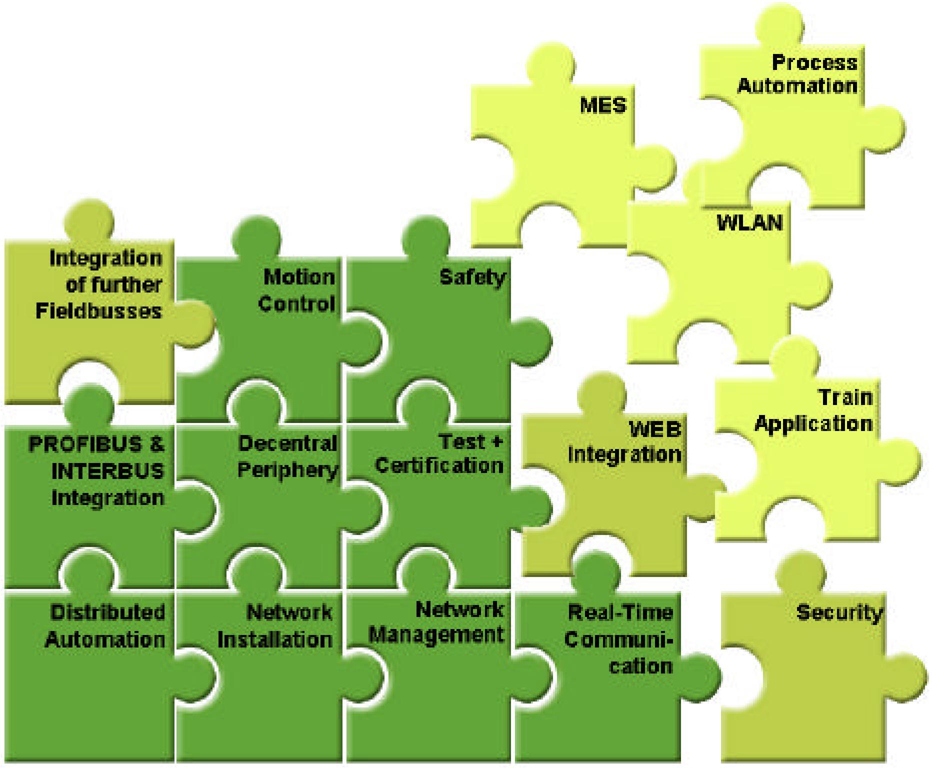
PROFINET
Technology and Application

System Description

Open Solutions for the World of Automation



Introduction

The ever-shorter innovation cycle for new products makes the continuous evolution of automation technology necessary. The use of fieldbus technology has been a significant development in the past few years. It has made it possible to migrate from central automation systems to decentralized ones. PROFIBUS, as a global market leader, has set the benchmarks for 15 years.

In today's automation technology, moreover, Ethernet and information technology (IT) is increasingly calling the shots with established standards like TCP/IP and XML. Integrating information technology into automation allows significantly better communication options between automation systems, extensive configuration and diagnostic possibilities, and network-wide service functionality. These functions have been an integral part of PROFINET from day one.

PROFINET is the innovative open standard for Industrial Ethernet. PROFINET satisfies all requirements for automation technology. With PROFINET, solutions can be implemented for factory and process automation, for safety applications, and for the entire range of drive technology right up to clock-synchronized motion control.

Besides the Real-Time capability and the use of IT technology, protection of investment also plays an important role in PROFINET. PROFINET enables the integration of existing fieldbus systems like PROFIBUS, AS-Interface, and INTERBUS, without changes to existing devices. That means that the investments of plant operators, machine and system engineers, and device manufacturers, are all protected.

The use of open standards, simple operation, and the integration of existing system segments have driven the definition of PROFINET from the beginning. PROFINET is standardized in IEC 61158 and IEC 61784.

The continual further development of PROFINET offers users a long-term perspective for the implementation of their automation tasks.

For the plant or machine engineers, the use of PROFINET minimizes the cost of installation, engineering, and commissioning. For the plant operator, PROFINET enables simple system extensibility and high system availability due to autonomously running system segments.

The establishment of certification now ensures a higher standard of quality for PROFINET products.

Contents

1. PROFINET in overview

PROFINET is the innovative open standard of PI for the implementation of integrated automation solutions based on Industrial Ethernet. With PROFINET, simple distributed I/O and time-critical applications can be integrated into Ethernet communication just as well as distributed automation system on an automation component basis.

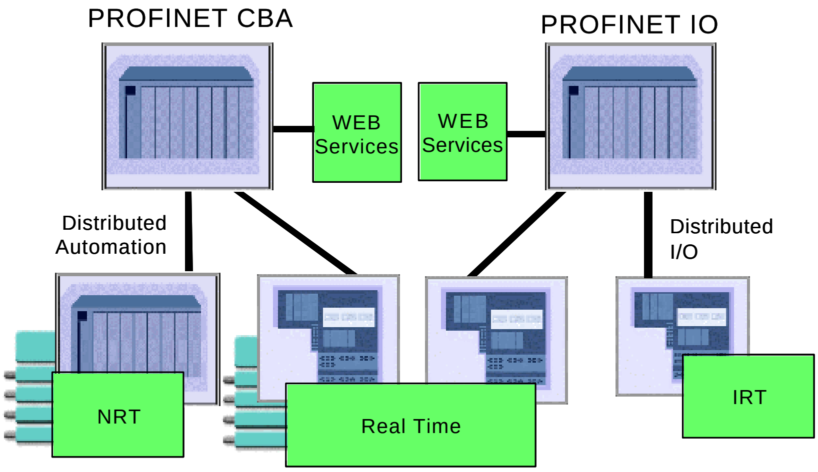


Figure 1.1: Choices of PROFINET Communication

1.1 Distributed I/O (PROFINET IO)

Distributed I/O is connected into communication through PROFINET IO. Here, the familiar I/O view of PROFIBUS is retained, in which the peripheral data from the field devices are periodically transmitted into the process model of the control system.

PROFINET IO describes a device model oriented to the PROFIBUS framework, consisting of places of insertion (slots) and groups of I/O channels (subslots). The technical characteristics of the field devices are described by the so-called GSD (General Station Description) on an XML basis.

The engineering of PROFINET IO is done in the way familiar to system integrators from years with PROFIBUS. The distributed field devices are assigned to one or more controllers during configuration.

1.2 Distributed automation (PROFINET CBA)

The PROFINET component model sees its real use in distributed automation systems. It is ideally suited for intelligent field devices with programmable functionality as well as controllers.

The component model describes autonomously acting partial units of machines or plants as technological modules. A distributed automation system designed on the basis of technological modules greatly simplifies the modularization of plants and machines, and therefore the reuse of plant and machine parts. That significantly reduces engineering costs.

PROFINET based on a component model is described using a PCD (PROFINET Component Description). It is XML-based and can be generated either by the Component Generator of a manufacturer-specific configuration tool, or by the free available PROFINET Component Editor.

The engineering of distributed automation systems differentiates between the programming of the control logic of the individual technological modules (manufacturer-specific configuration tools) and the manufacturer independent configuration of the overall installation, in which the communications relationships between the technological modules are determined.

1.3 Communication

Communications in PROFINET contain different levels of performance:

- The non-time-critical transmission of parameters, configuration data, and switching information occurs in PROFINET in the standard channel based on TCP or UDP and IP. This establishes the basis for the connection of the automation level with other networks (MES, ERP).
- For the transmission of time-critical process data within the production facility, there is a Real-Time channel (RT) available. For particularly challenging tasks, the hardware-based communication channel

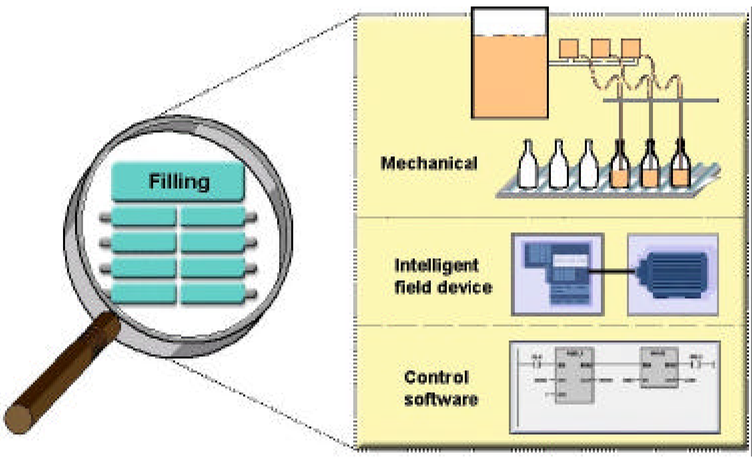


Figure 1.2: Mecanical, electrical/electronics and software are grouped as technological modules in the component model

Isochronous Real-Time (IRT) can be used – for example in case of Motion Control Applications und high performance applications in factory automation.

1.4 Network installation

PROFINET network installations are oriented towards the specific requirements of Ethernet networks in the industrial environment. These give device manufacturers clear specifications of device interfaces and their cabling. The docukent "Installation Guideline PROFINET" gives plant builders and operators well-proven rules for the installation of Ethernet networks.

1.5 IT integration

Network management includes functions for the administration of PROFINET devices and switches in Ethernet networks. This includes device and network configuration as well as network diagnostics (e.g. SNMP).

For Web integration, PROFINET uses basic Ethernet technology, enabling access to a PROFINET component using standard technology from the Internet arena.

To maintain an open connection between PROFINET and other systems, the open standard OPC can be used.

1.6 Security

Since available security concepts from the office area really do not suffice for the particular requirements in the automation arena, security concepts for automation technology have had to be developed.

The PROFINET security concept can handle the increased need for network security in Ethernet-based automation systems. It fulfills the requirements for access control, data encryption, authentication, and logging of security-relevant events.

1.7 Safety

PROFIsafe defines how safety-oriented devices (emergency shutoff switches, light grids, overfill protection systems, etc.) can communicate safety-information with controllers over a network securely enough that they can be used in safety-oriented automation tasks up to EN954's KAT4, AK6, or SIL3 (Safety Integrity Level). The PROFIsafe profile implements secure communication using standard PROFINET IO communication mechanizms. The interpretation of process data is defined in the profile.

1.8 Drive technology and motion control with PROFIdrive

The drive profile PROFIdrive describes the drive interface from the point of view of the control application, along with its mapping to the communication systems PROFIBUS and PROFINET.

The PROFIdrive profile covers application scenarios from simple frequency converters to highly dynamic servo drivers. The scalable functionality was broken down into six application classes.

1.9 Fieldbus integration

PROFINET offers a model for integration of existing field buses like PROFIBUS, AS-Interface, and INTERBUS. This allows the construction of arbitrarily mixed systems consisting of fieldbus- and Ethernet-based segments. Thus a smooth technology transition is possible from fieldbus-based systems to PROFINET.

The large number of existing fieldbus systems makes it necessary to support their simple integration into PROFINET for reasons of investment protection.

The integration is done with so-called "proxies". A proxy is a device which connects an underlying fieldbus with PROFINET.

The proxy concept allows the device manufacturer, the plant and machine builder as well as the end user a high degree of investment protection.

1.10 Implementation and certification

For PROFINET devices of different types and manufacturers to be able to communicate error-free, a standards-compliant implementation of the communications protocols and application profiles by the device manufacturer is a prerequisite.

To demonstrate the quality of PROFINET products, a certification process is available. A PROFINET certificate demonstrates standards-compliant behavior within a PROFINET network, as defined by IEC 61158.

2. PROFINET communication

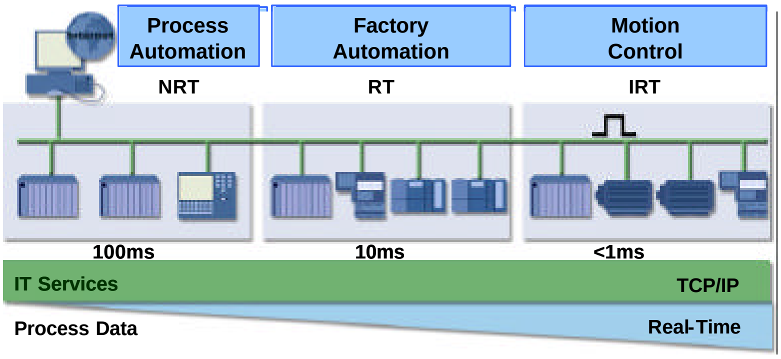


Figure 2.1: The scalable PROFINET – communications for any application area

PROFINET uses Ethernet as well as TCP, UDP, and IP as the basis for communications. TCP/IP is the de-facto standard for communication protocols in the IT arena. But for interoperability, it is not enough just to establish a common communication channel between field devices based on TCP, UDP, and IP, because these standards merely represent the basis for data exchange. Additional protocols and determinations are thus needed on top of TCP or UDP, the so-called application protocols, which ensure the interoperability of applications. The interoperability of applications between field devices is only ensured when the same application protocol is being used. Typical application protocols are, for instance, SMTP (email), FTP (file transfer), and HTTP (Web).

The different application areas in industrial automation require a wide performance range for communication. These range from non-time-critical through Real-Time capable to clock-synchronized.

For non-time-critical processes, PROFINET uses TCP/IP and UDP/IP. In industrial applications, however, it is usually not enough. Here, significantly stronger requirements for data bandwidth and for clock synchronization exist. Data exchange optimized for performance is called Real-Time communication (RT), the clock-synchronized communication is called Isochronous Real-Time (IRT).

PROFINET offers scalable data communications. The globally established standard IT services can be used just as easily as communications optimized for speed. This coexisting use of Real-Time and TCP/IP-based communications between PROFINET field devices can occur on the same bus lines at the same time.

The following examples will clarify the basic mechanisms of TCP/IP and RT communications for PROFINET CBA and PROFINET IO.

2.1 TCP/IP and UDP/IP communication

For non-time-critical processes, PROFINET uses communications with the standard Ethernet mechanisms over TCP/IP or UDP/IP which follow the international standard IEEE 802.3.

