PROFINET System Description

Technology and Application

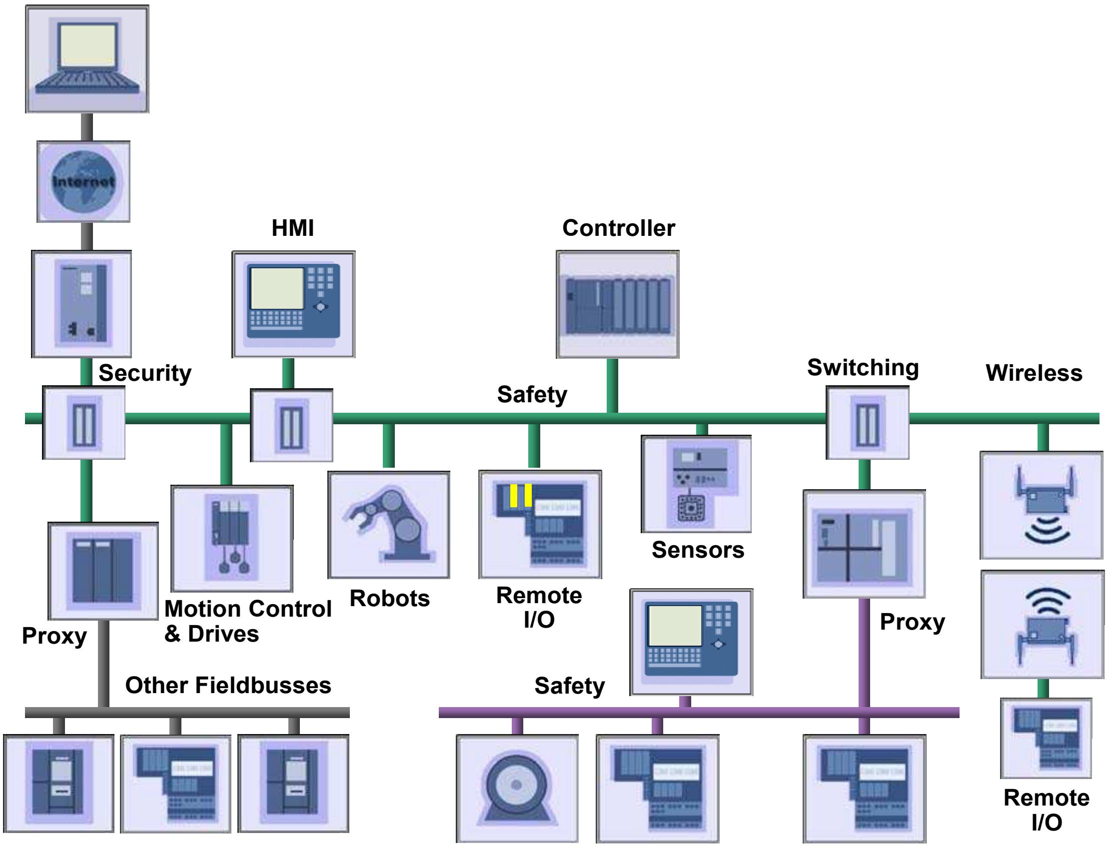

Figure 1: PROFINET satisfies all requirements of automation technology

Introduction

The ever-shorter innovation cycles 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 distributed ones. PROFIBUS, as the global market leader, has set the benchmark here for more than 20 years.

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

PROFINET is the innovative open standard for industrial Ethernet. PROFINET satisfies all requirements for automation technology. Whether the application involves factory automation, process automation, or drives (with or without functional safety), PROFINET is the first choice across the board. As technology that is standard in the automotive industry, widely disseminated in machine building, and well-proven in the food and beverage, packaging, and logistics industries, PROFINET has found its way into all application areas. New application areas are constantly emerging, such as marine and rail applications or even day-to-day operations in a beverage shop. And highly topical: the new PROFIenergy technology profile will improve the energy balance in production processes.

PROFINET is standardized in IEC 61158 and IEC 61784. The ongoing further development of PROFINET offers users a long-term view for the implementation of their automation tasks.

For plant and machine manufacturers, the use of PROFINET minimizes the costs for installation, engineering, and commissioning. For plant owners, PROFINET offers ease of plant expansion and high system availability due to autonomously running plant units and low maintenance requirements.

The mandatory certification for PROFINET devices also ensures a high quality standard.

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Notes on Content

This document describes all essential aspects of the PROFINET technology and reflects the level of technology available at the end of 2010.

Chapter 1 introduces PROFINET and provides an overview of the market position and modular design.

Chapter 2 describes the underlying models and the engineering of a PROFINET system.

Chapters 3 to 5 cover the basic functions of PROFINET communication from the perspective of conformance classes.

Chapter 6 contains a brief description of optional functions that are used in different applications.

Chapters 7 to 9 are dedicated to the integration of fieldbuses and other technologies, profiles, and specific process automation topics in PROFINET and describe the additional benefits for PROFINET systems.

Chapter 10 describes relevant aspects of PROFINET networks such as topologies, cables, connectors, web integration, and security.

Chapter 11 is directed at product managers and provides information on product implementation and certification.

Chapter 12 provides information on PROFIBUS & PROFINET International, the world's largest interest organization for industrial automation.

1. PROFINET at a glance

1.1 Markets and applications

PROFINET is the communication standard for automation of PROFIBUS & PROFINET International (PI). The modular range of functions makes PROFINET a flexible solution for all applications and markets. With PROFINET, applications can be implemented for production and process automation, safety applications, and the entire range of drive technology up to and including isochronous motion control applications. Application profiles allow optimal use of PROFINET in all areas of automation engineering.

For **plant and machine manufacturers**, the use of PROFINET minimizes the costs for installation, engineering, and commissioning.

The **plant owner** profits from ease of plant expansion, high plant availability, and fast and efficient automation.

The many years of experience with PROFIBUS and the widespread use of Industrial Ethernet have been rolled into PROFINET. PROFINET uses UDP/IP as the higher-level protocol for demand-oriented data exchange. In parallel with UDP/IP communication, cyclic data exchange in PROFINET is based on a scalable real-time concept.

In addition, PROFINET plays an important role when it comes to investment protection. PROFINET enables the integration of existing fieldbus systems like PROFIBUS, AS-Interface, INTERBUS, Foundation Fieldbus, and DeviceNet, without changes to existing devices. That means that the investments of plant operators, machine and plant manufacturers, and device manufacturers are all protected.

Establishment of the proven certification process ensures a high standard of quality for PROFINET products and their interoperability in plants.

1.2 Highlights

Everything on one cable

With its integrated, Ethernet-based communication, PROFINET satisfies a wide range of requirements, from data-intensive parameter assignment to extremely fast I/O data transmission. PROFINET thus enables automation in real-time. In addition, PROFINET provides a direct interface to the IT level.

Flexible network topology

PROFINET is 100% Ethernet compatible according to IEEE standards and adapts to circumstances in the existing plant thanks to its flexible line, ring, and star structures and copper and fiber-optic cable solutions. PROFINET saves on expensive custom solutions and enables wireless communication with WLAN and Bluetooth.

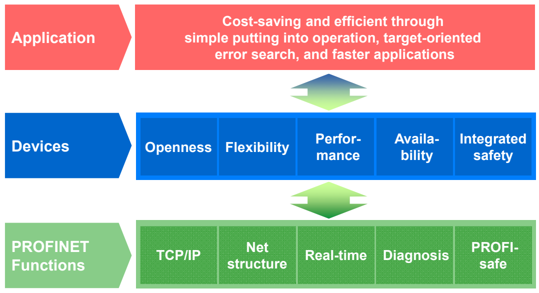


Figure 2: The functionality of PROFINET is scalable

Scalable real time

Communication takes place over the same cable in all applications, ranging from simple control tasks to highly demanding motion control applications. For high-precision closed-loop control tasks, deterministic and isochronous transmission of time-critical process data with a jitter of less than 1 µs is possible.

High availability

PROFINET integrates automatically reacting redundancy solutions and intelligent diagnostic concepts. Acyclic diagnostic data transmission provides important information regarding the status of the network and devices, including a display of the network topology. The defined concepts for media and system redundancy increase the plant availability significantly.

Safety integrated

The proven PROFIsafe safety technology of PROFIBUS is also available for PROFINET. The ability to use the same cable for standard and safety-related communication saves on devices, engineering, and setup.

1.3 Perspectives on PROFINET

The PROFINET concept has two perspectives: PROFINET CBA and PROFINET IO. Figure 3 shows how the two perspectives interrelate.

PROFINET CBA is suitable for component-based machine-to-machine communication via TCP/IP and for real-time communication required for modular plant designs. It enables a simple modular design of plants and production lines based on distributed intelligence using graphics-based configuration of communication between intelligent modules. PROFINET IO describes an I/O data view of distributed I/O. It includes real-time (RT) communication and isochronous real-time (IRT) communication for cyclic process data.

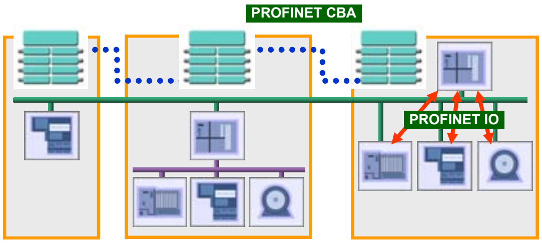


Figure 3: PROFINET perspectives

PROFINET CBA and PROFINET IO can be operated separately and in combination such that a PROFINET IO unit appears in the plant view as a PROFINET CBA modul.

This description provides a detailed explanation of PROFINET IO specifically.

1.4 Conformance classes

The scope of functions supported by PROFINET IO is clearly divided into conformance classes ("CC"). These provide a practical summary of the various minimum properties.

There are three conformance classes that build upon one another and are oriented to typical applications (Figure 4).

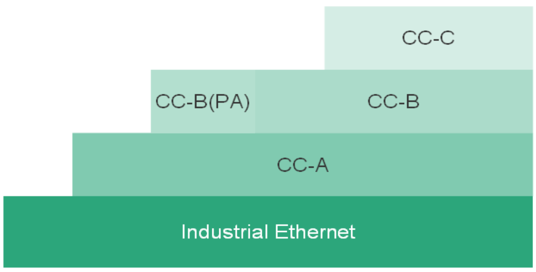


Figure 4: Structure of conformence classes

CC-A provides basic functions for PROFINET IO with RT communication. All IT services can be used without restriction. Typical applications are found, for example, in building automation. Wireless communication is only possible in this class.

