PROFINET
BASICS

- Deciding factors
- Function
- Device description
- Integration concepts
- International standardization

INTERBUS

PUBLISHER

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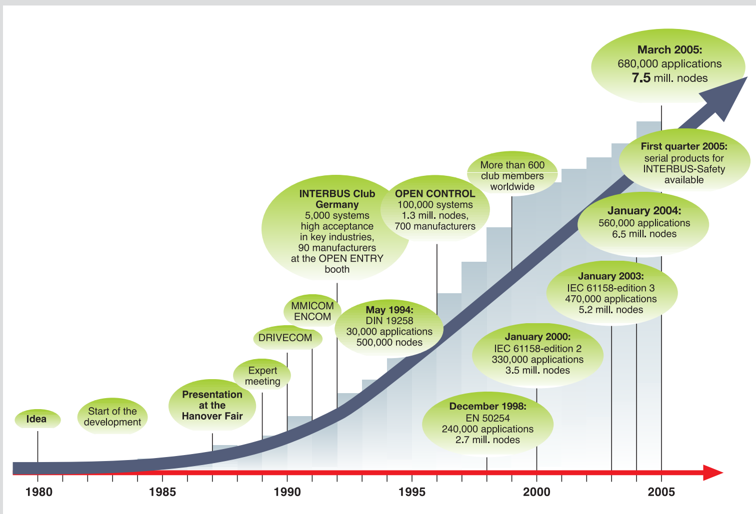
1. Ethernet in factory automation

The call for increased productivity of machines and plants, while at the same time cutting costs, has always been the driving force behind innovations in industrial automation. It was in the light of this that INTERBUS was developed over 15 years ago as the first sensor/ actuator bus system for the transmission of process data.

With its special transmission procedure and ring topology, the INTERBUS system provides not only excellent performance characteristics, such as fast, cyclic and time-equidistant data communication, but also simple handling, comprehensive diagnosis functions to minimize downtime, as well as a high degree of immunity to interference by using fiber optics. It is these characteristics, in combination with the inexpensive connection of sensors and actuators, that have led to the rapid acceptance of the fieldbus system. Currently (March 2005) over 7.5 million INTERBUS nodes are in use around the world in over 680,000 applications in numerous industrial fields. The existing installed base amounts to a value of 1.4 billion US dollars, as calculated by the INTERBUS Club using a Frost & Sullivan survey.



As one of the globally leading fieldbus systems, INTERBUS is currently used in over 680,000 applications in numerous industrial sectors

It is necessary to be able to adapt machines and plants quickly to new variants

Source: Magna Steyr/ AUTOMOBIL ENTWICKLUNG (German technical magazine)

More segments and market niches

Sixties (3)	Seventies (6)	Eighties (8)	Nineties (12)	2000 (14)
Sedan	Hatchback	Multipurpose vehicles	Pickup	Pickup
Sports car	Station wagon	Hatchback	Off-road	Off-road
Spyder	Sedan	Station wagon	Sports utility vehicle	Sports utility vehicle
	Small car	Sedan	Multipurpose vehicles	Multipurpose vehicles
	Sports car	Small car	Hatchback	Hatchback
	Coupé	Sports car	Station wagon	Station wagon
		Coupé	Sedan	Sedan
		Convertible	Small car	Small car
			Sports car	Sports car
			Coupé	Coupé
			Convertible	Convertible
			Roadster	Roadster
				Hybrid vehicles
				New drive systems

Opening up productivity potential

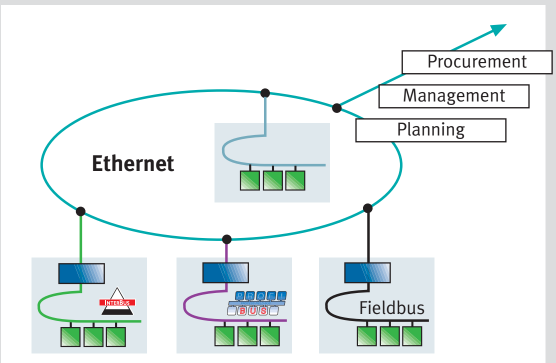
Today's sales markets are characterized by ever shorter product lifecycles with a constant growth in the different product types. In 1990, for example, the lifecycle of an automobile was 9.5 years and eight versions (sedan, station wagon, convertible etc.) were realized on the same platform. Currently, 14 different versions of one brand are produced with an average lifecycle of 6.5 years. In order to be able to manufacture cost-effectively, it is therefore essential for the production plants to reach the Return on Invest (ROI) mark considerably earlier than is currently the case. To achieve this, it is necessary to substantially reduce the development and engineering costs that account for the major share of the overall costs, and to ensure that existing solutions can be integrated simply in new concepts. Communication structures within a company are thus a deciding factor in opening up new productivity potential.