Similar to standard Ethernet, PROFINET field devices are addressed using a MAC and an IP address. In TCP/IP and UDP/IP communications, different networks are recognized based on the IP address. Within a network, the MAC address is a unique criterion for the addressing of the target device. PROFINET field devices can be connected to the IT world without limitations. A prerequisite for this is that the corresponding services, for instance File Transfer, must be implemented in the field device involved. This can differ from manufacturer to manufacturer.

The features of TCP/IP and UDP/IP are:

- *Detection* of frame losses by confirmation mechanisms
- *Repetition* of transmitted frames if the confirmation is omitted
- *Flow control*, that is, the receiver can control the transmission frequency of a sender. This ensures that the sender will only send a new frame after the previous one has been confirmed.

All PROFINET field devices must support data communication over UDP/IP.

Ethernet

Ethernet is standardized in IEEE 802.3. The specifications include access technology, the transmission process, and transmission media for Ethernet (10 Mb/s), Fast Ethernet (100 Mb/s) and Gigabit Ethernet (1 Gb/s). PROFINET uses Fast Ethernet.

Fast Ethernet introduced and standardized full-duplex operation and switching.

TCP

TCP guarantees the error-free, sequential, complete transmission of data from sender to receiver. TCP is connection-oriented, that is, two stations establish a connection before transmission of data, and the connection is disconnected after the transmission is complete. TCP includes mechanisms for continuous monitoring of the connection established.

UDP

Like TCP, UDP guarantees the error-free, sequential, complete transmission of data from sender to receiver. However, in contrast to TCP, UDP is connectionless, that is, each data packet is treated as an individual transmission and there is no transport confirmation. Omission of timeout monitoring and establishment and cleardown of connections makes UDP more suitable for time-critical applications than TCP. The data blocking and communications monitoring implicit in TCP can be performed in UDP on the application level, for instance through RPC (Remote Procedure Call).

2.2 Real-Time communication (RT)

A data communication over the TCP/IP or UDP/IP channel is provided with a certain amount of administrative and control information for addressing and flow control, all of which slows data traffic. To enable Real-Time capability for cyclical data exchange, PROFINET abandons partially IP addressing and flow control over TCP and UDP for RT communications. The communication mechanisms of the Ethernet (Layer 2 of the ISO/OSI model) are very suitable for this. RT communications can always run in parallel with NRT communications.

The RT communications in PROFINET offer the following options:

- *RT communication within a network.* In this communication, no addressing information about the target network is necessary. The administrative information of TCP/IP or UDP/IP are eliminated. The RT frames are already identified upon receipt using the Ethertype (0x8892) and processed in the RT channel. With RT communications, bus cycles in the single-digit millisecond range are possible.
- *RT communication between networks.* In some networks or during system extensions, it is necessary to exchange data over network boundaries. This kind of network-spanning communication requires addressing information about the target network (the IP address). "RT over UDP" is available for this application case.
- *Data multicasts with RT.* For cyclical data transmission to multiple nodes direct data transfer between IO-Devices is defined based on Ethernet Multicast. Network-spanning MCR data uses "RT over UDP" for data exchange.

Prioritization of data traffic

Real-Time communication uses for the prioritized transmission of RT-Frames the VLAN tag as defined in IEEE802.1Q, with which 7 priority levels can be configured.

TCP/IP, UDP/IP and RT communication can be implemented with any off-the-shelf Ethernet controller.

2.3 Isochronous Real-Time communication (IRT)

For particularly demanding tasks the hardware Isochronous Real-Time (IRT) is available. It is used for example in Motion Control applicationens and in high performance factory automation applicationns.

IRT communication is based on the following prerequisites:

- Communication is exclusively within *one* network segment.
- The bus cycle is divided into an IRT phase (red interval) and an succeeding non-isochronous phase (green interval; see Figure 2.2).
- During the IRT phase, time synchronization has to be supported. For this reason the PTCP protocol is implemented in PROFINET per IEC 61168. The precision of time synchronization depends on the application and is generally <1 µs.

IP

Data transmission with the internet protocol (IP) is not a secured packet transmission (datagrams) between an IP source and an IP destination. Datagrams can get lost because of noise on the transmission channel or network overload, they can be received several times or arrive in a different order than sent. It can be assumed however that an arriving datagram is correct. Thanks to the 32-bit checksum of the Ethernet packet the detection of errors in the packet is very likely.

Special hardware support is necessary for IRT communication, in the form of ASICs with integrated switch functionality and cycle synchronization. The send intervals of the field devices can be flexibly determined by the user. The transitions between the intervals are monitored by the hardware. The transition from the "green interval" to the "red interval" is called the "orange interval". In this interval, the ASIC decides whether an TCP/IP AND UDP/IP frame can be forwarded without delaying the beginning of the next red interval.

If IRT communication is necessary in an installation, the bus bandwith must already be divided into an IRT portion and a portion including TCP/IP, UDP/IP and RT portion during the engineering phase.

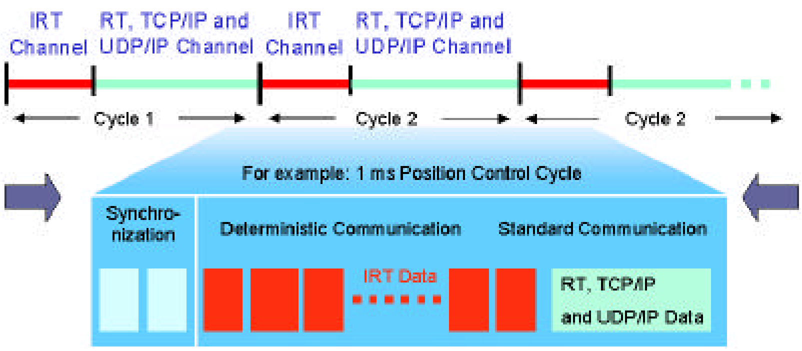


Figure 2.2: IRT communication is broken down into an IRT channel and an open channel.

3. Distributed I/O with PROFINET IO

In an automation installation, the direct connection of distributed I/O to the Ethernet is implemented using PROFINET IO. These field devices can either drive digital or analog input and output signals, or take over preprocessing functionality. The focus of PROFINET IO is data transmission tailored to performance but with simple communications equipment. Due to years of experience and in the interests of protecting existing investment, the user view from the PROFIBUS concept was incorporated. The most important are:

- the use of peripheral modules used under PROFIBUS,
- the process of installation engineering, and
- the programming of field devices.

With regards to data exchange, a few extensions were necessary due to user requirements. These are:

- Prioritization of the data exchange between different field devices
- Access from multiple control systems to the same field devices
- Description of multiple field device options in a single GSD file
- Extension of the PROFIBUS DP device model

3.1 Device roles

PROFINET IO distinguishes, similar to PROFBUS, between different device roles. A device can include multiple roles.

IO-Controller

A PROFINET IO-Controller (IO-Controller) has control over a process distributed over one or more field devices. It takes in process data and alarms, and processes them in a user program. In automation installations, an IO Controller is normally a programmable logic controller (PLC), a DCS system or a PC. It is responsible for the establishment of communication channels during system boot.

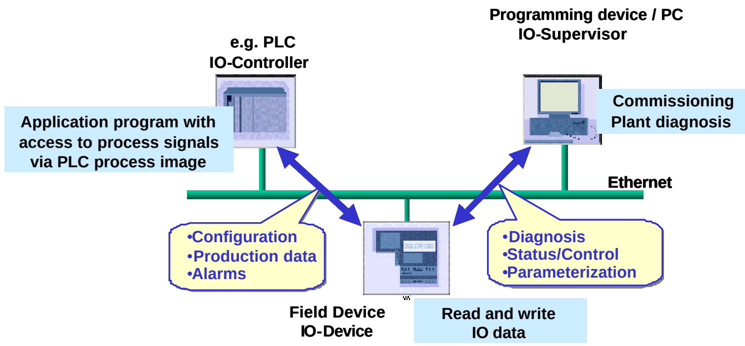


Figure 3.1: Communications pathways in PROFINET IO between different types of device

IO-Supervisor

A PROFINET IO-Supervisor (IO-Supervisor) might be an engineering station in an installation, which has temporary access to the field devices during the commissioning process.

IO-Device

A PROFINET IO-Device (IO-Device) is a decentrally connected field device near the process. It is configured by an IO-Controller or IO-Supervisor and transmits its process data periodically to the IO-Controller. An IO-Device can maintain communications connections to multiple IO-Controllers and IO-Supervisors simultaneously.

PROFINET IO follows during data exchange the Provider/Consumer model. The provider makes data available and the consumer processes the data.

3.2 The device model

Field devices have the duty to collect or outputthe process signals in an automation system. To do this, they need a degree of intelligence, functionality integrated by the manufacturer either in a fixed form or in a configurable way. There are therefore field devices in the following variants:

- *Compact devices* are field devices with fixed, unchangeable capabilities for the exchange of process data.
- *Modular devices* are field devices whose capabilities are adapted to the installation during configuration.

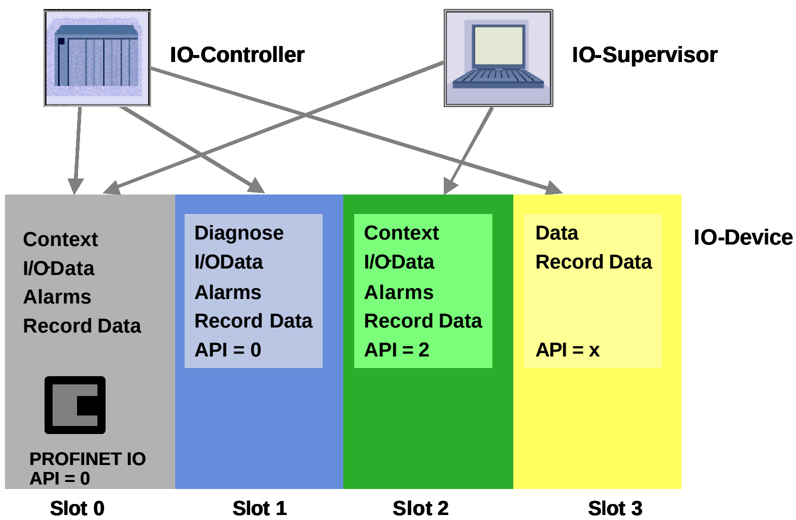


Figure 3.2: The PROFINET IO device model

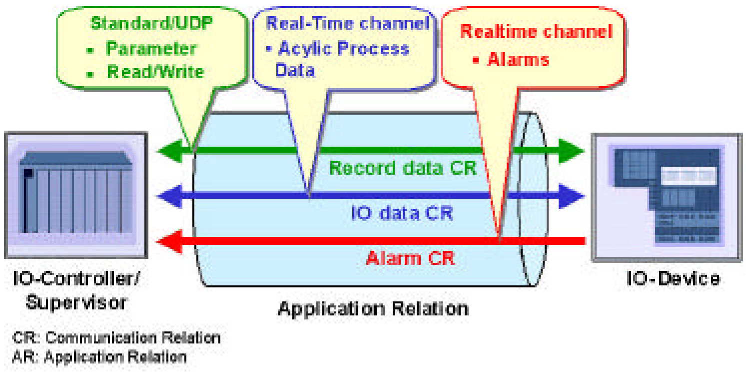


Figure 3.3: In PROFINET IO, I/O data can be sent in different bus cycles

The PROFINET IO application layer describes modular and compact devices in which the desribed modules are represented by physical slots. A slot can contain one or more subslots, and these can in turn have 1 to n channels, the structure of the inputs and outputs being mapped to these channels and set by the manufacturer.

Slot

A *slot* is the physical place of insertion of a peripheral assembly (module) in an IO-Device. Different subslots are located in the different slots, and contain data for cyclical data exchange. Field device manufacturers determine the capabilities of a module. The technical data are defined in the GSD file.

Subslot

PROFINET supports *subslots*, which are an additional addressing layer. Each slot has to own at least one subslot consisting of 1…n channels. For this reason, for example channels that belong together can be grouped. The definition is contained in the GSD file from the manufacturer.

Index

The *Index* specifies the data, related to a specific subslot, to be read or written acyclically.

The access possibilities allowed are determined in the definition of a slot and its subslots. They can be distributed over different IO-Controllers, where each subslot can be mapped to only one IO-Controller for write cycles or alarms. Read access to inputs is allowed from multiple IO-Controllers.

For the simple integration of application profiles (PROFIdrive, etc.) PROFINET IO provides special addressing elements, the so-called API (Application Programming Interface). It is therefore possible to use different APIs to support multiple application profiles in one device.

3.3 The user process

In order to be able to exchange cyclical and acyclical data between an IO-Controller/IO-Supervisor and an IO-Device, the communications channels required have to be established by the IO-Controller when the system boots. The IO-Controller establishes a connection based on the data supplied by the engineering system. The Application Relation (the AR corresponds to the connection) includes all data needed to establish this data exchange. It can be flexibly designed. One more APIs are given within one AR, allowing a finer division of the application (see Figure 3.3). One AR can include multiple communications relations (CRs). The following CRs are thus possible for each API:

- One or more *I/O-CRs* (these break down into input, output, or multicast)
- *Alarm-CR* for forwarding of events
- *Record data CR* for the exchange of acyclic data records

Each IO-Controller/IO-Supervisor can establish an AR to one or more IO-Devices. An IO-Device can exchange data with multiple IO-Controllers. Concurrent write accesses to the same data are prevented by the IO-Device.

3.4 The services of PROFINET IO

Cyclic data exchange

For the cyclic exchange of process signals and high-priority alarms, PROFINET IO uses the RT channel. For transmitting data, PROFINET IO uses the following options for this:

- *RT communication within a network:* For this performance-dependent communication, the fast RT channel, which means no use of UDP/IP, is used (Ethertype 0x8892).
- *RT communication between networks:* For this communication, both the fast RT channel (Ethertype 0x8892) and the protocol mechanisms over UDP/IP are used.
- *IRT communication* for deterministic and clock-synchronized data transmission.