CC-B extends the concept to include network diagnostics via IT mechanisms as well as topology information. The system redundancy function important for process automation is contained in an extended version of CC-B named CC-B(PA).

CC-C describes the basic functions for devices with hardware-supported bandwidth reservation and synchronization (IRT communication) and is thus the basis for isochronous applications.

The conformance classes also serve as the basis for certification and for the cabling guidelines.

A detailed description of the CCs can be found in the document "The PROFINET IO Conformance Classes" under "Downloads/Supplementary Documents".

1.5 Standardization

PROFINET is specified in IEC 61158 and IEC 61784. The PROFINET concept was defined in close collaboration with end users based on standard Ethernet according to IEEE 802. Additions to standard Ethernet were specified only in cases where requirements could not be met or could not be met satisfactorily with standard Ethernet.

2. Modeling and engineering

This section explains the models of a PROFINET IO system and uses an example planning process to describe the addressing options.

2.1 System model of a PROFINET IO system

PROFINET IO follows the Provider/Consumer model for data exchange. Configuring a PROFINET IO system has the same look and feel as in PROFIBUS. The following device classes are defined for PROFINET IO (5):

IO-Controller: This is typically the programmable logic controller (PLC) on which the automation program runs. This is comparable to a class 1 master in PROFIBUS. The IO-Controller provides output data to the configured IO-Devices in its role as provider and is the consumer of input data of IO-Devices.

IO-Device: An IO-Device is a distributed I/O field device that is connected to one or more IO-Controllers via PROFINET IO. It is comparable to the function of a slave in PROFIBUS. The IO-Device is the provider of input data and the consumer of output data.

IO-Supervisor: This can be a programming device, personal computer (PC), or human machine interface (HMI) device for commissioning or diagnostic purposes and corresponds to a class 2 master in PROFIBUS.

A plant unit has at least one IO-Controller and one or more IO-Devices. IO-Supervisors are usually integrated only temporarily for commissioning or troubleshooting purposes.

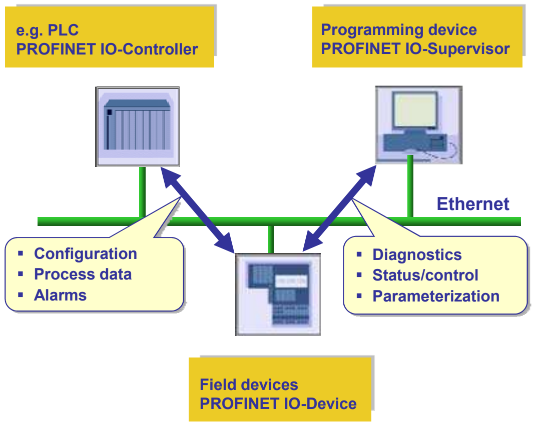


Figure 5: Communication paths for PROFINET IO

2.2 Device model of an IO-Device

The device model describes all field devices in terms of their possible technical and functional features. It is specified by the DAP (**D**evice **A**ccess **P**oint) and the defined modules for a particular device family. A DAP is the access point for communication with the Ethernet interface and the processing program. A variety of I/O modules can be assigned to it in order to manage the actual process data communication.

The following structures are standardized for an IO-Device:

- The **slot** designates the place where an I/O module is inserted in a modular I/O field device. The configured modules containing one or more subslots for data exchange are addressed on the basis of the different slots.
- Within a slot, the **subslots** represent the actual interface to the process (inputs/outputs). The granularity of a subslot (bitwise, bytewise, or wordwise division of I/O data) is determined by the manufacturer. The data content of a subslot is always accompanied by status information, from which the validity of the data can be derived.
- The **index** specifies the data within a slot/subslot that can be read or written acyclically via read/write services. For example, parameters can be written to a module or manufacturer-specific module data can be read out on the basis of an index.

Cyclic I/O data are addressed by specifying the slot/subslot combination. These can be freely defined by the manufacturer. For acyclic data communication via read/write services, an application can specify the data to be addressed using **slot**, **subslot**, and **index** (Figure 6).

To avoid competing accesses in the definition of user profiles (e.g., for PROFIdrive, weighing and dosing, etc.), the **API** (**A**pplication **P**rocess **I**dentifier/Instance) is defined as an additional addressing level.

PROFINET differentiates between **compact field devices**, in which the degree of expansion is already specified in the as-delivered condition and cannot be changed by the user, and **modular field devices**, in which the degree of expansion can be customized for a specific application when the system is configured.

2.3 Device descriptions

The GSD files (General Station Description) of the field devices to be configured are required for system engineering. This XML-based GSD describes the properties and functions of the PROFINET IO field devices. It contains all data relevant for engineering as well as for data exchange with the field device. The field device manufacturer must supply the XML-based GSD in accordance with the GSDML specification.

2.4 Communication relations

To establish communication between the higher-level controller and an IO-Device, the communication paths must be established. These are set up by the IO-Controller during system startup based on the configuration data in the engineering system. This specifies the data exchange explicitly.

Every data exchange is embedded into an AR (**A**pplication **R**elation) (Figure 7). Within the AR, CRs (**C**ommunication **R**elations) specify the data

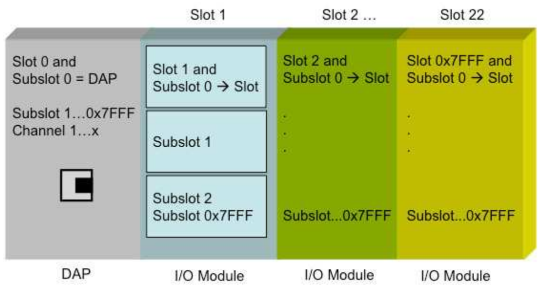


Figure 6: Addressing of I/O data in PROFINET IO based on slots and subslots

explicitly. As a result, all data for the device modeling, including the general communication parameters, are downloaded to the IO-Device. An IO-Device can have multiple ARs established from different IO-Controllers.

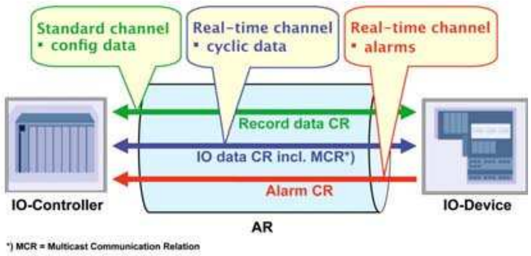


Figure 7: Application relations and communication relations

The communication channels for cyclic data exchange (IO data CR), acyclic data exchange (record data CR), and alarms (alarm CR) are set up simultaneously.

Multiple IO-Controllers can be used in a PROFINET system (Figure 8). If these IO-Controllers are to be able to access the same data in the IO-Devices, this must be specified when configuring (shared devices, shared inputs).

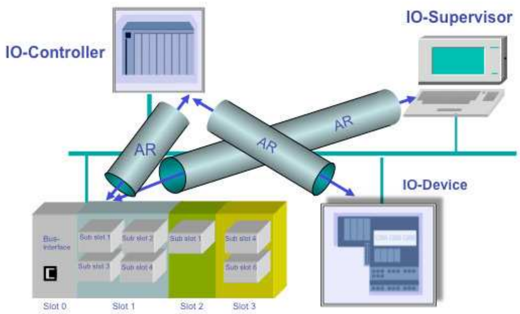


Figure 8: A field device can be accessed by multiple application relations

An IO-Controller can establish one AR each with multiple IO-Devices. Within an AR, several IOCRs and APIs can be used for data exchange. This can be useful, for example, if more than one user profile (PROFIdrive, Encoder, etc.) is involved in the communication and different subslots are required. The specified APIs serve to differentiate the data communication within an IOCR.

2.5 Addressing

In PROFINET IO, each field device has a symbolic name that uniquely identifies the field device within a PROFINET IO system. This name is used for assigning the IP address and the MAC address. The DCP protocol (Dynamic Configuration Protocol) integrated in every IO-Device is used for this purpose.

The IP address is assigned with the DCP protocol based on the device name. Because DHCP (Dynamic Host Configuration Protocol) is in widespread use internationally, PROFINET has provided for optional address setting via DHCP or via manufacturer-specific mechanisms. The addressing options supported by a field device are defined in the GSD file for the respective field device.

Optionally, the name can also be automatically assigned to the IO-Device by means of a specified topology based on neighborhood detection.

A PROFINET IO-Device is addressed for direct data exchange by its MAC address (see box).

MAC address and OUI (organizationally unique identifier)

Each PROFINET device is addressed based on a MAC address. This address is unique worldwide. The company code (bits 47 to 24) can be obtained free of charge from the IEEE Standards Department. This part is called the OUI (organizationally unique identifier).

PI offers MAC addresses to device manufacturers that do not want to apply for their own OUI, in other words, a fixed OUI and the manufacturer-specific portion (bits 23 to 0). This service allows components to acquire MAC addresses from the PI Support Center. The assignment can be completed in 4 K-ranges.

The OUI of PI is 00-0E-CF and is structured as shown in the table. The OUI can be used for up to 16,777,214 products.

Bit significance 47 to 24						Bit significance 23 to 0					
0	**0**	**0**	**E**	**C**	**F**	X	X	X	X	X	X
Company code → OUI						Consecutive number					

2.6 Engineering of an IO system

Each IO-Controller manufacturer also provides an engineering tool for configuring a PROFINET system.

During system engineering, the configuring engineer joins together the modules/submodules of an IO-Device defined in the GSD file in order to map them to the real system and to assign them to slots/subslots. The configuring engineer configures the real system symbolically in the engineering tool. Figure 9 shows the relationship between the GSD definitions, configuration, and real plant view.

After completion of system engineering, the configuring engineer downloads the system data to the IO-Controller, which also contains the system-specific application. As a result, an IO-Controller has all the information needed for addressing the IO-Devices and for data exchange.

Before an IO-Controller can perform data exchange with the IO-Devices, these must be assigned an IP address based on their configured name. This must take place prior to system power-up.