Uniform network structure

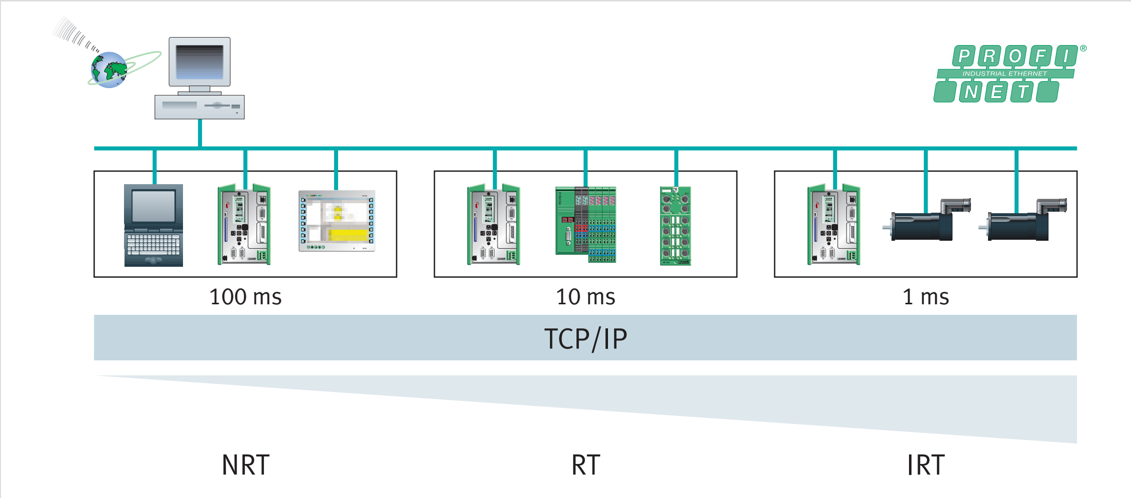
Company networks are at present characterized by complex couplings and data exchange mechanisms between the many island solutions in the production area and between the factory and command level. Transparent access to machine data as would be necessary for perfect job and production control is not possible without considerable effort. The aim must therefore be to develop a uniform network structure that will guarantee that all machine and plant parts are networked and connected to the production planning and company command level. The key to putting this into practice is Ethernet. This transmission medium has established itself in office communication and is already used in the industrial environment to connect distributed machine and plant segments to each other and to higher level systems.

Supplementing Ethernet protocols

The advantage of Ethernet, the globally uniform communication standard, is the seamless transmission of large volumes of data, simultaneous exchange of various services,and the availability of standard components and tools. Low realtime capability and high jitter are, however, the negative side effects at present. It is for this reason that various manufacturers and organizations are working on the development of supplementary Ethernet protocols that fulfill the special requirements of industrial field communication.



In its function as a uniform network structure, Ethernet connects the island solutions along the value added process of the company



Profinet covers the time requirements for all applications, whereby the three TCP/IP, RT and IRT channels can be operated parallel

2. Decision in favor of the most comprehensive Ethernet protocol

Producing companies will only opt for seamless networking on an Ethernet basis if the same scope of performance is offered in the field level as is provided by the bus systems currently used. Apart from fast, cyclic and time-equidistant transmission of process data and the synchronizing of drive systems, this scope of performance covers the transmission of safety-related signals and the transparent and seamless connection of the office and the factory world.

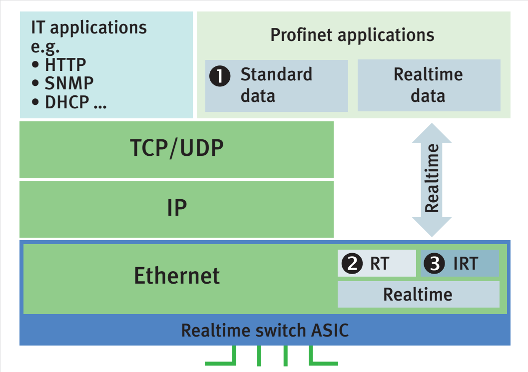
Furthermore, the substantial investments made to date in automation products and solutions by the manufacturers and users have to be protected and a smooth transition from fieldbus to Ethernet must be provided.