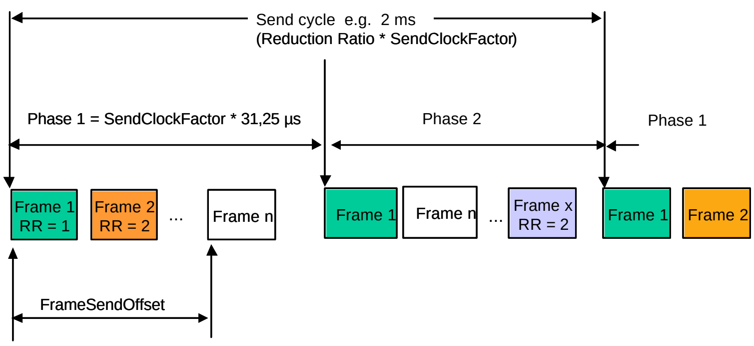


Figure 3.4: In PROFINET IO, I/O data can be sent in different bus cycles.

- *Multicast data traffic* (*MCR= Multicast Communication Relation*) is based on RT as well as IRT communication and consists of a provider which publishes data on the bus and one or more consumers which process the data.

The data exchange between the IO-Device and the IO-Controller occurs in a poll cycle configured by the IO-Controller. The update cycle from the IO-Controller to the IO-Device is specified during configuration with the engineering tool. This results in mutual monitoring of functional operability (watchdog function). All cyclic data has subslot granularity and is provided with a status encoding the validity of the data.

In contrast to PROFIBUS, data transmission in PROFINET IO can be optimized regarding frequency, that is, data can be sent in different phases (see Figure 3.4). To achieve this, PROFINET IO defines a "reduction ratio". It determines the frequeancy of the data transmission.

Acyclic data exchange (record data)

The reading and writing of information (read/write services) can be performed acyclically by the user. The following services run acyclically in PROFINET IO:

- The parameterization of individual submodules during system boot
- The reading of diagnostic information
- The reading of identification information according to the "Identification and Maintenance (I&M) functions"
- The reading of I/O data

Which data can be read or written acyclically is determined during addressing by the index. Some services are standardized. All other services have to be implemented on a user-specific basis.

3.5 Alarms

PROFINET IO sends events within an automation process as alarms which have to be acknowledged by the application process. These include both system-defined events (like the insertion or removal of assemblies) and user-defined events (e.g. defective load voltage) which are detected in the control systems used or have occurred in the process (e.g. boiler pressure too high). The following events are differentiated.

- *Process alarms:* Events which come from the process and are sent to the control system
- *Diagnostic alarms:* Events indicating the malfunction of a field device
- *Maintenance alarms:* Events to transmit information in order to omit a device breakdown by means of preventive maintenance
- *Manufacturer-specific diagnostics*

PROFINET defines a standard set of alarm causes, like

- *Pull and plug alarms* occur in connection with modular IO-Devices, when a module is pulled or plugged in.
- *Return-of-submodule alarms* occur when an IO-Device is supplying data again for a particular input element.

For unique identification, alarms are always raised on a slot/subslot. Diagnostic and process alarms can be prioritized differently by the user.

3.6 Engineering

Each PROFINET IO field device is described by a device description file (GSD). These are provided by the manufacturer.

During engineering the IO-Device is to be configured to the actual system expansion based on the content in the GSD file. The IO-Device is simultaneously integrated, appropriately parameterized and configured into the PROFINET topology (Figure 3.5 (1)).

After completion of the engineering process, the installer loads the data for the expansion into the IO-Controller (Figure 3.5 (2)). The IO-Controller independently takes over data exchange with the IO-Device (Figure 3.5 (3)).

3.7 Address assignment

In IP-based communications, all field devices are addressed by an IP address. PROFINET uses the Discovery and Configuration Protocol (DCP) for IP assignment.

In the factory configuration, each field device has, among other things, a MAC address and a symbolic name stored. These information are enough to assign each field device a unique name (appropriate to the installation). Address assignment is performed in two steps.

- 1. Assignment of a unique plant specific name to the field device.
- 2. Assignment of the IP address by the IO-Controller before system boot based on the plant specific (unique) name.

Both steps occur through the integrated standard DCP protocol.

3.8 The GSD file

All field devices have to be described with their technical and functional options in a GSD file (General Station Description) provided by the field device manufacturer. This is XML-based and written in the GSDML language (General Station Description Markup Language). It includes all data needed by the IO-Controller for engineering and for data exchange. This includes, for instance:

- Description of individual input and output assemblies
- Options for use of I/O modules in slots
- Parameters necessary for the correct operation of the field devices
- Diagnostics which can be produced by a field device, and their meanings
- Description of multiple devices of a family in one file.

The Organizationally Unique Identifier (OUI)

All PROFINET field devices are addressed based on a MAC address. This is globally unique. The part Company Code (Bits 47 ... 24) is obtained for a fee from the IEEE Standards Department. This part is called the Organizationally Unique Identifier (OUI).

PI offers a MAC addresses to all device manufacturers who do not want to apply for its own OOOUI, that is, the OUI of PI and a manufacturer-specific part (bits 23 … 0). Companies can request MAC addresses from the PI Support Center through this service. The assignment of the OUI can be granted in 4k steps.The OUI of PI is 00-0E-CF and is structured as shown in the table below. The OUI can be used to address up to 16,777,214 nodes.

Bit values 47 ... 24						Bit values 23 ... 0					
0	**0**	**0**	**E**	**C**	**F**	X	X	X	X	X	X
Company code						Serial number					

The contents of the GSD file follow the international ISO 15745 standard. One GSD file for PROFINET IO can describe an entire device family (multiple bus interfaces and peripheral modules). For each bus interface (Device Access Point, or DAP) available with the device family, the manufacturer can define a series of peripheral modules. The GSD file is multilingual.

For simple identification of a field device, PROFINET IO defines a device identification. This consists of a company code (Vendor_ID) and a manufacturer-specific code (Device_ID). The Vendor_ID is unique for each company and is assigned once by the PI Support Center. The Device_ID can be defined on a manufacturer-specific basis.

PI provides schemas for the creation of a GSD file and the GSDML specification. There is also a GSD viewer available for the validation and viewing of a GSD file.

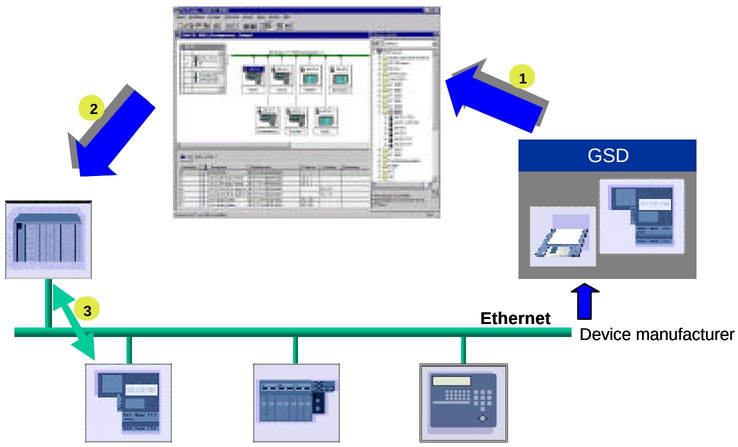


Figure 3.5: From engineering to data exchange

3.9 Replacing devices

Before system boot, each IO-Device must be assigned a unique name (see address assignment). This allows the IO-Device to be accepted in the bus system.

Convenient IO-Devices have all the necessary information in a swappable memory card. When exchanging devices, then, only this module has to be exchanged.

4. Distributed automation with PROFINET CBA

PROFINET CBA is a trand-setting concept for industrial automation which fulfills the requirements of plant builders and operators for an system-wide and manufacturer-independent engineering process. The seamless integration of existing fieldbus systems and Ethernet is an important aspect of the required continuity from the enterprise level down to the field level.

PROFINET CBA has a powerful runtime model available. For the implementation of the PROFINET runtime model in devices, there is an operating-system-independent runtime source software package available for download from the Web site www.profinet.com. It supports the entire PROFINET communication and can easily be integrated into PROFINET CBA devices.

4.1 Component model

Many automation systems can be divided into multiple autonomously working segments. These are called technological modules in PROFINET. They work autonomously and coordinate between one another using a small number of handshake signals.

PROFINET CBA is based on the object-oriented modeling of technological modules. Based on the object model, machines and plants are structured in PROFINET in the form of technological modules. The functionality of the technological modules is encapsulated in uniform PROFINET components. From the outside, PROFINET components are accessed through uniformly defined interfaces. They can be arbitrarily connected in this way.

A distributed automation system designed in this way allows to modularize plants and machines and therefore the reuse of segments of plants and machines. This significantly reduces engineering costs.

Figure 4.1 shows the path from a technological module to a PROFINET component located on the field device in software form.

4.2 PROFINET CBA engineering

For user-friendly configuration of a PROFINET system, a single manufacturer-independent engineering concept is defined. It is based on an engineering object model with which not only configuration tools can be developed which can use the components of different manufacturers, but also manufacturer- or user-specific functional extensions. Thanks to the separation of manufacturer-specific device configuration, parameterization, and programming from system-wide and manufacturer independent engineering with the PROFINET engineering tool (connection editor), products from different manufacturers can be easily integrated into one installation and diagnosed.

The establishment of communication relations is done by drawing lines between the components to be connected. The connection editor then immediately checks the desired connections for plausibility. Exchange of data between the PROFINET nodes is ensured by the configured connections. The technical options for a PROFINET CBA device are described in an XML-based file, the PROFINET Component Description (PCD) which is provided by the manufacturer of the field device.

The engineering model makes a distinction between the programming of the control logic of the individual technological modules and the technological configuration of the overall system. An system-wide application is thus built in three phases:

- Creation of components,
- Establishment of connections,
- Download of the connection information into the PROFINET devices.

4.3 Creation of components

Creation of components (as an image of the technological modules) is done by the machine or plant builder. The programming and configuration of the individual devices (intelligent field devices, controllers) is done as always, with the corresponding manufacturer-specific tools. Afterwards, the user software is encapsulated in the form of PROFINET components.

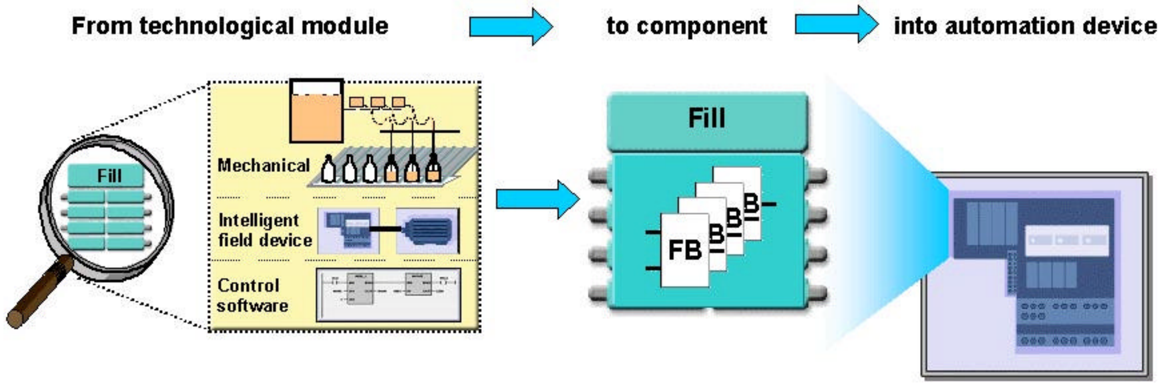


Figure 4.1: A PROFINET component represents an autonomous part of an automation system.

To do this, the device manufacturers merely need to extend their software tools with the new component interface. This generates the PCD with the prescribed structure, and with contents as specified in PROFINET. In this way, existing user programs, and the know-how of programmers and service personnel, can continue to be used.

4.4 Component connections

The PROFINET components generated are connected up into an application from a library using the connection editor. This connection replaces the previous costly programming of component relationships with simple graphical configuration.

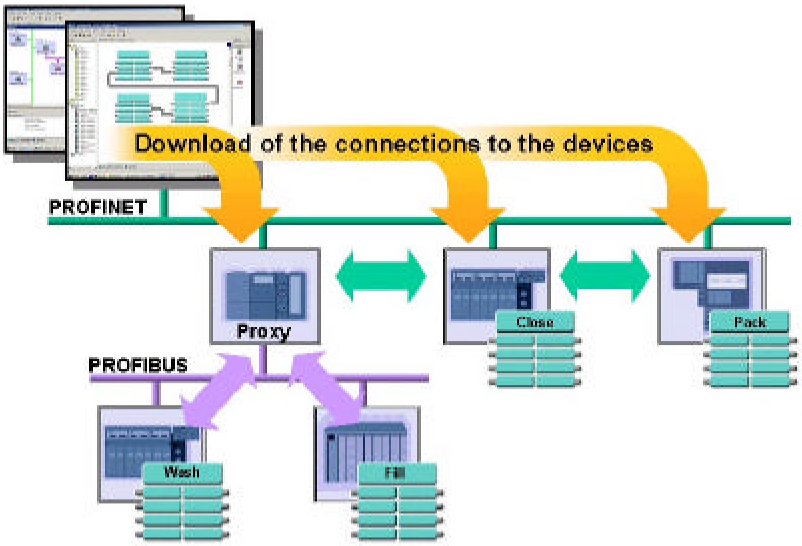


Figure 4.2: The download of connection information to PROFINET devices is done in each consumer.

The PROFINET engineering tool binds the individual distributed applications together throughout the plant. It works in a manufacturer-independent manner and can therefore connect PROFINET components from any manufacturer together. The decisive advantage is that communications must no longer be programmed.

4.5 Download of connection information

Connection information is loaded into the PROFINET devices according to the component connection plan. This means that each component knows its own communications partners, communications relationships, and the information to be exchanged.

Establishment of the communications connections to the partner and data exchange occur automatically. The connection information is loaded into each consumer, which then independently creates and monitors the communications connections to the participating partner devices.

PROFINET CBA communications work based on the TCP/IP, UDP/IP or RT mechanisms.