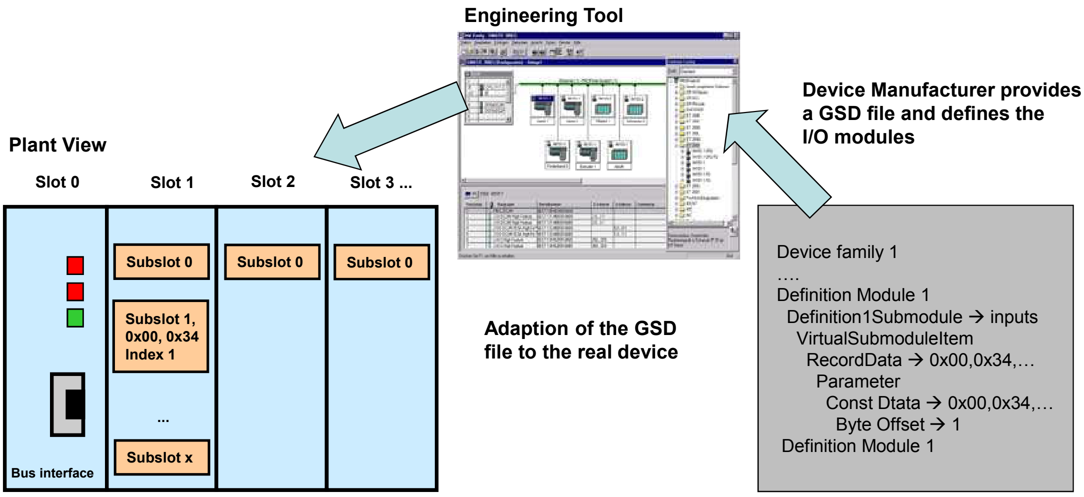


Figure 9: Assignment of definitions in the GSD file to IO Devices when configuring the system

The IO-Controller performs this automatically using the DCP protocol.

After a startup/restart, an IO-Controller always initiates system power-up based on the configuration data without any intervention by the user. During system power-up, an IO-Controller establishes an explicitly specified communication relation (CR) and application relation (AR) with an IO-Device. This specifies the cyclic I/O data, the alarms, the exchange of acyclic read/write services, and the expected modules/submodules. After successful system power-up, the exchange of cyclic process data, alarms, and acyclic data traffic can occur.

2.7 Web integration

PROFINET is based on Ethernet and supports TCP/IP. This enables use of web technologies for accessing an integrated web server in a field device, among other things. Depending on the specific device implementation, diagnostics and other information can be easily called up using a standard web browser, even across network boundaries. Thus, an engineering system is no longer necessary for simple diagnostics. PROFINET itself does not define any specific contents or formats. Rather, it allows an open and free implementation.

3. Basic functions of Conformance Class A

The basic functions of Conformance Class A include cyclic exchange of I/O data with real-time properties, acyclic data communication for reading and writing of demand-oriented data (parameters, diagnostics), including the Identification & Maintenance Function (I&M) for reading out device information and a flexible alarm model for signaling device and network errors with three alarm levels (maintenance required, urgent maintenance required, and diagnostics) (Table 1).

Requirement	**Technical function/solution**
Cyclic data exchange	PROFINET with RT communication
Acyclic parameter data/ device identification (HW/FW)	Read Record/ Write Record I&M0
Device/ network diagnostics (alarms)	Diagnostics and maintenance

Table 1: List of basic functions

3.1 Cyclic data exchange

Cyclic I/O data are transmitted via the “IO Data CR” unacknowledged as real-time data between provider and consumer in an assignable time base. The cycle time can be specified individually for connections to the individual devices and are thus adapted to the requirements of the application. Likewise, different cycle times can be selected for the input and output data, within the range of 250 µs to 512 ms.

The connection is monitored using a time monitoring setting that is derived from a multiple of the cycle time. During data transmission in the frame, the data of a subslot are followed by a provider status. This status information is evaluated by the respective consumer of the I/O data. As a result, it can evaluate the validity of the data from the cyclic data exchange alone. In addition, the consumer statuses for the opposite direction are transmitted.

The data in the message frames are followed by accompanying information that provides information about the data's validity, the redundancy, and the diagnostic status (data status, transfer status). The cycle information (cycle counter) of the provider is also specified so that its update rate can be determined easily. Failure of cyclic data to arrive is monitored by the respective consumer in the communication relation. If the configured data fail to arrive within the monitoring time, the consumer sends an error message to the application (Figure 10).

The cyclic data exchange can be realized with standard network components, such as switches

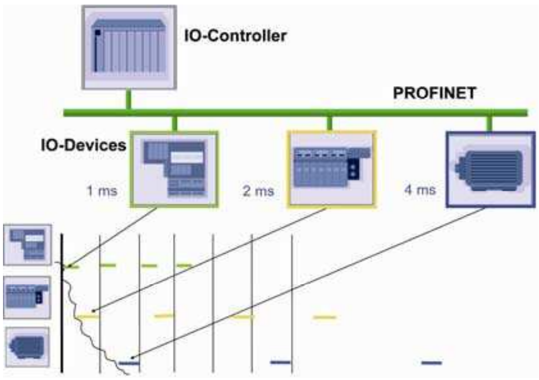


Figure 10: Real-time communication with cycle time monitoring

and standard Ethernet controllers and takes place directly on Layer 2 with Ethertype 0x8892 and without any TCP(UDP)/IP information. For optimized processing of cyclic data within a network component, the VLAN tag according to IEEE802.1Q is additionally used with a high priority.

3.2 Acyclic parameter data

Acyclic data exchange can be used for parameter assignment or configuration of IO-Devices or reading out status information using the “Record Data CR”. This is accomplished with read/write frames using standard IT services via UDP/IP, in which the different data records are distinguished by their index. In addition to the data records available for use by device manufacturers, the following system data records are also specially defined:

- **Diagnostic information** on the network and device diagnostics can be read out by the user from any device at any time.
- **Error log entries** (alarms and error messages), which can be used to determine detailed timing information about events within an IO-Device.
- **Identification and Maintenance information** (I&M)

The ability to read out identification information from a field device is very helpful for maintenance purposes. For example, this allows inferences to be drawn in response to incorrect behavior or regarding unsupported functionality in a field device. This information is specified in the I&M data structures.

The I&M functions are subdivided into 5 different blocks (IM0 ... IM4) and can be addressed separately using their index. Every IO-Device must support the IM0 function with information about hardware and firmware versions.

The I&M specification titled “Identification & Maintenance Functions” can be downloaded from the PI website.

3.3 Device/network diagnostics

A status-based maintenance approach is currently gaining relevance for operation and maintenance. It is based on the capability of devices and components to determine their status and to communicate this using agreed mechanisms. A system for reliable signaling of alarms and status messages by the IO-Device to the IO-Controller was defined for PROFINET IO for this purpose.

This alarm concept covers both system-defined events (such as removal and insertion of modules) as well as signaling of faults that were detected in the utilized controller technology (e.g., defective load voltage or wire break). This is based on a state model that defines “good” and “defective” status as well as the “maintenance required” and “maintenance demanded” pre-warning levels. A typical example for this is the loss of media redundancy, which signals “maintenance required” but, because of its redundancy, the media is still fully functional.

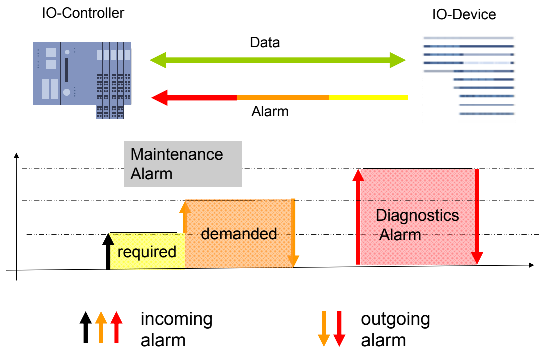


Figure 11: Diagnostic model for signaling faults with different priority

Diagnostic alarms must be used if the error or event occurs within an IO-Device or in conjunction with the connected components. They can signal an incoming or outgoing fault status (Figure 11).

In addition, the user can define corresponding **process alarms** for messages from the process, e.g., limit temperature exceeded. In this case, the IO-Device may still be operable. These process alarms can be assigned different priorities than the diagnostic alarms.

4. Network diagnostics and management of Conformance Class B

Conformance Class B expands devices to include functions for additional network diagnostics and for topology detection. PROFINET uses SNMP (**S**imple **N**etwork **M**anagement **P**rotocol) for this. Portions of MIB2 (**M**anagement **I**nformation **B**ase **2**) and LLDP-EXT MIB (**L**ower **L**ink **D**iscovery **P**rotocol-MIB) are integrated into devices. In parallel to SNMP, all diagnostics and topology information can also be called up from the PDEV (**P**hysical **Dev**ice Object) using acyclic PROFINET services.

4.1 Network management protocol

In existing networks, SNMP has established itself as the de facto standard for maintenance and monitoring of network components and their functions. SNMP can read-access network components, in order to read out statistical data pertaining to the network as well as port-specific data and information for neighborhood detection. In order to monitor PROFINET devices with an established management system, implementation of SNMP is mandatory for devices of Conformance Classes B and C.

4.2 Neighborhood detection

Automation systems can be configured flexibly in a line, star, or tree structure. To compare the specified and actual topologies, i.e., to determine which field devices are connected to which switch port and to identify the respective port neighbor, LLDP according to IEEE 802.1 AB was applied in PROFINET IO.

PROFINET field devices exchange existing addressing information with connected neighbor devices via each switch port. The neighbor devices are thereby unambiguously identified and their physical location is determined (example in Figure 12: The delta device is connected to port 003 of switch 1 via port 001).

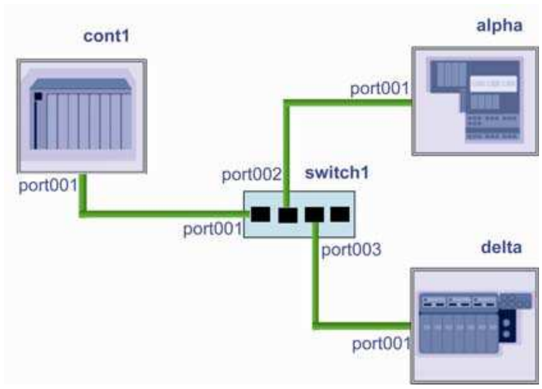


Figure 13: PROFINET field devices detect their neighbors

4.3 Representation of the topology

A plant owner can use a suitable tool to graphically display a plant topology and port-granular diagnostics (Figure 12). The information found during neighborhood detection is collected using the SNMP protocol. This provides the plant operator a quick overview of the plant status.

