts for automation. But it is a complex technology resulting in a strong dependency from comfortable vendor tools. Today only a few products are on the market, mostly from Siemens. Source code of the PROFInet stack is available for PNO members, thus supporting the implementation of PROFInet devices and applications.

In future the PROFInet standard will be extended by addressing hard real time issues. Additional extensions will cover WWW integration and protocol extensions for decentral I/Os on Ethernet, that functionally correspond to PROFIBUS DP.

## REFERENCES

[1] S.M. Schmeling, B. Flockhart, S. Lüders, G. Morpurgo: "The Detector Safety System for LHC Experiments", *Proc. 13th IEEE-NPSS Real Time Conference*, Montreal, Canada, May 2003
[2] P. Chevtsov: "PLC Support Software at Jefferson Lab", *Proc. PCaPACs2002*, Frascati, Italy, October 2002.
[3] H. Kleines, K. Zwoll, M.Drochner, J. Sarkadi: "Integration of Industrial Automation Equipment in Experiment Control Systems via PROFIBUS – Developments and Experiences at Forschungszentrum Jülich", *IEEE Trans. on Nucl. Sci.*, Volume 47, Number 2, Part I, April 2000, p. 229-233
[4] W. Eppler, A. Beglarian, H. Gemmeke: "Slow Control System Aspects for a Large Neutrino Experiment", *Proc. 13th IEEE-NPSS Real Time Conference*, Montreal, Canada, May 2003.
[5] "PROFInet Architecture Description and Specification Version 2.0", PROFIBUS Nutzerorganisation, Order No. 2.202, Karlsruhe, 2003, also available at http://www.profibus.com