5. Network installation

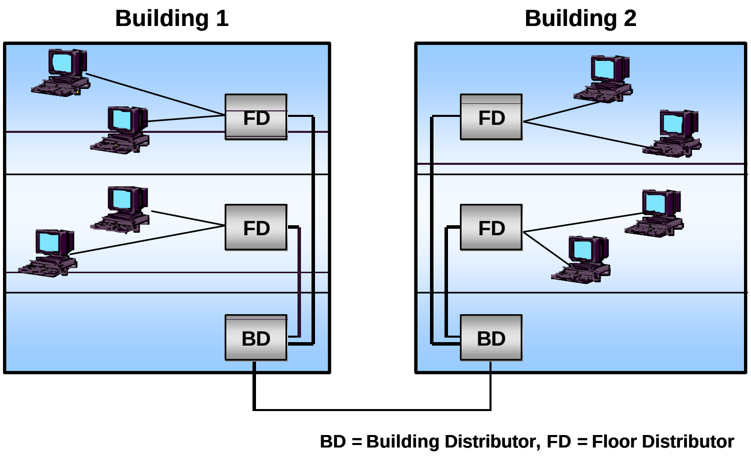


Figure 5.1: The structure of Ethernet network in the office usually has a star topology

The international standard ISO/IEC 11801 and its European equivalent EN 50173 define an application-neutral information technology standard networking for a building complex. They are largely identical in content. Both standards assume an office-like usage for the building and include the requirement of application neutrality.

The specific requirements for Ethernet networks in the industrial environment, like

- installation-specific cabling
- individual degree of net-working for each machine/plant
- line network structures
- rugged, industry-compatible cables and plug connectors designed to meet particular EMC, temperature, moisture, dust, or vibration requirements

are not taken into account in these standards. The "PROFINET Installation Guideline " thus defines an industry-standard cabling for Fast Ethernet based on the determinations of IEC 11801.

5.1 Network topologies

Network topologies are oriented towards the requirements of the installations to be networked. The most common include star, line, tree, and ring structures. In practice, a system consists of a mixed form of the structures examined individually below. They can be implemented and used with PROFINET with either copper wiring or with fiber optics.

Star

The defining characteristics of the star structure is a central signal distributor (switch) with individual connections to all the terminals of the network. Applications for star network structures are areas with high device density in small distances, like small manufacturing cells or a single production machine.

Tree

The tree topology results from the combination of multiple stars into one network, possibly mixing fiber optic and twisted pair cabling. It is used when dividing complex systems into system segments.

Line

The line structure can be realized by a switch in the vicinity of the terminal to be connected, or by a switch integrated into the terminal.

The line structure is used preferentially in systems with far-flung structure, such as conveyor systems and when connecting manufacturing cells.

Ring (redundancy)

If the ends of a line are connected together, the result is a ring structure.

Ring topologies are used in systems with increased availability requirements to protect against line breaks or the failure of one network component.

Office Area	Automation Area
Fixed basic installation in a building	Largely system-related cabeling
Laid under raised floors	System-related cable routing
Variable device connection at workplace	Connection poins are seldom changed
Pre-fabricated device connection cable	Field-preparable device connections
Tree-shape network structures	Quite often: line-form network structures and (redundant) ring structures
Large data packets (e.g. images)	Small data packets (measured values)
Medium network availability	Very high network availability
Moderate temteratures (form 0 to 50°C)	Extreme temperatures (from -20 to +70°C)
No moisture	Moisture possible (IP65)
Virtually no vibrations	Vibrating machines
Low EMC burden	High EMC burden
Low mechanical danger	Danger of mechanical damage
Virtually no chemical danger	Chemical burden from oily or aggressive atmospheres

Table 5.1: The differences between office and automation technology are taken into account in PROFINET.

5.2 PROFINET cabling

Industry-standard cables can be subjected to extreme mechanical stress. They require special construction. The Installation Guideline has defined different cable types which are optimally adapted to a variety of particular industrial conditions. Sufficient system reserves allow the construction of an industry-standard installation with no limitation on transmission distance.

At the field level, there is a similar requirement for the cabling as for PROFIBUS. Since some nodes are supplied with 24V power in addition to the data connection, a hybrid

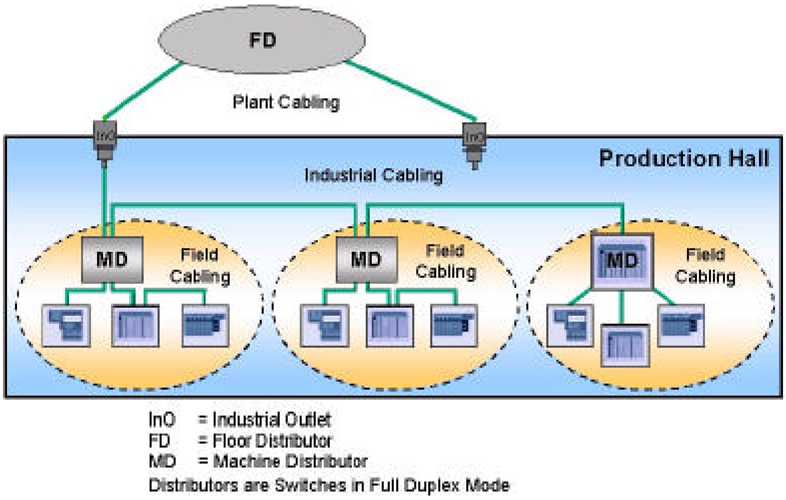


Figure 5.2: Ethernet networks in industrial applications usually have linear topology

wiring structure works well here. Hybrid cables include lines not just for signal transmission, but for power transmission as well.

Optical fibers are not sensitive to electromagnetic influences and can allow longer network spans than copper twisted pair wiring.

PROFINET cabling with copper twisted pair

Signal transmission over symmetrical copper cables (twisted pair) uses 100BASE TX with a transmission speed of 100 Mb/s (Fast Ethernet). The transmission medium is defined as two shielded copper cable pairs, twisted in pairs (STP = Shielded Twisted Pair).

Only shielded cables and connection elements are permitted. The individual components have to fulfill at least the requirements of Category 5 of IEC 11801. The entire transmission path must satisfy the requirements of Class D as defined in IEC 11801. PROFINET cables have also to have a cable cross-section of AWG 22 so that attenuation is minimized and complex wiring structures thereby enabled. For this reason, the specification for PROFINET cables supports a modular setup, which states that if simple installation rules are followed, an IEC 11801-compliant structure is ensured.

Detachable connections are made using RJ45 or M12 plug connector systems. The device connections are implemented as jacks. The connecting cables (device connection, ranging cables) are equipped with appropriate plugs on both ends which can be configured with the specified AWG 22 cable.

All devices are attached to an active network component. Network components in PROFINET are switches. The specification of network components ensures simple installation. Transmission cables are configured with the same plugs on both ends and in the same pin layout. The maximum segment length is 100 meters.

PROFINET cabling with fiber optics

PROFINET can be operated with multimode or single mode fiber optic conductor lines. Signal transmission occurs over 2 optical fibers in accordance with 100BASE-FX at a transmission rate of 100 Mb/sec. The optical interfaces conform to the specifications of ISO/IEC 9314-3 (multimode) or ISO/IEC 9314-4 (single mode).

For applications outside the switchgear cabinet, the outer sheathing has to meet the appropriate requirements for the installation location (mechanical, chemical, thermal, etc.).

For multimode, the maximum segment length is 2 km, and for single mode 14 km.

5.3 Plug connectors

A significant criterion for industrial usability is the manageability of the connector technology on site. That is why there are plug connectors for both M12 and RJ45 available. They are easy to configure on site with standard tools.

Connetors for copper area

In the switching cabinet, the RJ45 is used in the IP20 variant for PROFINET. It is compatible with office plug connectors. Plug connectors outside the switching cabinet must meet industrial requirements to an unusual degree. Here, the RJ45 types in IP65 or IP67 or type M12 are used.

Figure 5.3: Example of an RJ45 plug in IP20

The RJ45 in IP65/IP67 is housed in a rugged housing with a push/pull lock. Special variants allow protection classes up to IP68.

The RJ45 plug connectors specified for PROFINET are the variants 14 and 5 in the IEC 61076-3-106.

Figure 5.4: Example of an RJ45 plug connector in IP67

For the M12 plug connectors, the shielded D-coded variant from the IEC 61076-2-101 is used.

Hybrid plug connectors are used in places where distributed I/O modules are connected through a combined plug connector with data and power supply. These are RJ45 connectors in IP67 with a 2-pair, shielded data line for communications and 4 copper lines for power supply. Here, too, the fully touch-protected plug connector enables the use of the same plugs on both ends, since the integrated touch protection makes it unnecessary to swap pins.

Figure 5.5: Example of an RJ45 hybrid plug connector in IP67

Connetors for fiber optics

Connections using fiber optics are preferably implemented compliant with ISO/IEC 11801 with the duplex SC plug connector system. This is described in IEC 60874-14.

The latest device generations contain SC-RJ connector technology in accordance with EN 50377-6. This plug connector system links the advantage of a smaller form factor with the robustness of the SC plug connector required in an industrial environment. The SC-RJ plug connector is employed for the first time in the PROFINET networking

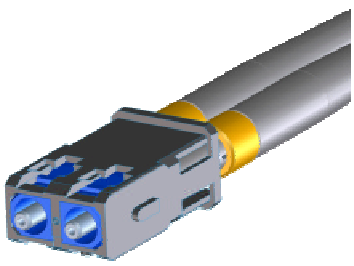


Figure 5.6: Example for a SC-RJ Connector

with optical plastic fiber. The robust connector is well-suited for field assembly. IP65/67 variants in a housing with push/pull lock permit optical connecting points for rugged industrial use outside of a control cabinet.

5.4 Switches

PROFINET generally uses switches for network components. Switches are devices which lie in the transmission path between terminals and regenerate and resend any signals received. They serve to structure the network. The basic specifications are found in ISO/IEC 15802-3.

Switches suitable for PROFINET are designed for Fast Ethernet (100 Mb/sec, IEEE 802.3u) and full-duplex transmission. In full-duplex mode, a switch sends and receives data simultaneously on the same port. When using switches, no collisions occur. Thus no bandwidth is lost to the Ethernet collision process. Network configuration is significantly simplified in that the inspection of segment lengths within a collision domain is unnecessary.

To maintain compatibility with older systems or individual older terminal devices or hubs, 10BASE-TX (10 Mb/sec, CSMA/CD) is supported. Furthermore, a PROFINET switch supports prioritized telegrams per IEEE 802.1Q, standardized diagnostic channels, and auto polarity exchange, autonegotiation mode, and the auto-cross-over function. Port mirroring for diagnostic purposes is optional.

Office switches may be used if they conform to industrial specifications. Industrial Ethernet switches are designed mechanically (IP protection class, etc.) and electrically (24 V power supply, etc.) for rugged industrial use. On the other hand, they have also to fulfill the EMC requirements of the machine in the industrial environment in order to permit reliable operation.

5.5 Wireless

The advantages of wireless data transmission are increasingly being applied in the industrial arena. This is not just for the savings in cabling costs and installation expenditure. The flexibility and mobility of wireless network infrastructure also enables completely new solutions in areas where electrical lines cannot be used, or can only be used with limitations, due to mechanical limitations, security requirements, or other environmental considerations. Application fields, for instance, are the integration of moving system parts into the communications infrastructure, or the connection of difficult to reach sensor, and also mobile operation and observation, driverless transport systems, and the like.

PROFINET communications is also possible on these wireless communications networks. PROFINET has to be ready to operate with different radio technologies for different application areas, with specific parameters regarding transfer rates, range, number of nodes, and similar. Thus profiles are specified for each technology which specify how integration into PROFINET is done, which topologies and performance values can be achieved with the technology, and what sorts of conditions apply, for instance regarding security requirements.

The specification of these profiles is an ongoing task and must keep pace with the availability of radio technologies and the requirements in the field. As a first step, a profile for WLAN is being prepared corresponding to the standards from 802.11.

6. IT integration

By using the Ethernet as a communication medium, not only the described automation technology functionality can be integrated into Ethernet, but also IT functions.

Ethernet imposes additional requirements on network management in contrast with the fieldbus world in connection with TCP, UDP and IP. In order to regulate all technical aspects of the integration of PROFINET devices into such networks, a network management concept has been specified for PROFINET. The components of the concept are basically the topics of network infrastructure, IP management, network diagnostics, and clock time synchronization. Network management simplifies the administration and management of the Ethernet by using standard protocols from the IT world.

An additional aspect is the use of Internet techniques in automation technology. PROFINET specifies a concept in the framework of Web integration which enables access to PROFINET devices. This is done using Web services based on standard technologies from the Internet arena.

6.1 Network management

Network management includes all functions for the administration of the network, like configuration (assignment of IP addresses), error monitoring (diagnostics), and performance optimization.

IP management

The use of TCP, UCP, and IP in PROFINET results in the requirement of assigning node participants, e.g. the PROFINET devices, their own IP parameters (IP addresses, subnet masks, etc.)

- *Automatic address assignment with the PROFINET engineering system*: PROFINET specifies the DCP protocol (Discovery and Basic Configuration), which enables the assignment of IP parameters with manufacturer-specific configuration/ programming tools or in plant-wide engineering, e.g. in the PROFINET connection editor. DCP is mandatory in PROFINET, ensuring the uniform behavior of all PROFINET devices.

- *Automatic address assignment with DHCP:* In the office arena, the Dynamic Host Configuration Protocol (DHCP) has established itself as the de facto standard. PROFINET provides for the use of this standard and describes how DHCP can be used sensibly in the PROFINET environment. The implementation of DHCP in PROFINET devices is optional.

Diagnostics management

The reliability of network operations has a very high priority in network management. In existing networks, the *Simple Network Management Protocol (SNMP)* has established itself as the de facto standard for maintenance and monitoring of network components and their functions. In order to be able to monitor PROFINET devices with established management systems, SNMP is to be implemented. SNMP provides for both read access (monitoring, diagnostics) and write access (administration) to a device.

In PROFINET, only read access to device parameters are currently specified. Optionally, SNMP can also be implemented. When implementing SNMP in components, most access is to the standard information for SNMP (Management Information Base 2 (MIB 2)).

The specific diagnosis of PROFINET components is possible using the mechanisms described in the PROFINET specification. SNMP should not open any other diagnostic channels in this context. It should only enable integration into network management systems which do not ordinarily process PROFINET-specific information.

6.2 Web services

Not only the use of modern Ethernet-based technologies is possible for PROFINET. A PROFINET component can also be accessed by an application using Web clients based on standard technologies from the Internet sector, like HTTP, XML, HTML, and scripting.