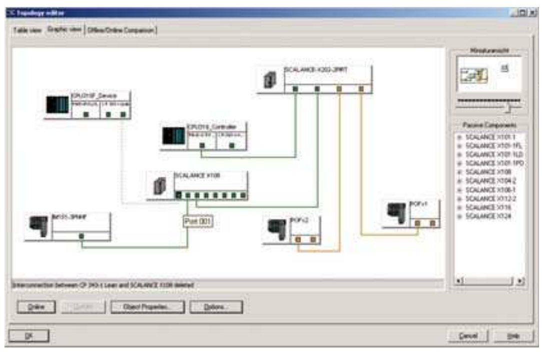


Figure 12: Plan topology

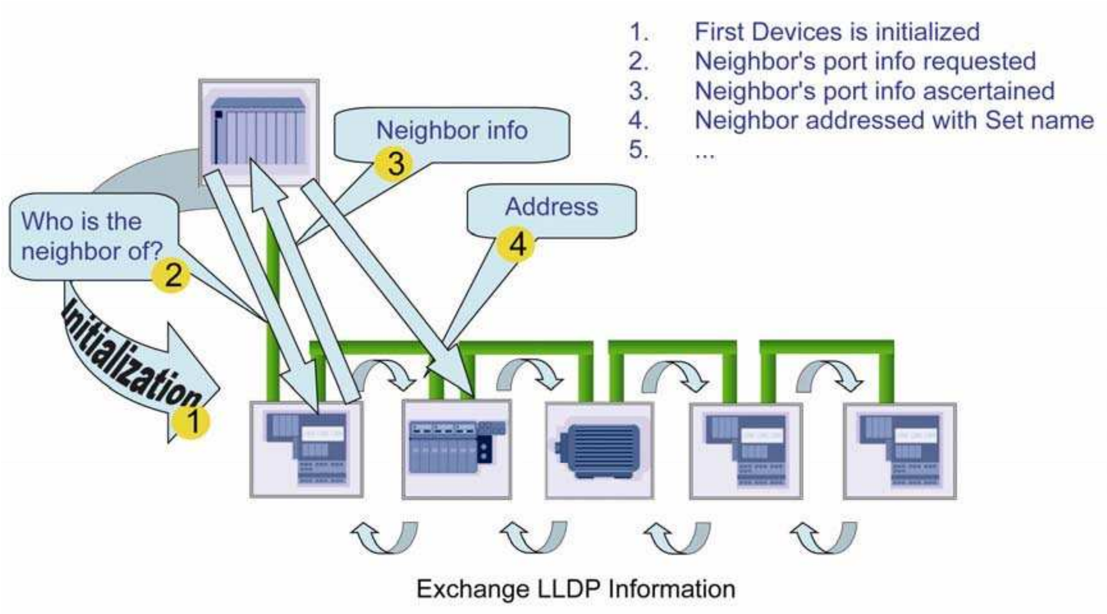


Figure 14: PROFINET IO supports convenient device replacement and display of plant topology.

4.4 Device replacement

If a field device fails in a known topology, it is possible to check whether the replacement device has been reconnected in the proper position. It is even possible to replace devices without the use of an engineering tool: when replaced, a device at a given position in the topology receives the same name and parameters as its predecessor (Figure 14).

4.5 Integration of network diagnostics into the IO system diagnostics

A switch must also be configured as a PROFINET IO-Device and signal the detected network errors of a lower-level Ethernet line directly to the IO-Controller. Acting as an IO-Device, this type of switch can signal faults and specific operating modes to its IO-Controller by transmitting acyclic alarms using the “alarm CR”. In this way, the network diagnostics can be integrated into the IO system diagnostics (Figure 15).

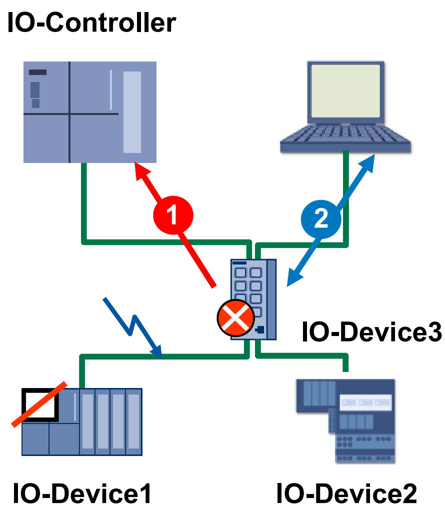


Figure 15: Integration of network diagnostics into IO system diagnostics

5. Isochronous real-time with Conformance Class C

Conformance Class C includes all necessary network-wide synchronization functions for applications with the most stringent requirements for deterministic behavior. Networks based on Conformance Class C enable applications having a jitter of less than 1 microsecond. Cyclic data packets are transferred as synchronized packets on a reserved bandwidth. All other packets, such as packets for diagnostics or TCP/IP, share the rest of the Ethernet bandwidth.

By default, the minimum update rate is defined at 250 µs in Conformance Class C. For maximum control performance, this can be reduced to as low as 31.25 µs, depending on the hardware used. In order to expand data volumes when cycle times are set at less than 250 µs, a message frame optimization method (dynamic frame packing, DFP) is incorporated. With this method, nodes that are wired together in a line structure are addressed with one message frame. In addition, for cycle times less than 250 µs, the TCP/IP communication is fragmented and transmitted in smaller packets.

5.1 Synchronized communication

In order for the bus cycles to run synchronously (at the same time) with a maximum deviation of 1 µs, all devices involved in the synchronous communication must have a common clock. A clock master uses synchronization frames to synchronize all local clock pulse generators of devices within a clock system (IRT domain) to the same clock (Figure 16). For this purpose, all of the devices involved in this type of clock system must be connected directly to one another, without crossing through any non-synchronized devices. Multiple independent clock systems can be defined in one network.

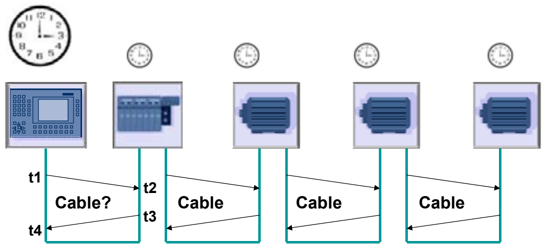


Figure 16: Synchronization of clock pulse generators within an IRT domain by the clock master

To achieve the desired accuracy for the synchronization and synchronous operation, the runtime on each connecting cable must be measured with defined Ethernet message frames and figured into the synchronization. Special hardware precautions must be taken for implementing this clock synchronization.

The bus cycle is divided into different intervals for synchronized communication (Figure 17). First, the synchronous data are transmitted in the red interval. This red interval is protected from delays caused by other data and allows a high level of determinism. In the subsequent open green interval, all other data are transmitted according to IEEE 802 and the specified priorities.

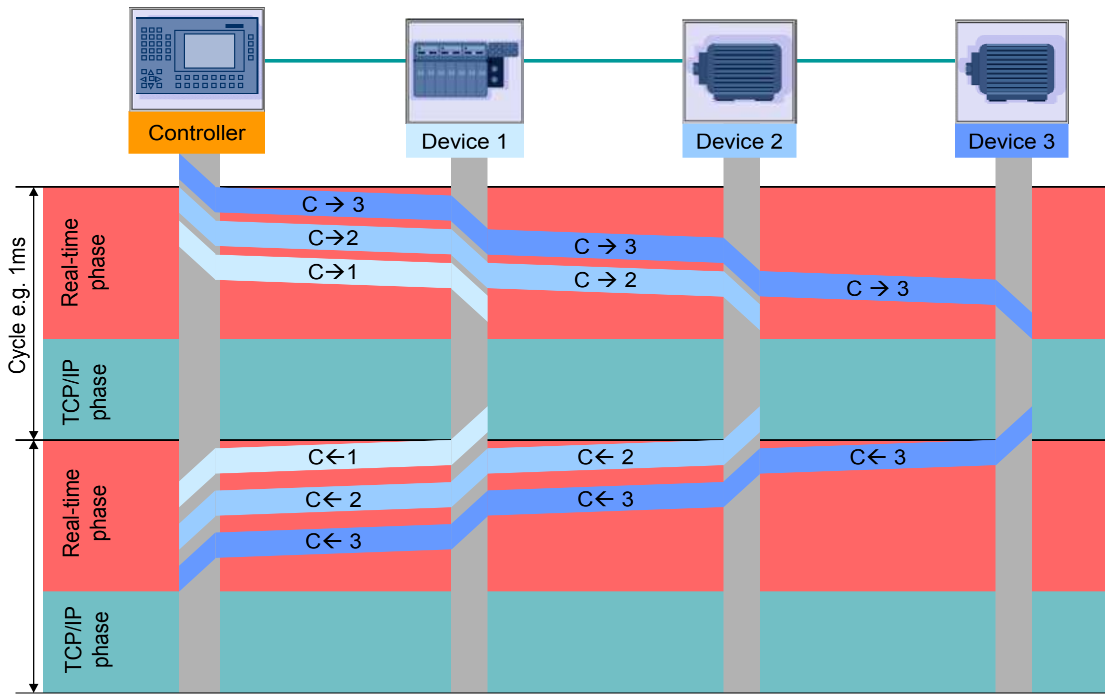


Figure 17: IRT communication divides the bus cycle into a reserved interval (red) and an open interval (green)

The division of the individual intervals can vary. If forwarding of the data before the start of the next reserved interval is not assured, these frames are stored temporarily and sent in the next green interval.

5.2 Mixed operation

A combination of synchronous and asynchronous communication within an automation system is possible, if certain preconditions are met. A mixed operation is shown in Figure 18. In this example, a synchronizable switch has been integrated in the field device for devices 1 to 3. This enables the runtime to be determined and precise synchronization of the clock system to be maintained. The other two devices are connected via a standard Ethernet port and thus communicate asynchronously. The switch ensures that this communication occurs only during the green interval.

5.3 Optimized IRT mode

When the time ratios are subject to stringent requirements, the efficiency of the topology-oriented synchronized communication can be optimized using dynamic frame packing (DFP) (Figure 19).

For a line structure, the synchronous data of several devices are optionally combined into one Ethernet frame. The individual cyclic real-time data can be extracted for each node. Because the data from the field devices to the controller are

also strictly synchronized, these data can be assembled by the switch in a single Ethernet frame.