The data is transmitted in a standardized format (HTML or XML) and displayed using standard front ends (browsers like Netscape, MS Internet Explorer, Opera, etc.) This enables the integration of information from PROFINET components into modern multimedia-supported information systems. The advantages of Web integration into the IT area, like

- the use of browsers as uniform user interfaces,
- location-independent access to information on an arbitrary number of clients,
- platform-independence of the clients, and
- reduction of the cost of installation and maintenance for client-side software

are all made possible for PROFINET components.

Functional characteristics

The main focus of the PROFINET Web integration is the aspect of commissioning and diagnostics. Web-based concepts can be used particularly effectively within this area of application.

- No special tools are needed for access, since established standard tools can be used.
- Due to worldwide accessibility, it is simple for the manufacturer to support the user during commissioning.
- The self-description of components enables access with a standard tool without configuration information.

Possible usage scenarios for Web integration in the areas of commissioning and maintenance are, among others, testing and commissioning, an overview of device master data, device diagnostics, and installation and device documentation.

The representation of the information available should be in both a format readable by humans (e.g. using a browser) and in a machine-readable form (e.g. an XML file). Using PROFINET Web integration, both variants are consistently available. For certain information, PROFINET Web integration also provides standardized XML schemas.

Technical characteristics

The basic component of Web integration is the Web server. It forms the interface between PROFINET and the basic technologies for Web integration.

Web integration in PROFINET can scale up with the performance and characteristics of the Web server. This means that even simple PROFINET devices, equipped only with an "embedded Web server", have equal rights with a PROFINET device with an "MS Internet Information Server" or the "Apache Web server" when participating in Web integration.

The Web functionality is scalable. This makes scalable solutions realizable which are configured as perfectly as possible for the current application case. The PROFINET-specific elements can be integrated seamlessly into the existing Web implementation of a component.

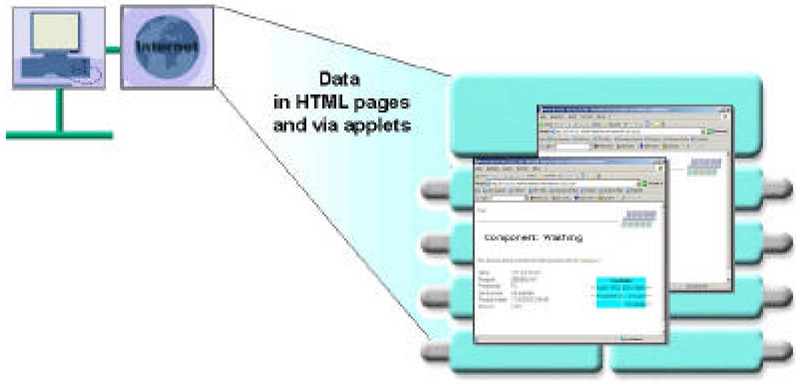


Figure 6.1: Web integration enables Web access to PROFINET components

6.3 OPC and PROFINET

OPC can be used for the integration of PROFINET systems with business systems, since OPC has already been a wide spread standard in the IT world.

Through the OPC interface, process and maintenance information can be transmitted from production to the business system.

OPC servers for PROFINET are already available. Arbitrary OPC clients can be used to access PROFINET data transparently through these server.

7. Security

The current trends of automation technology and the increasing usage of Ethernet in the automation industry, the options for remote maintenance through the Internet, and the networking of installation networks with offices networks or company-internal Intranets, all increase the potential risk considerably (hacker attacks, data manipulation and espionage, viruses, worms, and Trojans).

Since security concepts from the office area really do not suffice for the particular requirements in the automation arena, security concepts for data security in automation technology must be developed.

The PROFINET security concept can handle the great need for network security in Ethernet-based automation systems. This concept fulfills the requirements for access control, data encryption, authentification, and logging of security-relevant events.

7.1 Types of threat

The particular focus of security in automation technology is to ensure the availability, reliable operation, and protection of industrial plants and production processes. Potential threats in automation systems can come from outside via the Internet just as well as from inside via the office network.

Firewalls protect against risks coming from the Internet.

From the internal office network, there can for instance be temporarily high communications traffic (e.g. triggered by broadcasts) which lead to a production process being affected or even interrupted. Here, it is necessary to limit unnecessary communications.

Basically, access from the office network to the automation network has to be permited.

Malicious software like viruses, worms, and trojans are seen by most companies as the greatest security risk. The spread of these programs can be so fast that not even multilevel firewalls can provide sufficient protection, since appropriate patches for operating systems or virus signatures for virus scanners are generally available only after 1 or 2 days.

In order to keep potential risks as low as possible, installation and production networks must be locked away from the networks of the rest of the company. This can be achieved by controlled and uniquely identifiable communication between the systems network and the office network or company Intranet.

Until now, however, existing security concepts have largely been designed for protection against threats from the Internet, and can counter this sort of threat from the office network only partially at best. The special requirements of automation technology are also not taken into account.

7.2 PROFINET security concept

The core of the security concept is in the security-motivated segmentation of the automation network. Secure automation cells are built. The network nodes within a cell are protected by special security network components (e.g. switches or security appliances) which control the data traffic from and to the cell and check access privileges. Only authorized data traffic is permitted. Access from client PCs to secure automation devices can be performed with a special security client software. The terminals thus require no security functionality of their own.

Data traffic between secure cells or between clients and the cell nodes can also be encrypted, thus secure against data espionage and data manipulation. This is especially interesting in the case of communication over insecure networks, such as is the case with remote access over the Internet for maintenance intervention.

The PROFINET security concept offers the following significant advantages:

Protection of devices without their own security functionality

Existing networks or automation devices can be secured with no side effects. In many cases, extension of automation devices with their own security functionality is either, technically infeasible, particularly due to the fact that smaller automation devices do not have the necessary technical hardware features, or it would not be economical. The cell concept provides a very efficient option for securing existing networks.

Simultaneous protection of multiple devices

With the cell concept, multiple devices can be secured simultaneously, meaning smaller costs for the user and also significantly lower configuration effort, since not all terminals have to be individually configured for security.

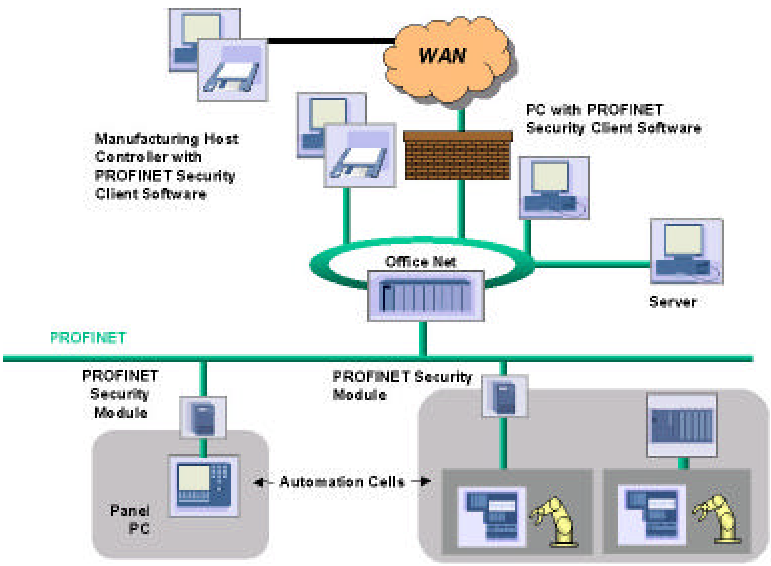


Figure 7.1: The core of the PROFINET security concept is the security-motivated segmentation of the automation network

Real-Time and security

Real-Time capability and security are basically conflicting requirements. Any security mechanism have to check, based on rules or configurations, whether certain connections or access are allowed or not. That costs time and performance, too. But with the cell concept, it is possible to achieve both at once.

Within the cell, Real-Ttime data traffic can run free of influence from any security mechanism. Access to devices inside the cell is only checked at the cell input.

Integrated protection from malicious software

Viruses, worms, and trojans have to be ranked as serious threats. However, virus scanners cannot be used as the usual counter in many cases in the industrial segment, since it weighs down performance to such an extent that production data traffic can be suppressed or break down.

Another disadvantage of virus scanners is their very high maintenance cost. Updates to the virus patterns have to be made often – in some situations multiple times per day. In the automation field, it is not practical for industrial PCs to be rebooted several times a day.

For new threats, the time elapsed between appearance of the virus (or similar) and availability of a corresponding update is at least 1 or 2 days. During this time, the virus scanner is helpless against the threat. All in all, this means that in the industrial environment virus scanners are only of partial usefulness.

Since PROFINET security network components allow only authorized access to the automation devices, only the accessing device have to be correspondingly protected, insofar as the possibility of a virus attack exists. The industrial PCs within a secure cell thus generally need no virus scanners, reducing costs to an enormous degree and avoiding performance hits.

Moreover, PROFINET security network components are capable of blocking unneeded ports, greatly reducing the risk of infection by malicious software, since these often require specific ports to be open, e.g. email viruses needing port 80.

Despite all this, a virus infection can never be fully ruled out. Here, too, the security segmentation of the installation network is an advantage, since the entire network is not affected and further spread is prevented or at least slowed.

Protection of underlying fieldbuses

The underlying fieldbuses, like PROFIBUS, are connected via proxies in PROFINET, and thus correspond to an automation component from the point of view of the Ethernet. It is fully sufficient to secure Ethernet data traffic, so the PROFINET security concept is also capable of securing a fieldbus connected to the Ethernet.

The protection functions of the security components

The protection function can be implemented from and to cells (including blocking and releasing of IP and layer-2 services) by control of the entire data traffic (based on IP and layer 2), and suitable processes can be used for secure identification (authentification) of the network node or serve to encrypt the data.

PROFINET security components use open and established IT security mechanisms, whereby the integration into the collection of networks in the office environment can be achieved. Firewall mechanisms are available for control of data traffic, and certificate-based VPN or SSL for the secure identification and encryption of the data. VPN and SSL certificates have the advantage that, unlike IP or MAC addresses, they cannot be falsified, rendering them suitable for higher security requirements.

8. PROFINET and MES

The integration of automation systems, Manufacturing Execution Systems (MES) and Enterprise Resource Planning (ERP) is gaining importance in company-wide, integrated information systems. While the interfaces between MES and ERP are defined in the context of the IEC 62264 specifications, until now there has been no specification for interfaces between MES and automation systems.

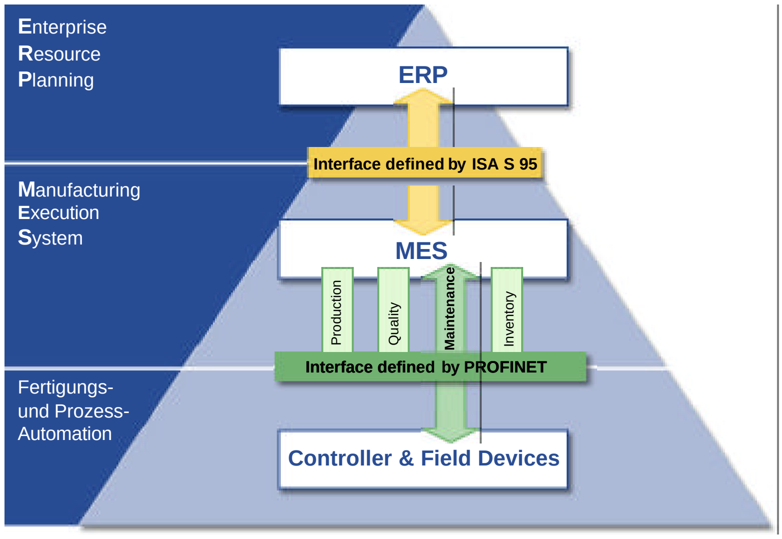


Figure 8.1: Maintenance operations

8.1 Operations in MES

IEC 62264 divides MES into the following four operations:

- Maintenance Operations
- Production Operations
- Quality Operations, and
- Inventory Operations.

Since the topic of maintenance has great significance in both factory and process automation, Maintenance Operations is supported first by PROFINET. The result is a corresponding document in which, among other things, the information content important for an MES interface is defined.

8.2 Maintenance State

In maintenance, the procedure of state-based maintenance is currently gaining significance. It is based on the capability of devices and components to determine their states and to communicate them over agreed mechanisms.

PROFINET devices send their status to higher-level devices in a standardized format. A state model is available for this purpose, which besides the states "good" and "failure" also defines the two pre-warning levels "maintenance request" and "maintenance demand."

8.3 Identification

Besides the Maintenance State, the capability of devices and components to provide up-to-date "type plate information" and the information needed for functional and local assignment is an important prerequisite of MES Maintenance Operations.

The functions already defined in the document "Identification and Maintenance Functions (I&M)" have therefore also to be integrated into PROFINET devices.

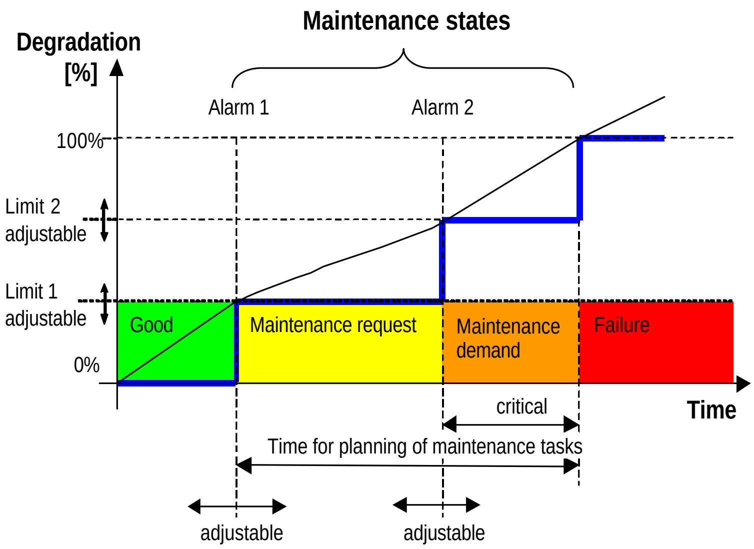


Figure 8.2: Maintenance states

9. Application profiles

Application profiles are common specifications by manufacturers and users about particular characteristics, performance features, and behaviors of devices and systems. This unification with the help of application profiles has the following advantages:

- ***Plant operators:*** The existence of certified profile-conform devices provides a wide independency from single device manufacturers without loosing a profound set of functionality,
- ***System integration and installation:*** The use of certified devices guarantees a high degree of conformity and interoperability, since the devices pass a wide range of tests being elaborated and agreed within PI.
- ***Planing:*** Through the unification of the device basic functionality a unified nomenclature comes up that brings a tremendeous simplification of the product choice.
- ***Device manufacturer:*** Unification of the use and extension of the achievable integration depts of the devices in different automation systems

The concept of the profile extends from a few specifications for a particular class of devices to thorough specifications for applications in a particular industrial branch. The term *application profile* is used as an overarching concept.

In general, two groups of application profiles are distinguished:

- *General application profiles* with applicability to different application fields (this includes the PROFIsafe profile, for instance).
- *Specific application profiles* which are developed only for a particular type of application, like PROFIdrive, Encoder, Ident Systems, or PA Devices.

PROFIBUS offers a large number of these profiles and can therefore be used in an application-oriented way. These profiles are integrated into PROFINET step by step as required.

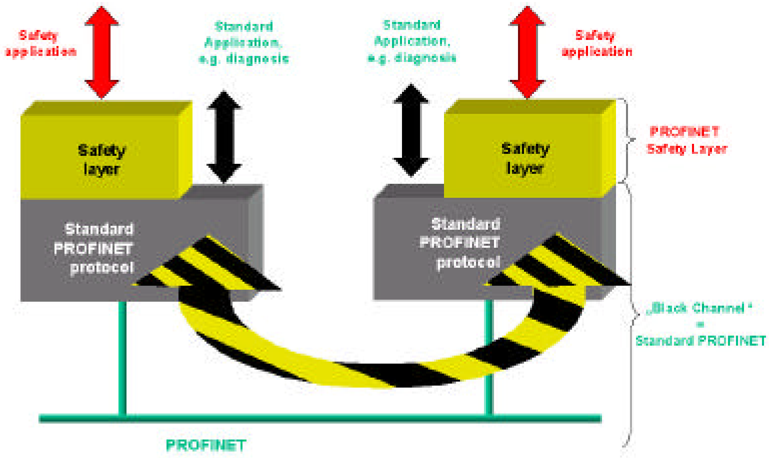


Figure 9.1: Safety-oriented operation with PROFIsafe

9.1 PROFIsafe for PROFINET

Distributed I/O for factory and process automation had to live for a long time with the restriction that security tasks could only be triggered with conventional technology on a second level or decentrally over special buses. PROFIBUS with PROFIsafe for security-relevant applications was the first system to create a complete, open solution able to handle the known user scenarios. PROFIsafe for PROFINET follows the same principles.

PROFIsafe defines how safety-oriented devices (emergency shutoff switches, light grids, overfill protection systems, etc.) can communicate safety control information over a network securely enough that they can be used in safety-oriented automation tasks up to EN954's KAT4, AK6, or SIL3 (Safety Integrity Level). It implements secure communication with a profile, that is, using a particular format for user data and a special protocol.

The specification was collaborated upon by manufacturers, users, standardization organizations, and testing institutes (TÜV, BGIA). It is based on uniform standards, particularly on IEC 61508, which specially addresses requirements for software development.

PROFIsafe takes all error possibilities into consideration (except for sabotage – Sequrity has to be used for this) which can arise in serial bus communications, like delay, loss or repetition of data, incorrect order, incorrect addressing, or data falsification.

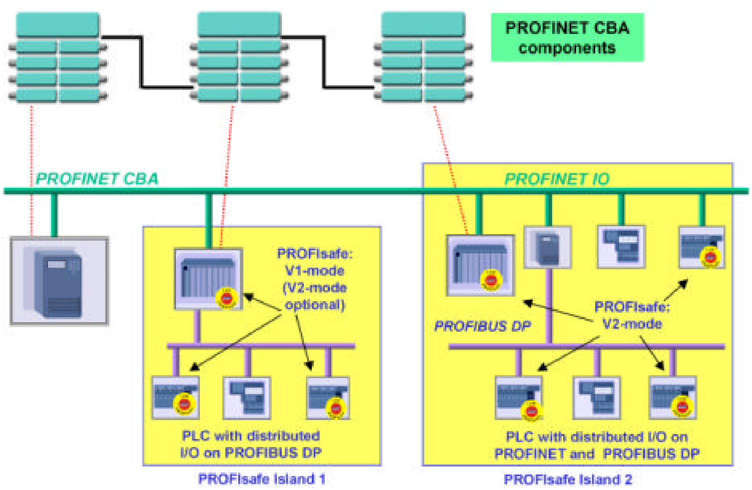


Figure 9.2: PROFIsafe is available for PROFIBUS and PROFINET IO

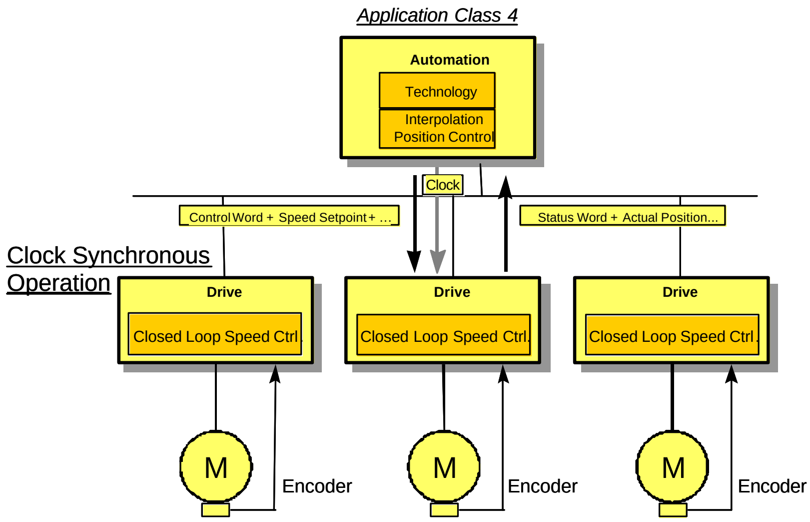


Figure 9.3: PROFIdrive positioning with central interpolation and orientation regulation

There are a series of protective measures from which the following were selected for PROFIsafe:

- Serial numbering of security telegrams
- Time expectation for incoming telegrams, with a new consecutive number and confirmation
- Passwords between sender and receiver
- Additional data security (Cyclic Redundancy Check, CRC)

The skillful combination of these protective measures, along with a patented "SIL monitor" (to monitor the frequency of defective messages) allows PROFIsafe to reach security classes up to SIL 3 and higher.

The PROFIsafe profile V2 is also available for use with PROFINET. It is suitable for use with PROFIBUS as well as with PROFINET. The possibilities of Ethernet-based communications, such as significantly higher resources (address space, telegram size, etc.) and the use of active network components (switches, routers) are taken into account in the new version.

9.2 PROFIdrive for PROFINET

The drive profile PROFIdrive describes a common interface between drives and the overlying control process as well as the mapping of this interace to the communication systems PROFIBUS and PROFINET.

Scope of function

The PROFIdrive profile covers all application scenarios from simple frequency converters to highly dynamic servo drivers. The functionality was broken down into six application classes.

Application class 1 targets applications with simple drives, like frequency converter, in which the drive is controlled through an RPM or frequency target by the overlying automation system.

In *application class 2*, the automation processes overlying the drive are subdivided into many subprocesses and distributed over the drives. The interface between control and drive corresponds to a high-level technology interface. All drive-related regulation processes run in the appropriate drive.

In *application class 3*, the drive functions as an autonomous one-axis positioning drive, while the control coordinates the overlying technological processes.

In *application class 4*, RPM regulation is done on the drive, and position regulation in the control; this is typical for motion control and robotics applications. The strong requirements for movements accuracy assume clock-synchronized operation (see Figure 9.3).

In *application class 5*, a position target interface is used. Positional regulation in this case is done in the drive.

Application class 6 covers applications with distributed automation and angle synchronization between drives. In these applications, clock-synchronized operation and multicast communications between drives are necessary.

Drive model

The drive model defined in PROFIdrive is built on the device model for PROFIBUS and PROFINET. The data exchange between control and rive is based on corresponding services of the communications system used (see Figure 9.4).

Drive parameterization

The configuration of a drive is done by setting parameters. PROFIdrive defines a protocol for the trans-

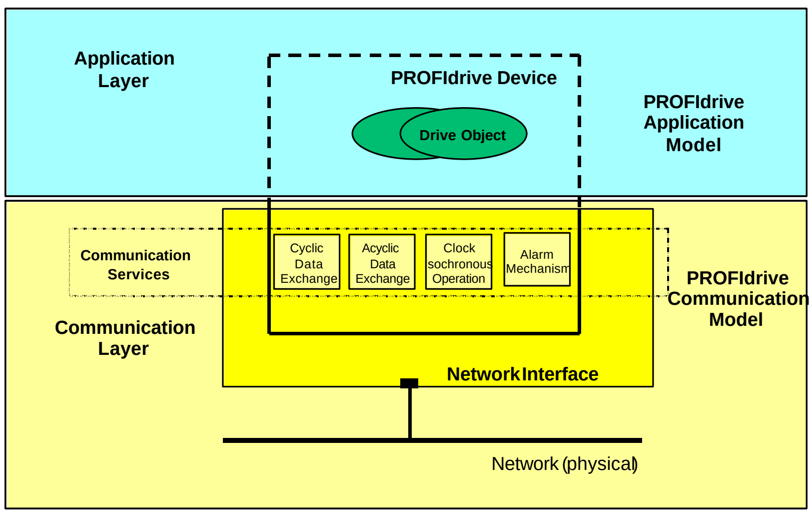


Figure 9.4: PROFIdrive basic model (application layer and communication layer)

mission of parameters between the control or engineering system and the drive. The protocol is transmitted over the standardized services of PROFIBUS or PROFINET. In a profile-specific area, PROFIdrive defines parameters for the configuration of the PROFIdrive interface. This enables the interoperability between drives from different manufacturers.

Migration

The functionality of PROFIdrive, previously available only for PROFIBUS, was extended to PROFINET with the version PROFIdrive V4.0, while keeping the user interface. This makes a problem-free migration from PROFIBUS to PROFINET possible. The functionality is independent of the communication system used.

9.3 PROFINET profile for devices in process automation (PA)

Requirements from the process engineering sector of the physical transmission technology implemented especially with PROFIBUS PA, such as intrinsic safety and bus power from devices, will also be available for systems based on PROFINET via gateway between PROFINET and PROFIBUS PA. PROFINET protects the investment in existing PROFIBUS PA systems and otherwise provides migration options from PROFIBUS PA to PROFINET. These gateway solutions are based on the PROFIBUS integration in PROFINET IO (see Chapter 11).

This secures the already taken investments.

9.4 Communication Function Blocs

The communication services for PROFIBUS and PROFINET are defined in IEC 61158-5. The representation of these services in applications depends on the respective control systems and devices supplied by different manufacturers.

In the field of PLC, IEC 61131-3 is recognized as the worldwide standard that specifies the programming model and the programming languages. The standard defines a set of language elements and mechanisms (e.g. data types, function blocks) that are used similarly in a well-defined set of programming languages (e.g. ladder diagram, structured text).

There is available a common set of communication building blocks for PROFINET IO and PROFIBUS DP. These building blocks can be used in application programs, that use the IEC 61131-3 languages.

Thus, a vendor independent interface for access to PROFINET IO-Devices and PROFIBUS DP-Slaves is defined.

The application profiles to couple identification and weighing already use these communication buidling blocks. There are correspondent application specific buidling blocks available.

9.5 Additional profiles

Besides the application profiles described, a series of additional profiles for PROFINET will be released soon. The profiles already available for PROFIBUS will be converted to PROFINET, and new profiles are also being specified. The Train Applications profile is one of those initial new profiles.

Train Applications

Train Applications include application profiles for devices in rail automation. Through the use of PROFINET, Real-Time and IT communications are made available for applications in rail vehicles.

The standardization of subsystems is furthered by the creation of device profiles. A PROFINET profile for the rail communications network standardized and widespread in rail vehicles is being specified based on Wired Train Bus (WTB) and UIC specifications. Later steps will result in profiles for a variety of subsystems in rail automation.

10. Fieldbus integration

PROFINET specifies a model for the integration of existing PROFIBUS and other fieldbus systems like INTERBUS and DeviceNet. This allows the construction of arbitrarily mixed systems consisting of fieldbus- and Ethernet-based segments. Thus a smooth technology transition is possible from fieldbus-based systems to PROFINET.

The large number of existing fieldbus systems makes it necessary to support their simple integration into PROFINET for reasons of investment protection. The following cases are distinguished:

- The *system operator* would like to be able to integrate existing installations into a newly installed PROFINET system easily.
- The *plant and machine builder* would like to use the established, available device lines unchanged for PROFINET automation projects.
- The *device manufacturer* would like to be able to integrate existing field devices into PROFINET installations without any costs of change.

Fieldbus solutions can easily and seamlessly be connected into a PROFINET system using proxies. The proxy functions as a representative of the fieldbus device on the Internet. It integrates the nodes connected to the underlying fieldbus system into the overlying PROFINET system. This allows the advantages of fieldbuses like high dynamics, locally exact diagnostics, and automatic system configuration to be used in the PROFINET world without settings in the devices. The transfer of system advantages simplifies planning due to well-understood workflows and the commissioning and operation using the complete diagnostic capabilities of the fieldbus system. Device and software tools are also supported in the usual manner and integrated into the management of the PROFINET system.