Ideally, only one frame is then transmitted for all

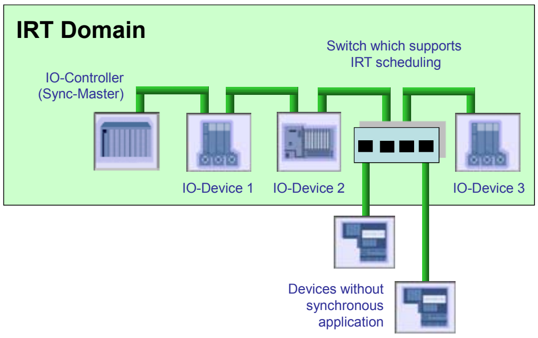


Figure 18: Mixed operation of synchronized and unsynchronized applications

the field devices in the red interval. This frame is disassembled or assembled in the corresponding switch, if required.

This DFP technology is optional for systems with-stringent requirements. The functionalities of the other intervals are retained, i.e., a mixed operation is also possible here. To achieve short cycle times of up to 31,25 µs, however, the green interval must also be sharply reduced. To accomplish this, the standard Ethernet frames for the application are disassembled transparently into smaller fragments, transmitted in small pieces, and reassembled.

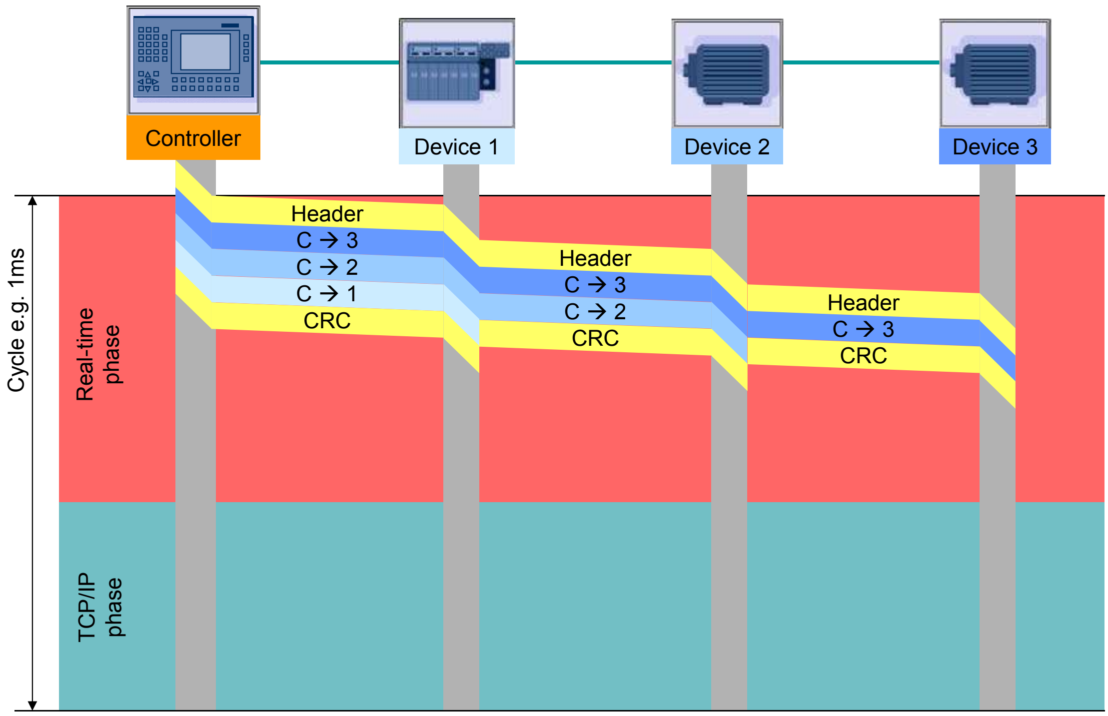


Figure 19: Packing of individual message frames into a group message frame

6. Optional functions

Additionally, PROFINET provides a large number of optional functions that are not included in devices by default by way of Conformance Classes (Table 1). If additional functions are to be used, this must be checked on a case-by-case basis using the device properties (data sheet, manuals, GSD file).

Requirement	Technical function/solution
Multiple access to inputs by various controllers	Shared input
Distribution of device functions to various controllers	Shared device
Extended device identification	Identification & Maintenance IM1-4
Automatic parameter assignment of devices using parameter sets	Individual parameter server
Configuration changes during operation	Configuration in Run (CiR)
Time stamping of I/O data	Time sync
Fast restart after voltage recovery	Fast start-up (FSU)
Higher availability through ring redundancy	MRP/MRPD
Call of a device-specific engineering tool	Tool Calling Interface (TCI)

Table 1: List of possible optional fuctions

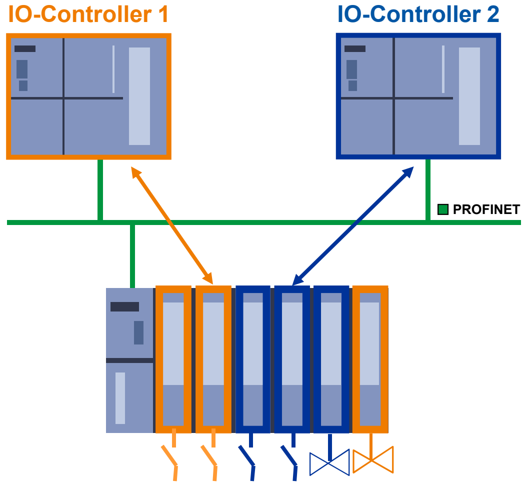


Figure 20: Shared device: Access of multiplecon trollers to different modules in a device

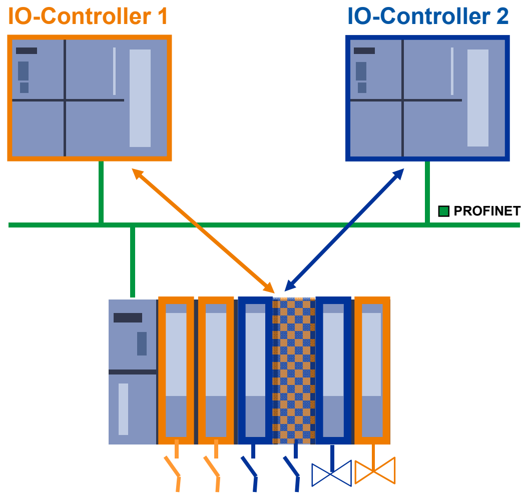


Figure 21: Shared input: Multiple controllers read the same inputs a device

6.1 Multiple access to field devices

The innovative starting point for **shared devices** is the parallel and independent access of two different controllers to the same device (Figure 20). In the case of a shared device, the user configures a fixed assignment of the various I/O modules used in a device to a selected controller. One possible application of a shared device is in fail-safe applications in which a fail-safe CPU controls the safe portion of the device and a standard controller controls the standard I/O within the same station. In the safety scenario, the F-CPU uses the fail-safe portion to safely switch off the supply voltage of the outputs.

In the case of a shared input, there is parallel access to the same input by two different controllers (Figure 21). Thus, an input signal that must be processed in two different controllers of a plant does not have to be wired twice or transferred via CPU-CPU communication.

6.2 Extended device identification

Further information for standardized and simplified identification and maintenance is defined in additional I&M data records. I&M1-4 contain plant-specific information, such as installation location and date, and are created during configuration and written to the device (Table 3).

IM1	TAG_FUNCTION TAG_LOCATION	Plant designation Location designation
IM2	INSTALLATION_DATE	Installation date
IM3	DESCRIPTOR	Comments
IM4	SIGNATURE	Signature

Table 3: Extended device identification

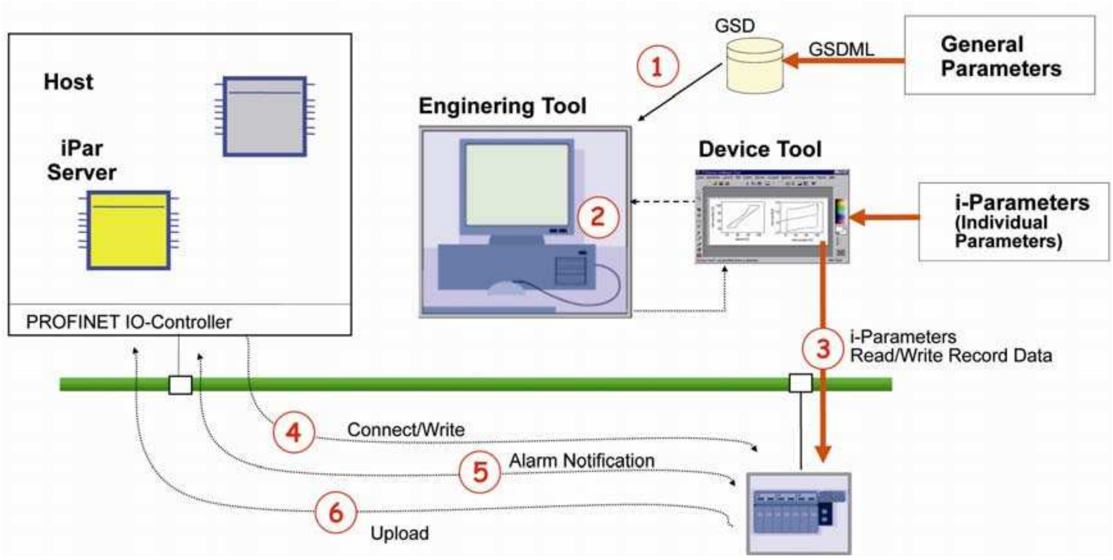


Figure 23: A parameter server can be used to automatically reload backed-up data during device replacement

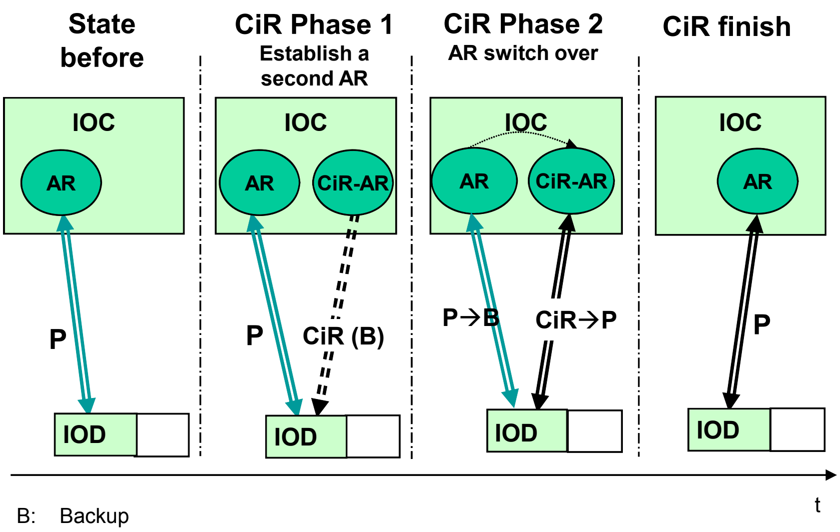
6.3 Individual-Parameter-Server

The individual parameter server functionality is available for backing up and reloading of other optional individual parameters of a field device (Figure 22).