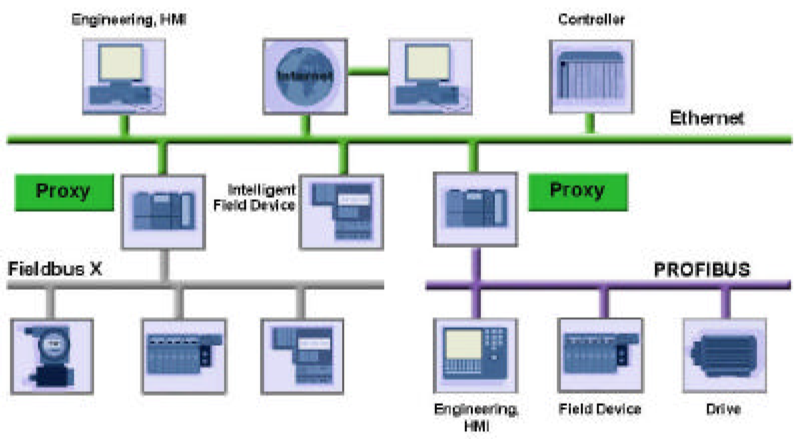


Figure 10.1: The integration of fieldbus systems is easy with PROFINET

10.1 Integration into PROFINET IO

Fieldbus integration into PROFINET IO is based on the proxy concept. Usually, fieldbus systems are integrated into PROFINET IO as modular device.

Each fieldbus node is built on their own module in only one IO-Device. Thus the data of all modules can be transmitted in one Ethernet frame. The characteristics of the fieldbus nodes continue to be available to the corresponding submodule. No additional configuration tool is necessary for the fieldbus proxy, since the connection of a modular devices is supported by any programming system.

The following fieldbusses will be integrated in the first phase:

- PROFIBUS DP
- PROFIBUS PA
- AS-i
- INTERBUS
- DeviceNet

The integration of further fieldbusses are being considered.

Integration example with INTERBUS

INTERBUS systems are integrated into PROFINET very comfortable.

In the context of modular integration, slot 1 of the PROFINET IO-Device model is reserved for the INTERBUS master. Over the cyclic process data channel, which is used for status messages and control registers, the state of the INTERBUS system can be queried and special actions like the connection and disconnection of nodes can be performed.

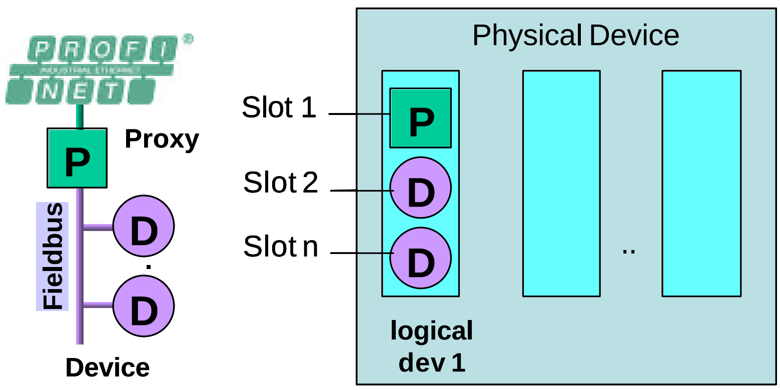


Figure 10.2: Modular integration: Every INTERBUS device is mapped on a module in an IO device

The cyclic process data of slots from 2 on up are directly assigned to the input and output data of the individual INTERBUS slaves, while the PROFINET IO parameters are used to set node-specific data and for the modeling of device-specific PCP parameters. Diagnostic messages from the INTERBUS system are available as PROFINET IO channel diagnostics.

The device model works like an INTERBUS connection assembly which is not connected to the backplane of the control system, but rather is contacted through a PROFINET connection.

INTERBUS devices are described using the language FDCML. Since the description options of GSD can also be covered by FDCML, the effort to describe a component is significantly reduced for the device manufacturer, since the description must only be written once, in FDCML. GSD files are then generated at the push of a button from the FDCML editor.

10.2 Integration in PROFINET CBA

In PROFINET CBA, there are two variants available for the connection of fieldbus systems:

- connection of fieldbus devices through proxies, and
- the connection of entire fieldbus applications.

Connecting fieldbus devices

The proxy concept in PROFINET enables the integration of existing fieldbus systems in a simple way and with high transparency.

The proxy is a representative on the Ethernet for one or more fieldbus devices (e.g. on the PROFIBUS). This representative maintains a transparent conversion of communications (no protocol tunneling) between the networks. For instance, it forwards cyclical data transparently to the fieldbus devices.

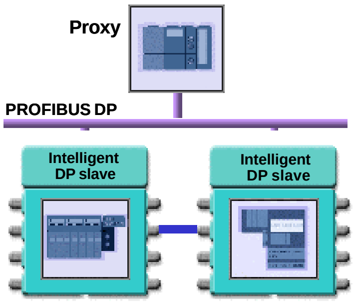


Figure 10.3: The principle of integration of individual fieldbus devices using a proxy

In PROFIBUS, the proxy is a PROFIBUS master on one side, coordinating the data exchange of the PROFIBUS nodes, and on the other side it is an Ethernet node with PROFINET communications. Proxies can be implemented as e.g. PLCs, PC-based controllers, or as pure gateways.

In the component view, intelligent slaves as used as independent PROFINET components. In the PROFINET connection editor, such PROFIBUS components are not distinguishable from the components on the Ethernet. Proxies make the communications between devices on different bus systems transparently possible.

Integration of fieldbus applications

An entire fieldbus application can be modeled as a PROFINET component in the framework of the component model. This is important when an already existing system has to be extended using PROFINET. It is not at all important which fieldbus is used to automate the segment.

For communications between the existing system and PROFINET, the fieldbus master in the PROFINET component has to be PROFINET-capable. Thus the existing fieldbus mechanisms are used within the components, and PROFINET mechanisms outside the components.

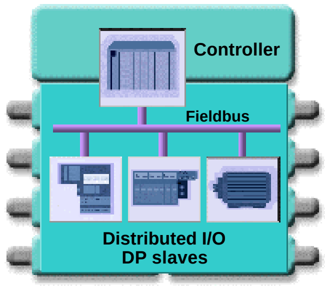


Figure 10.4: The principle of integration of fieldbus applications

This migration option ensures the user (system operator or builder) protection on the investment in existing systems and wiring. Moreover, existing know-how in the user programs is preserved. This makes the seamless transition to new system segments with PROFINET possible.

11. Implementation of devices

11.1 Implementation of PROFINET IO

For PROFIINET IO, there is a specification which details the device model and the behavior of a field device in the form of protocols and communication workflows (so-called state machines). This type of description has already been established for PROFIBUS. The level of detail of the PROFINET IO specification allows the software generation of a standard stack of from different stack suppliers.

Software stacks

For PROFINET IO field device development, pretested software stacks and ASICs are available nowadays which completely or partially contain the functionality of an IO-Device. Using these components, a field device developer is able to develop a certifiable field device. The software stacks are generally independent of operating system and Ethernet controller, and include the mandatory services. Figure 11.1 shows the structure of the software stacks for IO-Devices.

Example implementations with easily manageable user interfaces exist. The scope of delivery of the software stack includes the areas shown in blue in Figure 11.1. Adaptation to the operating system used, a TCP/IP or UDP/IP stack, and the changes to the Board Support Package are all done by the field device manufacturer.

Hardware

The spectrum of hardware support ranges from ASICs with or without integrated switch ports to piggy-back solutions which has only to be adapted to the application. The development basis is an Ethernet ASIC in any case. ASICs are currently available on the market which already integrate the switch functionality in hardware.

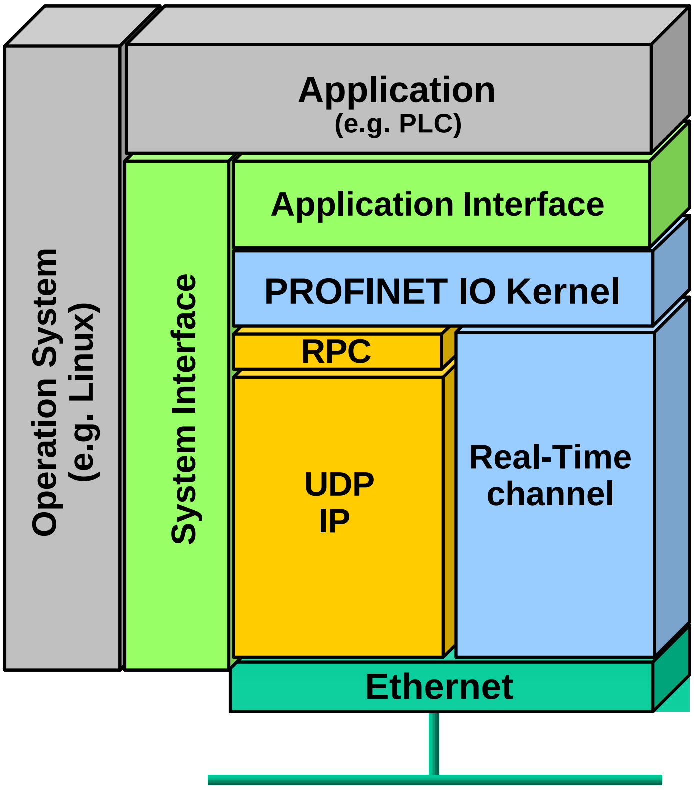


Figure 11.1: The PROFINET CBA software is made available by PI for members.

Development packages

For the development of PROFINET IO-Devices, some companies offer development packages which are customized to a particular Ethernet controller. For all other Ethernet controllers, there are software stacks available which have to be correspondingly adapted.

The following sections contain three examples for available support from different companies for the development of PROFINET products.

Solution by Siemens

The ERTEC400 is a high-performance communications ASIC with integrated 4-port switch, ARM 946 processor and PCI bridge. It is also optimized for both the realization of an IO-Controller and an IO-Device.

The ERTEC 200 is optimized for the implementation of IO-Devices. It has a 2-port switch with PHYs and an ARM 946 processor integrated.

Beyond providing the PROFINET mechanisms, the ERTECs contain all functions on a chip that are needed for high-performance system capacities.

Since PROFINET field devices must always be connected to the communications system through a switch, the ERTEC-ASIC offers decisive cost advantages in comparison to other Ethernet controllers, since it already has 4 full-duplex switch ports integrated. A bus connection to external switches is therefore not needed. The ASICs of the ERTEC family support the PROFINET Real-Ttime characteristics Real-Time and Isochronous Real-Time and time stamping according to IEEE 1588

Development kits for developing a IO-Device and worldwide technical support is available for users during implementation. Detailed documentation on the ASICs and development kits are available at www.ad.siemens.de/csi/pnio-doc.

Solution by Hilscher

In order to ensure a high degree of flexibility, Hilscher has defined the netX product family based on a system-on-a-chip design.

The netX is based on an ARM 926 EJ-S CPU which runs at 200 MHz. The two 10/100 Mb/s Ethernet interfaces include IEEE 1588 clock synchronization and have both hub and switch functionality built in. The PHYs, with automatic cross-over detection, are part of the netX.

The central element in netX is the data switch, which connects the 32-bit ARM CPU and the other bus master to the memory and the internal peripherals.

The features of the netX enable the operation of standard operating systems like Windows® CE or Linux. There is also a license-free netX-optimized operating system rcX available.

netX products support RT, and will soon also support IRT.

A particular feature of netX is the support of different Ethernet-based and conventional fieldbuses activated based on corresponding configuration of the communication channels.

Detailed information on netX products are available on the www.hilscher.com Web site.

Solution by Softing

Softing offers implementations of PROFINET IO using hyNet32 processors and other hardware.

The hyNet32 processor family is a series of different highly integrated network processors, which use the same 32 RISC/DSP kernels. The individual processors are optimized to different application cases. The spectrum ranges from the hyNet32 LS as a starting point, to the high-end processor hyNet32 EXS. The hyNet32 EXS has 4 Ethernet MACs, 2 PHYs, and hub and switch functionality. This lets it implement solutions with the strictest of requirements. Its little brothers have a smaller number of MACs and PHYs.

Together with the processors, the operating systems Linux, 4NetOS, and Nucleus can be used with the corresponding tool chains. A power DSP library is also available.

HyNet32 processors are suitable either for hardware platforms for PROFINET IO-Devices or for PROFINET IO-Controllers. There are a variety of evaluation boards available with appropriate software and drivers.

11.2 Implementation of PROFINET CBA

For PROFINET component technology, just as for PROFINET IO, there is a detailed specification available. The specification describes the communications, device model, engineering, network management, Web integration, and fieldbus connections.

In addition to the specification, PI offers a PROFINET software package in source code form. This PROFINET runtime software has a modular structure and consists of several layers, each of which must be adapted to the system environment. The adaptations are limited to the porting interfaces to the different functional parts of the environment, the operating system, such as WinCE, and the device application, e.g. PCS. As support for porting tasks, there is also an extensive user description, including example applications.

The PROFINET software includes the entire run-time communication. With this combination of specification and operating system independent software as source code, the possibility of a low-cost integration of PROFINET into the different operating system environments of the devices has been created. The PROFINET runtime source software is structured in such a way that it supports the simple integration of existing application software into the runtime object model. Example portations are available.

12. Certification and tools

For PROFINET devices of different types and manufacturers to be able to perform different tasks in the automation process correctly, they must exchange information over the bus without errors. A prerequisite for this is a standards-compliant implementation of the communications protocols and application profiles by the device manufacturer.

To ensure the quality of PROFI-NET products, PI has established a certification process. A PROFINET certification demonstrates standard compliant behavior within a PROFINET network, as defined by IEC 61158.

A certification test is a standardized testing procedure performed by experts in Test Laboratories accredited by PI. Only certified devices guarantee worldwide conformity of a PROFINET product in an automation facility with nodes from different manufacturers. For this reason, only a certified field device may carry the PROFINET name.

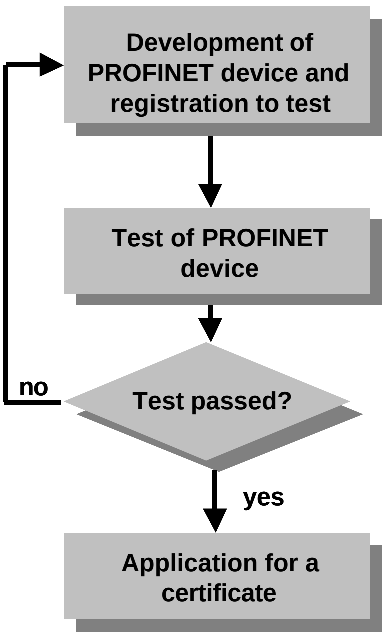


Figure 12.1: The process of PROFINET certification.

12.1 Process of a certification

The process of a certification, as shown in Figure 12.1, proceeds in the same way as for PROFIBUS. The certification test for PROFINET checks the compliance with the hardware guidelines according to the PROFINET specification. The main part is concentrated on compliance with PROFINET functionality.

The defined test cases which are run through in a certification test are entirely practically oriented and are reflected in industrial requirements. Therefore, only those test cases are checked which could arise daily in any installation, in order to give all users optimum safety from day one in using their device in an automation system.

The certification test is structured as follows:

- Test of the hardware
- Automated PROFINET state machine test
- Simulation of diagnostics and alarms
- Interoperability test
- Inspection of the GSD file

As a system operator, you can be sure that the automation facility will exhibit stable behavior for years.

12.2 Granting certification

Once a device has passed all tests, the manufacturer can request a certification from the PI Support Center. Each certified device includes a certification number as reference. The certificate has a validity of 3 years and can be extended after new testing.

Tests which lead to certification can only be performed by accredited Test Laboratories. The addresses of the Test Laboratories can be found on the Web site www.profinet.com .

12.3 Tools

XML Viewer

It is often important for the user to inspect the functionality of a PROFINET field device without having detailed knowledge of the contents of the description file. This is done using the XML Viewer, available at www.profinet.com .

Using the XML Viewer, GSD files for PROFINET IO and PCD files for PROFINET CBA can be viewed.

The XML Viewer interprets such a file and is capable of checking it for correctness.

Any off-the-shelf XML editor can be used to create a GSD or PCD.

Ethereal

The bus monitor available for download at www.ethereal.com can be used to view all PROFINET and Ethernet frames and display them in a convenient format. Due to its rich variety of trigger options, this tool is a must-have for developers.

Test tool for PROFINET CBA

In order to be able to prepare newly developed products for certification, a test tool for PROFINET CBA devices is available for download at www.profinet.com. This test tool allows device manufacturers to perform static tests before certification.

Component Editor

PROFINET components can be constructed using the Component Editor that is available for download at www.profinet.com. This tool ist of value for all who need to create PROFINET components. It generates automatically all necessary information the PROFINET connection editor requires.

13. PI – the organization

For its maintenance, ongoing development, and market penetration, an open technology needs a company-independent institution as a working platform. For this reason, the PROFIBUS Nutzerorganisation e.V. (PNO) was founded in 1989 as a non-profit interest group for manufacturers, users, and institutions. The PNO is a member in the umbrella group PROFIBUS/PROFINET International (PI) founded in 1995. With 24 regional user organnizations (the Regional PROFIBUS/PROFINET Associations, or RPA) and about 1300 members, including those in the USA, China, and Japan, PI represents the largest interest group in the world in the area of industrial communications. The RPAs organize presentations on fairs and informational evens and also ensure that new requirements in the market are taken into account during further development.

13.1 Tasks

The significant tasks of PI are:

- Maintenance and development of the technologies PROFIBUS and PROFINET.
- Support for the global reach of the technologies.
- Protection of investment for users and manufacturers through influence on standardization.
- Representation of the interests of members to standards bodies and unions.
- Global technical support through the Competence and Training Center
- Quality control through device certification.

Membership

Membership is organized regionally. It is open to all companies, unions, institutions, and persons wanting to participate constructively in the development and spread of the PROFIBUS and PROFINET technologies. Through the combined efforts of often very different members from different industries, there is a significant synergetic effect and a healthy exchange of information is generated. This leads to innovative solutions, effective use of resources, and finally to competitive advantages on the market.

13.2 Organization of technology development

Activity in technological development is controlled by the Advisory Board.

Development teams are organized into Technical Committees (TCs) with more than 50 fixed working groups (WGs). There are also a changing number of ad-hoc WGs taking on limited topics temporarily.

The WGs work through new specifications and profiles, support quality control and standardization, participate in standards bodies, and lead effective marketing measures (presentations, conferences) to spread the technologies.

The PI Support Center coordinates all ongoing activities.

More than 500 experts are active in the working groups for the development and marketing of the technologies.

The subdivision into over 50 WGs allows very efficient development work, concentrating on particular topics and industries.

All members have the right to participation in the working groups and can therefore influence further development. All new results are presented to the members for comment before being released by the Advisory Board.

13.3 Technical support

PI supports more the 30 Competence and Training Centers worldwide and has accredited 7 Test Laboratories for certification work. These organizations advise, train, and support users and manufacturers in many ways, or perform testing for certification. As institutions of the PI, they provide their services in the context of the uniform regulations in a company-independent manner. They are regularly checked for their suitability in one of the accreditation processes customized for each group. Current addresses can be found on the organization's Web site.

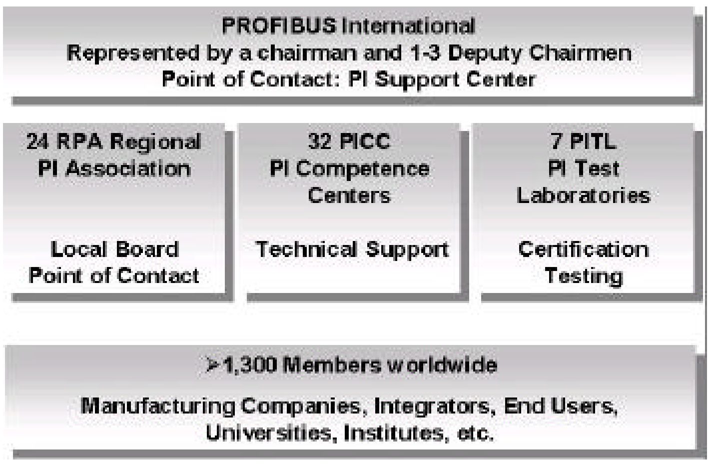


Abbildung 13.1: PI Organization

13.4 Documentation

As support for users and manufacturers, PI provides a wide variety of documentation. This is available in the English language.

PROFINET Standard
Contains the basic specifications of PROFINET CBA and PROFINET IO, along with a selection from other documentation, like the GSDML device description for PROFINET IO.

PROFINET Guidelines
Includes specifications for implementation, test processes, and installation.

PROFINET Profiles
Include the approved profile specifications. There is a distinction drawn here between industry-specific and general application profiles.

Brochures and books
Significant topics are presented in brochures from a marketing standpoint. There is a corresponding brochure available for PROFINET.

The documents can be downloaded from the Web site www.profinet.com . If needed, they can also be ordered electronically or on CD-ROM. A list of documentation available can also be obtained from the Web site.

13.5 Web site

PI maintains a shared Web site in English for both the PROFIBUS and PROFINET technologies (www.profibus.com and www.profinet.com). The RPAs additionally provide their own Web site in local languages which are accessible through the PI Web site.

These local site present current topics/events (news and events, press releases), provide information on the technologies (short technical descriptions, FAQs, WBT), have a series of application reports, and provide a point for members to freely download all technical and marketing documents.

For discussion of technical questions, there are two open forums for PROFIBUS and PROFINET.

The product catalog for PROFIBUS and PROFINET products give an excellent overview of the performance capabilities of member companies.

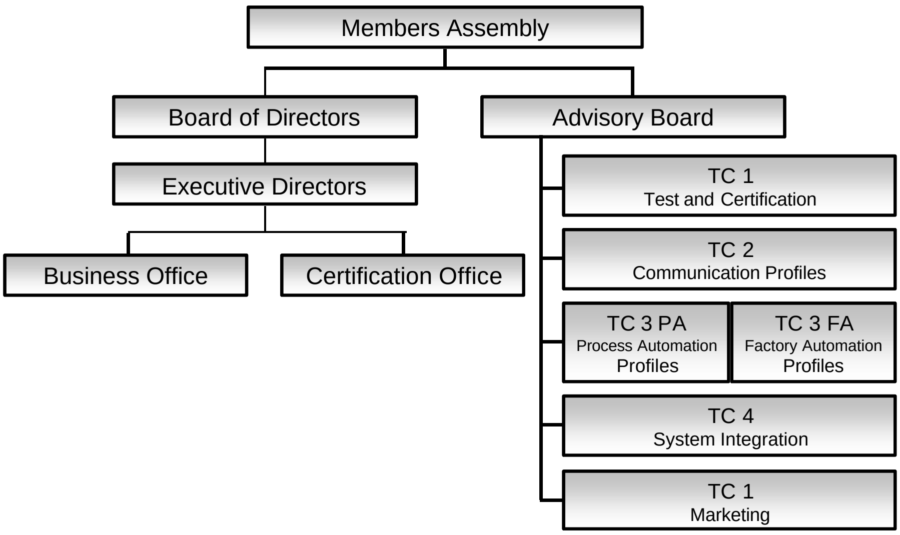


Figure 13.2: Organizational structure of the technology development

14. Glossary

AR	Application Relation	Logical application relation between two participants, that can comprise more than one communication relations.
Client/Server	Principle of establishment of connections	The network node which establishes the connection is called the client. A server is then the node to which the connection is established.
Component		Software representation of a technological module with defined functionality. An automation solution consists of several PROFINET components. A PROFINET component contains in general one technological function and the assigned hardware device.
Component Generator		Functional extension of a manufacturer-specific configuration tool to generate the XML-based PROFINET Component Description (PCD).
Connection editor		Manufacturer-independent engineering tool for the configuration of system-wide applications. The connection editor consolidates the individual distributed applications together graphically throughout the installation.
CR	Communication Relation	Logical communication relation (channel) between two participants, that is driven by a specific protocol.
CSMA/CD	Carrier Sense Multiple Access/Collision Detection	Process to regulate access of individual nodes to the bus.
DCP	Discovery and Basic Configuration	Defines the assignment of IP parameters using manufacturer-specific configuration/programming tools or in system-wide engineering, e.g. in the PROFINET connection editor.
DHCP	Dynamic Host Configuration Protocol	De facto standard for the dynamic assignment and administration of IP addresses in a predefined range
ERP	Enterprise Resource Planning	
Ethernet	Protected trademark of Xerox (since 1975)	Ethernet is standardized and describes the physical and data link layers of a network.
Ethertype		Part of a Ethernet frame showing the protocol type. Ethertypes are granted by IEEE. They are therefore an unanimous differentiating criterion from other protocols. The RT communication within one network is indicated in PROFINET by the Ethertype 0x8892.
FTP	File Transfer Protocol	Protocol for the transfer of files; based on TCP/IP
Gateway		Connection between two networks with different software and hardware
GSD	General Station Description	A GSD (General Station Description) contains an XML-based description of the characteristics of I/O devices like communications parameters, as well as the number, type, configuration, parameters, and diagnostic information of modules.
GSDML	General Station Description Markup Language	GSDML is the descriptive language for creating a GSD file for PROFINET IO-Devices. She is based onXML.
HMI	Human Machine Interface	Appearance of a system on the operating and observation platform
HTML	Hypertext Markup Language	Document description language
HTTP	Hypertext Transfer Protocol	Application protocol supported by the World Wide Web.
I&M Functions	Identification and Maintenance Functions	I&M functions are general information providing functions about devises, like manufacturer, veresion, ordering data, e.t.c.
IO-Controller		A device (typically a controller) that initiates I/O data exchange.
IO-Device		Decentrally located field device assigned to an I/O controller.
I-/O-Supervisor		Programming device/PC with commissioning and diagnostic functionality in PROFINET IO.
IP	Internet Protocol	Connectionless protocol for the transfer of data telegrams. IP is often used in combination with TCP in order to ensure secure transfer of data.

IRT	Isochronous Real-Time	Isochronous Real-Time channel for particularly high-performance requirements of, for instance, motion control applications (clock-synchronized applications). When implemented in hardware, clock rates of under 1 ms and a jitter precision of µs can be achieved.
MAC Address	Media Access Control Address	Also known as Ethernet address; used to identify an Ethernet node. The Ethernet address is 6 bytes long and is assigned by the IEEE.
MES	Manufacturing Execution System	
Object		Information container which has a temporally changeable state and for which it is defined how it must react to incoming messages.
OLE	Object Linking and Embedding	Mechanism for the generation and editing of documents containing objects created by different applications.
OPC	OLE for Process Control	Generally accepted interface introduced in 1996 for the exchange of data between Windows-based applications in automation technology.
PCD	PROFINET Component Description	XML-based file containing information about the functions and objects of PROFINET components.
PROFINET Component Editor		Stand-alone tool for the generation of XML-based PROFINET Component Description (PCD) files; available for download from the www.profibus.com Web site.
Proxy		A representative object in the object model which stands for a field device or a field device group from the point of view of PROFINET. The proxy is a representative on the Ethernet for one or more PROFIBUS devices.
RPC	Remote Procedure Call	Defined interface which allows programs on remote devices to be invoked.
Runtime	.	Name of the status of a system "in operation", as opposed to the status of the system "during engineering".
SNMP	Simple Network Management Protocol	A TCP/IP-based communications protocol for maintenance and monitoring of network components.
RT	Real-Time	Real-Time channel for the transmission of time-critical process data within the production system in the area of factory automation. May be implemented in software based on existing controllers.
Switch technology		Technology for the segmentation of an Ethernet network into different subnets; serves to avoid collisions and better utilize bandwidth.
TCP	Transmission Control Protocol/Internet Protocol	Communication protocol for the transfer of data between local networks. TCP is connection-oriented and is used for communications on the Internet. TCP is usually used in combination with IP (TCP/IP).
UDP	User Datagram Protocol	Transport protocol with broadcast characteristics, suitable for transmission of time-critical I/O data
UIC	Union Internationale des Chemins de Fer	International Railway Union
XML	Extensible Markup Language	Definition of a structure *data* description
VLAN Tag	Virtual Local Network	Part of the Ethernet frame used for the prioritized transmission of RT data. It mainly contains the priority information of the frame, and causes the priority-oriented forwarding in switch devices.
XML	Extensible Markup Language	Definition of a structured data description
WTB	Wire Train Bus	

Additional information, along with PROFIBUS and PROFINET documentation, tools, and the PROFINET Runtime Source Software, is available on the www.profinet.com Web site.

PROFINET

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