The basic parameter assignment of a field device is carried out using the parameters defined in a GSD file for the field device. A GSD file contains module parameters for I/O modules, among other things. These are stored as static parameters and can be loaded from the IO-Controller to an IO-Device during system power-up. For some field devices it is either impossible or inappropriate to initialize parameters using the GSD approach due to the quantities, the user guidance, or the security requirements involved. Such data for specific devices and technologies are referred to as individual parameters (iPar). Often, they can be specified only during commissioning. If such a field device fails and is replaced, these parameters must also be reloaded to the new field device without the need for an additional tool. The individual parameter server provides plant operators a convenient and uniform solution for this.

6.4 Configuration in Run

Like redundancy, uninterrupted plant operation – including when reconfiguring devices and networks and when inserting, removing, or replacing devices or individual modules – plays an important role in process automation (Figure 22). All of these “Configuration in Run” measures (CiR) are carried out in PROFINET bumpless and without adversely affecting network communication. This ensures that plant repairs, modifications, or expansions can be performed without a plant shutdown in continuous production processes, as well.



B: Backup
P: Primary
CiR: the CiR-AR is always Backup

Figure 22: Configuration changes without plant interruption thanks to redundant connection

6.5 Time stamping

In large plants, the ability to assign alarms and status messages to a sequence of events is often required. For this purpose, an optional time stamping of these messages is possible in PROFINET IO. In order to time stamp data and alarms, the relevant field devices must have the same time of day. To accomplish this, a master clock and the time synchronization protocol are used to set the clocks to the same time.

6.6 Fast restart

Fast **S**tart **U**p (FSU) defines an optimized system power-up in which data exchange begins much faster starting with the second power-up since many parameters are already stored in the field devices. This optional path can be used in parallel to standard power-up (which is still used after a Power On and during the first power-up or reset). It must be possible to store communication parameters retentively for this.

6.7 High availability

Chaining of multiport switches allowed the star topology widely used in Ethernet to be effectively combined with a line structure. This combination is especially well-suited for control cabinet connections, i.e., line connection between control cabinets and star connection to process-level field device. If the connection between two field devices in a line is interrupted, the field devices situated after the interruption are no longer accessible. If increased availability is required, provision must be made for redundant communication paths when planning the system, and field devices/switches that support the redundancy concept of PROFINET must be used.

The line can be closed to form a ring to easily provide a redundant communication path. In the event of an error, the connection to all nodes is ensured via the alternative connection. This achieves a tolerance for *one* fault. Organizational measures must be taken to ensure that this fault is eliminated before a second error occurs.

PROFINET has two mechanisms for setting up ring-shaped media redundancy, depending on the requirements:

Media redundancy protocol (MRP)

The MRP protocol according to IEC 62439 describes PROFINET redundancy with a typical reconfiguring time of < 200 ms for communication paths with TCP/IP and RT frames after a fault. Error-free operation of an automation system involves a media redundancy manager (MRM) and several media redundancy clients (MRC) arranged in a ring, as shown in Figure 24.

The task of a media redundancy manager (MRM) is to check the functional capability of the configured ring structure. This is done by sending out cyclic test frames. As long as it receives all of its test frames again, the ring structure is intact. As a result of this behavior, an MRM prevents frames from circulating and converts a ring structure into a line structure.

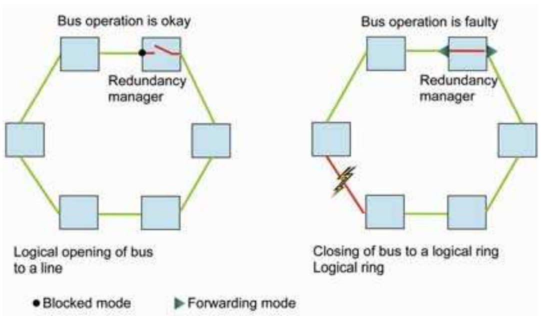


Bild 24: Verhindern von zirkulierenden Frames durch das logische Auftrennen des Busses

A media redundancy client is a switch that acts only as a "passer" of frames and generally does not assume an active role. It must have two switch ports in order to connect to other MRCs or the MRM in a single ring.

Media redundancy for planned duplication (MRPD)

IEC 61158 describes the redundancy concept MRPD (**M**edia **R**edundancy for **P**lanned **D**uplication) for topology-optimized IRT communication, which enables smooth switchover from one communication path to another in the event of a fault. During system power-up, the IO Controller loads the data of the communication paths for both communication channels (directions) in a communication ring to the individual nodes. Thus, it is immaterial which node fails because the loaded "schedule" for both paths is available in the field devices and is monitored and adhered to without exception. Loading of the "schedule" alone is sufficient to exclude frames from circulating in this variant, because the destination ports are explicitly defined.

6.8 Calling an engineering tool

Complex devices, such as drives, laser scanners, etc., often have their own engineering software and tools for making settings for these IO-Devices. With the tool calling interface (TCI) these device tools can now be called directly from the plant engineering system for parameter assignment and diagnostics. In this case, the communication of PROFINET is used directly for the settings in the field device. In addition to the directly integrated device tools, other technologies such as EDDL and FDT can also be used with appropriate adaption software. TCI consists of the following main components:

- **Call interface:** The user can call various field device user interfaces (Device Tools = DT) from the engineering system (ES). Functions are primarily initiated in the device tools through user interaction.
- **Communication interface:** The TCI communication server allows the field device user interface (DT) to communicate with the field device.

Thanks to the freely available TCI specification, every manufacturer can create a DT that works autonomously and integrate it into any TCI-capable ES. The use of TCI is well-suited for field devices in the lower price bracket as well as complex devices already equipped with a user interface, because the implementation effort is manageable.

7. Integration of fieldbus systems

PROFINET specifies a model for integrating existing PROFIBUS and other fieldbus systems such as INTERBUS and DeviceNet (Figure 25). This means that any combination of fieldbus and PROFINET-based subsystems can be configured. Thus a smooth technology transition is possible from fieldbus-based systems to PROFINET. The following requirements are taken into consideration here:

- Plant owners would like the ability to easily integrate existing installations into a newly installed PROFINET system.
- Plant and machine manufacturers would like the ability to use their proven and familiar devices without any modifications for PROFINET automation projects, as well.
- Device manufacturers would like the ability to integrate their existing field devices into PROFINET systems without the need for costly modifications.

Fieldbus solutions can be easily and seamlessly integrated into a PROFINET system using proxies and gateways. The proxy acts as a representative of the fieldbus devices on the Ethernet. It integrates the nodes connected to a lower-level fieldbus system into the higher-level PROFINET system. As a result, the advantages of fieldbuses, such as high dynamic response, pinpoint diagnostics, and automatic system configuration without settings on devices, can be utilized in the PROFINET world, as well. These advantages simplify planning through the use of known sequences. Likewise, commissioning and operation are made easier through the comprehensive diagnostics properties of the fieldbus system. Devices and software tools are also supported in the accustomed manner and integrated into the handling of the PROFINET system.

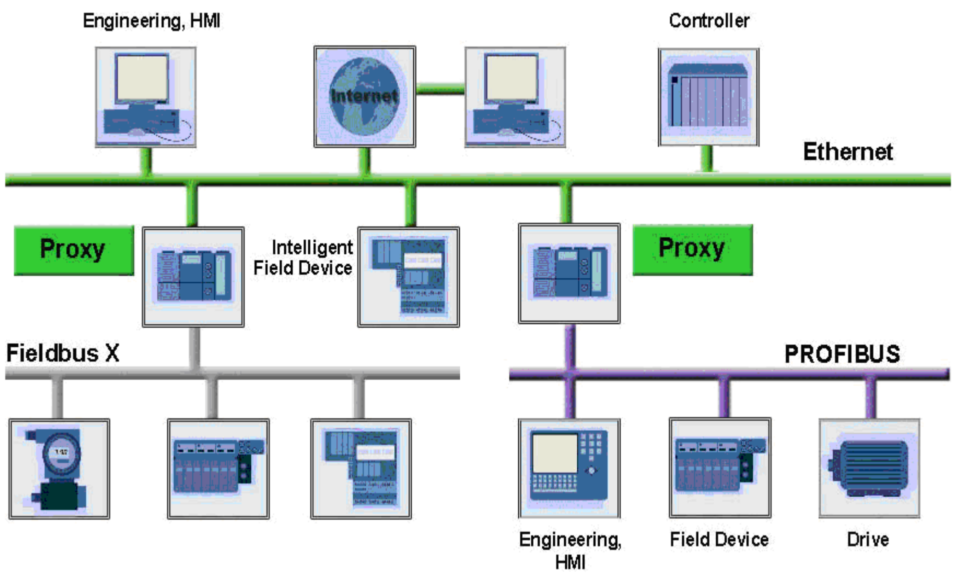


Figure 25: Integration of fieldbus systems is easy with PROFINET

8. Application profiles

By default, PROFINET transfers the specified data transparently. It is up to the user to interpret the sent or received data in the user program of a PC-based solution or programmable logic controller.

Application profiles are specifications for particular properties, performance characteristics, and behavior of devices and systems that are developed jointly by manufacturers and users. The term “profile” can apply to a few specifications for a particular device class or a comprehensive set of specifications for applications in a particular industry sector.

In general, two groups of application profiles are distinguished:

- **General application profiles** that can be used for different applications (examples of these include the profiles PROFIsafe and PROFIenergy)
- **Specific application profiles** that were each developed for a specific type of application, such as PROFIdrive or devices for process automation.

These application profiles are specified by PI based on market demand and are available on the PI-website.

8.1 PROFIsafe

The PROFIsafe designation refers to a protocol defined in IEC 61784-3-3 for implementation of functional safety (fail-safe) and recognized by IFA and TÜV. PROFIsafe can be used with PROFIBUS and PROFINET alike.

The use of PROFIsafe enables elements of a fail-safe controller to be transferred directly to the process control on the same network. The need for additional wiring is eliminated.

8.2 PROFIdrive

The PROFIdrive designation refers to the specification of a standardized drive interface for PROFIBUS and PROFINET. This application-oriented profile, which has been standardized in IEC 61800-7, contains standard definitions (syntax and semantics) for communication between drives and automation systems, thus assuring vendor neutrality, interoperability, and investment protection.

The PROFIdrive application profile provides the foundation for almost every drive task in the field of industrial automation engineering. It defines the device behavior and the procedure for accessing drive data of electric drives and also optimally integrates the additional PROFIsafe and PROFIenergy profiles.

8.3 PROFIenergy

The high cost of energy and compliance with legal obligations are compelling industry to engage in energy conservation. Recent trends toward the use of efficient drives and optimized production processes have been accompanied by significant energy savings. However, in today's plants and production units, it is common for numerous energy consuming loads to continue running during pauses. PROFIenergy addresses this situation.

PROFIenergy enables an active and effective energy management. By purposefully switching off unneeded consumers and/or adapting parameters such as clock rates to the production rate, energy demand and, thus, energy costs can be drastically reduced. In doing so, the power consumption of automation components such as robots and laser cutting machines or other subsystems used in production industries is controlled using PROFIenergy commands. PROFINET nodes in which PROFIenergy functionality is implemented can use the commands to react flexibly to idle times. In this way, individual devices or unneeded portions of a machine can be shut down during short pauses, while a whole plant can be shut down in an orderly manner during long pauses. In addition, PROFIenergy can help optimize a plant's production on the basis of its energy consumption.

9. PROFINET for Process Automation

Compared with production automation, process automation has a few special characteristics that contribute to defining the use of automation to a large extent. Plants can have a service life of many decades. This gives rise to a requirement, on the part of plant operators, for older and newer technologies to coexist in such a way that they are functionally compatible. In addition, requirements for reliability of process plants, particularly in continuous processes, are often considerably greater. As a result of these two factors, investment decisions regarding new technologies are significantly more conservative in process automation than in production automation.

For optimal use of PROFINET in all sectors of process automation, PI has created a requirements catalog in collaboration with users. In this manner, it is ensured that plant owners can rely on a future-proof system based on PROFIBUS today and can change to PROFINET at any time. The requirements mainly include the functions for cyclic and acyclic data exchange, integration of fieldbuses (PROFIBUS PA, HART, and FF), integration and parameter assignment of devices including Configuration in Run, diagnostics and maintenance, redundancy, and time stamping.

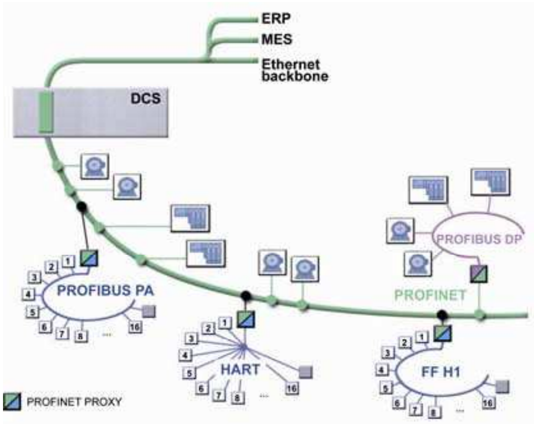


Figure 26: Example architecture for use of PROFI NET in process automation

The energy-limited bus feed of devices in hazardous areas on Ethernet has not been formulated as a requirement as there is already an ideal, proven solution with PROFINET PA. In addition, proven, field-tested Ethernet solutions currently do not exist for this.

10. Network installation

PROFINET is based on a 100 Mbps, full-duplex Ethernet network. Faster communication is also possible on all transmission sections (e.g., between switches, PC systems, or camera systems).

PROFINET defines not only the functionality but also the passive infrastructure components (cabling, connectors). Communication may take place on copper or fiber-optic cables. In a Conformance Class A (CC-A) network, communication is also allowed over wireless transmission systems (Bluetooth, WLAN) (Table 4).

The cabling guide defines for all Conformance Classes a 2-pair cable according to IEC 61784-5-3. The use of 4-pair cables is also allowed for transmission systems with Gigabit cabling requirements.

For a CA-A network, complete networking with active and passive components according to ISO/IEC-24702 is allowed, taking into consideration the CC-A cabling guide. Likewise, active infrastructure components (e.g., switches) according to IEEE 801.x can be used if they support the VLAN tag with prioritization.

Easy-to-understand and systematically structured instructions have been prepared to enable problem-free planning, installation, and commissioning of PROFINET IO. These are available to any interested party on the PI-website. These manuals should be consulted for further information.

10.1 Network configuration

The connection of PROFINET IO field devices occurs exclusively with switches as network components. Switches typically integrated in the field device are used for this (with 2 ports assigned). PROFINET-suitable switches must support "autonegotiation" (negotiating of transmission parameters) and "autocrossover" (autonomous crossing of send and receive lines). As a result, communication can be established autonomously, and fabrication of the transmission cable is uniform: only 1:1 wired cables can be used.

PROFINET supports the following topologies for Ethernet communication:

- Line topology, which primarily connects terminals with integrated switches in the field (Figure 27).
- Star topology, which requires a central switch located preferably in the control cabinet.
- Ring topology, in which a line is closed to form a ring in order to achieve media redundancy.
- Tree topology, in which the topologies indicated above are combined.

Network cabling and infrastructure components	Solution	Conformance class
Passive network components (connector, cable)	RJ45, M12	A, B, C
Copper and fiber-optic transmission systems	TX, FX, LX,	A, B, C
Wireless connections	WLAN, Bluetooth	A
IT switch	With VLAN tag according to IEEE 802.x	A
Switch with device function	PROFINET with RT	B
Switch with device function and bandwidth reservation	PROFINET with IRT	C

Table 3: Network installation for different conformance classes

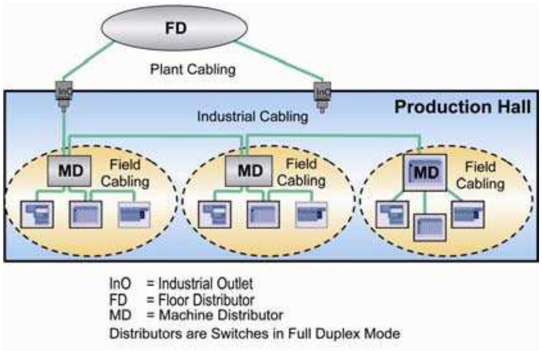


Figure 27: Ethernet networks in industrial environments usually have line topology

10.2 Cables for PROFINET

The maximum segment length for **electrical data transmission** with copper cables between two nodes (field devices or switches) is 100 m. The copper cables are designed uniformly in AWG 22. The installation guide defines different cable types, whose range has been optimally adapted to general requirements for industry. Sufficient system reserves allow industry-compatible installation with no limitation on transmission distance.

The PROFINET cables conform to the cable types used in industry:

- **PROFINET Type A:** Standard permanently-routed cable, no movement after installation
- **PROFINET Type B:** Standard flexible cable, occasional movement or vibration
- **PROFINET Type C:** Special applications: for example, highly-flexible, constant movement (trailing cable or torsion)

Due to their electrical isolation, the use of **fiber-optic cables for data transmission** is especially suitable if equipotential bonding between individual areas of the plant is difficult to establish. Optical fibers also offer advantages over copper in the case of extreme EMC requirements. For fiber-optic transmission, the use of 1 mm polymer optic fibers (POF) is supported, whose handling conforms optimally to industrial requirements.

10.3 Plug connectors

PROFINET has divided the environmental conditions into just two classes. This eliminates unnecessary complexity and allows for the specific requirements of automation. The PROFINET environmental classes for automation applications are subdivided into one class **Inside** protected environments, such as in a control cabinet, and one class **Outside** of control cabinets for applications located directly in the field (Figure 28).

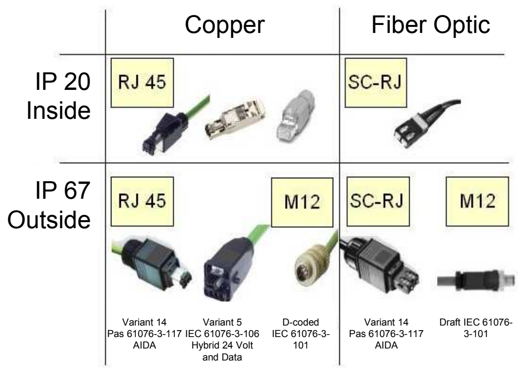
The selection of suitable PROFINET plug connectors accords with the application. If the emphasis is on a universal network that is to be office-compatible, electrical data transmission is via RJ 45, which is prescribed universally for “Inside” environmental conditions. For the “Outside” environment, a push-pull plug connector has been developed that is also fitted with the RJ 45 connector for electrical data transmission. The M12 connector is also specified for PROFINET.

For **optical data transmission** with polymer optic fibers, the SCRJ plug connector, which is based on the SC plug connector, is specified. The SCRJ is used both in the “Inside” environment as well as in connection with the push-pull housing in the “Outside” environment. An optical plug connector is available for the M12 family and can be used for PROFINET and the 1 mm polymer optic fiber transmission (POF).

At the same time, the plug connectors are also specified for the **power supply**, depending on the topology and the supply voltage. Besides the push-pull plug connector, a 7/8" plug connector, a hybrid plug connector, or an M12 plug connector can also be used. The difference between these connectors lies in their connectable cross sections and thus, their maximum amperages.

10.4 Security

For networking within a larger production facility or over the Internet, PROFINET relies on a phased security concept. It recommends a security concept optimized for the specific application case, with one or more upstream security zones. On the one hand, this unburdens the PROFINET devices, and on the other it allows the security concept to be optimized to changing security requirements in a consistent automation engineering solution.



Figures 27: PROFINET offers a range of industrial connectors

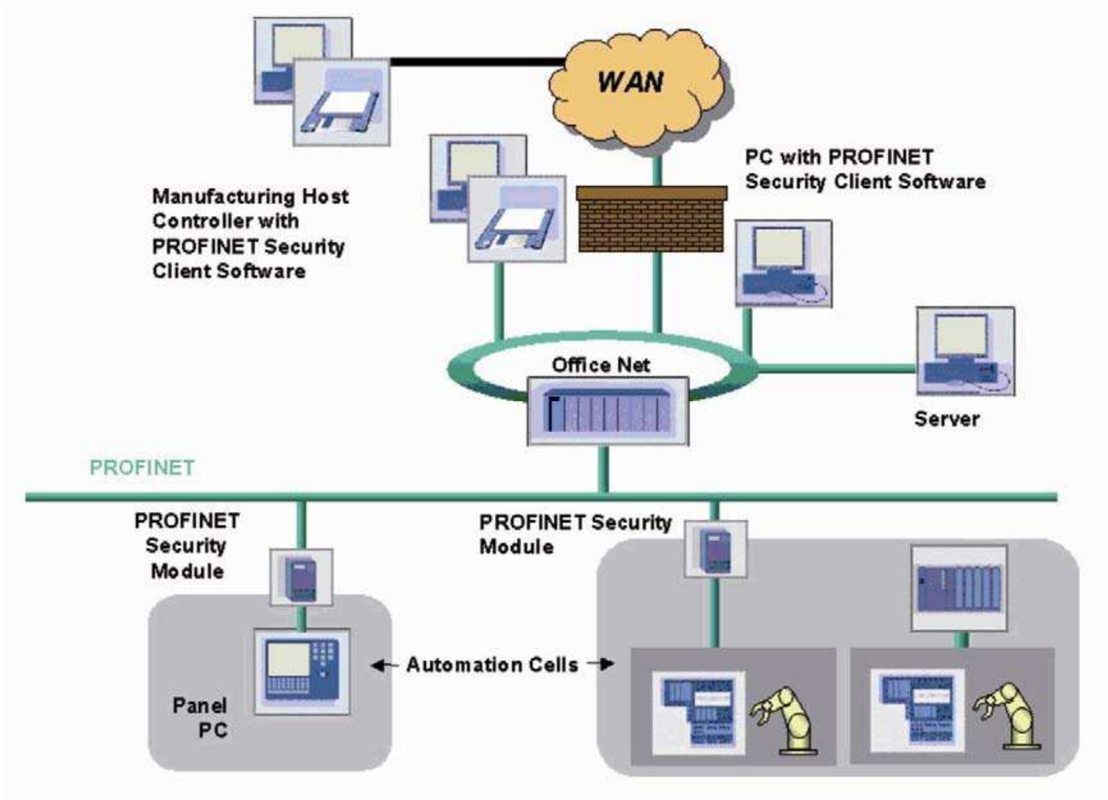


Figure 28: Segmentation of automation network

The security concept provides for protection of both individual devices as well as whole networks from unauthorized access. In addition, there are security modules that will allow networks to be segmented and, thus, also separated and protected from the safety standpoint. Only uniquely identified and authorized messages will be allowed to reach devices within such segments from outside (Figure 29).

11. PROFINET IO-Technology and Certification

PROFINET is standardized in IEC 61158. It is on this basis that devices in industrial plants can be networked together and exchange data without errors. Appropriate quality assurance measures are required to ensure interoperability in automation systems. For this reason, PI has established a certification process for PROFINET devices in which certificates are issued based on test reports of accredited test labs. While PI certification of a field device was not required for PROFIBUS, the guidelines for PROFINET have changed such that any field device bearing the name PROFINET must be certified. Experience with PROFIBUS over the last 20 years has shown that a very high quality standard is needed to protect automation systems, plant owners, and field device manufacturers.

11.1 Technology support

Device manufacturers that want to develop an interface for PROFINET IO have the choice of developing field devices based on existing Ethernet controllers. Alternatively, member companies of PI offer many options for efficient implementation of a PROFINET IO interface.

To make development of a PROFINET IO interface easier for device manufacturers, the PI Competence Center and member companies offer PROFINET IO basic technology (enabling technology). Consulting services and special developer training programs are also available. Before starting a PROFINET IO development project, device manufacturers should always perform an analysis to determine whether internal development of a PROFINET IO device is cost-effective or whether the use of a ready-made communication module will satisfy their requirements.

More detailed information on this topic can be found in the brochure “PROFINET Technology – The easy way to PROFINET”, which can be downloaded from the PI website.

11.2 Tools for product development

Device manufacturers are assisted by software tools when developing and checking their products. These tools are provided to members of PI at no additional charge. A GSD editor assists the manufacturer when creating the GSD file for its product. This GSD editor can be used to create the proper files and check them.

Likewise, PROFINET tester software is available for testing PROFINET functionalities. The current version supports testing of all Conformance Classes as well as IRT functions. The additional security tester allows testing for secure function of a field device, including under load conditions.

For detailed analysis, the Wireshark freeware tools can be used for problem-free interpretation of individual PROFINET frames since the decoding of PROFINET is already included in the standard version.

11.3 Certification test

A certification test is a standardized test procedure that is performed by specialists whose knowledge is kept up to date at all times and who are able to interpret the relevant standards unequivocally. The test scope is described in binding terms in a test specification for each laboratory. The tests are implemented as so-called black box tests in which the tester is the first real user.

All the defined test cases that are run through in a certification test are field-oriented and reflect industrial requirements. This affords all users the maximum possible security for use of the field device in a system. In very many cases, the dynamic behavior of a system can be simulated in the test laboratory.

PI awards the certificate to the manufacturer based on the test report from an accredited test lab. A product must have this certificate in order use the PROFINET designation. For the plant manufacturer/owner, the use of certified products means time savings during commissioning and stable behavior during the entire service life. They therefore require certificates from their suppliers for the field devices used, in accordance with the utilized Conformance Class.

12. PROFIBUS & PROFINET International (PI)

As far as maintenance, ongoing development, and market penetration are concerned, open technologies need a company-independent institution that can serve as a working platform. This was achieved for the PROFIBUS and PROFINET technologies by the founding of the PROFIBUS Nutzerorganisation e.V. (PNO) in 1989 as a non-profit interest group of manufacturers, users, and institutions. The PNO is a member of PI (PROFIBUS & PROFINET International), an umbrella group which was founded in 1995. With its 27 regional PI Associations (RPA) and approximately 1,400 members, PI is represented on every continent and is the world's largest interest group for the industrial communications field (Figure 30).

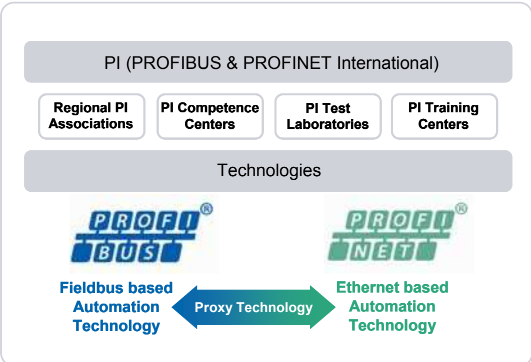


Figure 29: Structure of PROFIBUS & PROFINET International (PI)

12.1 Tasks performed by PI

The key tasks performed by PI are:

- Maintenance and ongoing development of PROFIBUS and PROFINET.
- Promoting the worldwide use of PROFIBUS and PROFINET
- Protection of investment for users and manufacturers by influencing the standardization.
- Representation of the interests of members to standards bodies and associations.
- Providing companies with worldwide technical support through PI Competence Centers (PICC).
- Quality control through product certification based on conformity tests at PI Test Labs (PITL).
- Establishment of a worldwide training standard through PI Training Centers (PITC).

Technology development

PI has handed responsibility for technology development over to PNO Germany. The Advisory Board of PNO Germany oversees the development activities. Technology development takes place in the context of more than 50 working groups with input from more than 500 experts mostly from engineering departments of member companies.

Technical support

PI supports more than 40 accredited PICCs worldwide. These facilities provide users and manufacturers with all manner of advice and support. As institutions of PI, they are independent service providers and adhere to the mutually agreed regulations. The PICCs are regularly checked for their suitability as part of an individually tailored accreditation process. A list of the current addresses can be found on the website.

Certification

PI supports 10 accredited PITLs worldwide for the certification of products with a PROFIBUS or PROFINET interface. As institutions of PI, they are independent service providers and adhere to the mutually agreed regulations. The testing services provided by the PITLs are regularly audited in accordance with a strict accreditation process to ensure that they meet the necessary quality requirements. A list of the current addresses can be found on the website.

Training

The PI Training Centers have been set up with the specific aim of establishing a global training standard for engineers and technicians. The accreditation of the Training Centers and the experts that are based there ensures the quality of the training and, thus, the quality of the engineering and installation services for PROFIBUS and PROFINET. A list of the current addresses can be found on the website.

Internet

Current information on PI and the PROFIBUS and PROFINET technologies is available on the PI website www.profibus.com or www.profinet.com. This includes, for example, an online product guide, a glossary, a variety of web-based training content, and the download area containing specifications, profiles, installation guidelines, and other documents.

Space for your notes:

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Regional PI Associations (RPA)

Regional PI Associations represent PI around the world and are your personal local contacts. They are responsible for local marketing activities for purposes of spreading PROFIBUS, PROFINET, and IO-Link, which include trade fair appearances, seminars, workshops, and press conferences, as well as public relations activities.

PI Competence Center (PICC)

The PI Competence Centers collaborate closely with the RPAs and are your first point of contact when you have technical questions. The PICCs are available to assist you in the development of PROFIBUS or PROFINET devices and the commissioning of systems, and they provide user support and training.

PI Training Center (PITC)

PI Training Centers support users and developers in gaining experience with the PROFIBUS and PROFINET technologies and their possible uses. Individuals who successfully complete the final exam of the Certified Installer or Engineer course receive a certificate from PI.

PI Test Labs (PITL)

PI Test Labs are authorized by PI to conduct certification tests for PROFIBUS and PROFINET. You receive a certificate from PI for your product once it passes the test. The certification program plays a major role in the sustainable quality assurance of products and thus assures that the systems in use exhibit a high level of trouble-free operation and availability.

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