The INTERBUS Club has scrutinized these and other relevant criteria pertaining to the performance features of the Ethernet protocols currently developed by various manufacturers and organizations and has come to the conclusion that Profinet best fulfills the requirements of industrial communication for the following reasons:

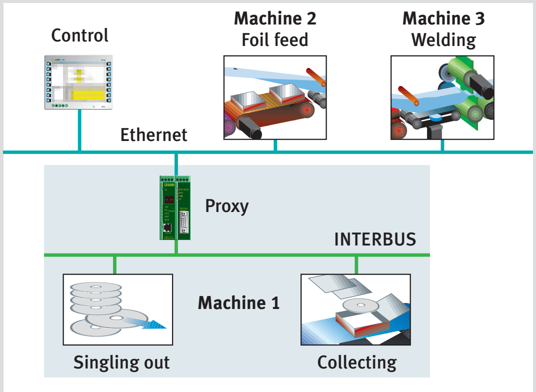
2.1 Scalable realtime solutions

Profinet provides three communication channels adapted to the various equipment classes and can run simultaneously on the same network or device.

- **Standard channel (TCP/IP, UDP/IP)**
  The standard channel serves simple devices with typical reaction times in the range of 100 ms. It can be used for device parameterizing and configuration, for example, as well as for reading diagnosis data.
- **Realtime channel RT (Real Time)**
  With typical cycle times of under 10 ms, RT is in the same performance class as modern fieldbus systems. The channel can be implemented as a software solution in devices and supports the high-performance cyclic transmission of user data



Communication channels in the Profinet system



Profinet CBA supports setting up modular distributed machines and system concepts

and event-driven messages and alarms.

- **Realtime channel IRT (Isochronous Real Time)**
  Highly dynamic drive applications are covered by the IRT channel with cycle times of under 1 ms and jitter of less than 1 µs. IRT is based on an Ethernet chip that organizes the highly dynamic behavior in RT networks.

2.2 Compatibility with the “Open Ethernet World”.

Being able to access all the automation system data directly at the control and production level in order to optimize manufacturing processes is an important requirement for production planning systems. Profinet puts this requirement into practice by using Ethernet standards from communication technology and IT, such as OPC, XML, COM/DCOM, DHCP, SNMP, FTP or HTTP in conjunction with TCP/IP and RT.

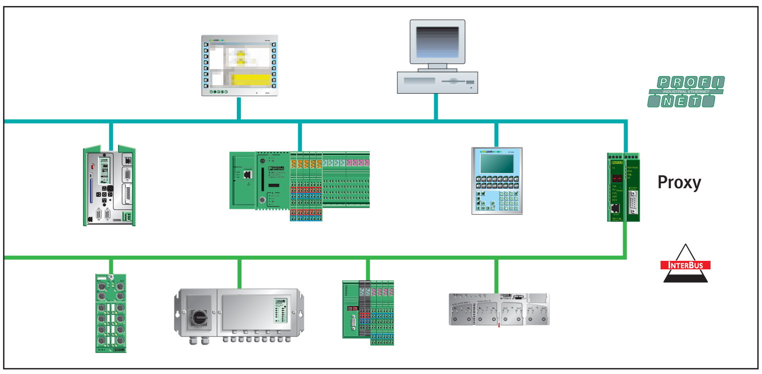
2.3 Architecture model for distributed automation

The component-based architecture model, Profinet CBA (Component Based Automation), supports the trend towards distributing automation functions to various intelligent subsystems, since it defines both the plant engineering and communication between the subsystems and their devices.

While the components within the function units are connected to one another via Profinet or the INTERBUS system with a proxy taking care of “translating” the fieldbus standard into the Profinet protocol, the configuration of the communication relationships is required for the interaction of the function units at runtime. For this purpose, the data to be exchanged between the function units is described while the units are programmed with the programming system together with a Profinet CBA file. The parameter data of the individual subsystems is then imported to the link editor and the function units linked at the click of a mouse.

2.4 Simple integration of existing fieldbus systems

Seamless integration of fieldbus solutions in a Profinet system is simple when proxies are used. The proxy acts here as representative for the fieldbus devices in Ethernet. It integrates the devices connected to a lower level INTERBUS system in the higher level Profinet system. It is thus possible to exploit the advantages of INTERBUS in the Profinet world, such as high dynamics, localized diagnosis and automatic configuration of the system without making settings on the devices. Transferring the system advantages simplifies planning due to familiar processes, and simplifies startup and operation due to comprehensive diagnosis features of the INTERBUS system. The devices and software tools are



Fieldbus systems are integrated in Profinet IO with a proxy to protect the investments of the users

also supported in the familiar manner and integrated in the handling of the Profinet system.

2.5 Support by suppliers of control engineering

Equally important as the technical performance data of the communication system is access to the major control systems. Many control manufacturers such as Siemens or Phoenix Contact have already implemented a Profinet interface in their devices, thus providing broad support for the protocol and consequently access to many automation solutions in all industrial sectors.

The activities of the Profibus User Organisation, the INTERBUS Club, and their members contribute to the continuous development of the Profinet system and the provision of corresponding products, and thus also to guaranteeing the future of Profinet. Additionally, work is being done on a Profinet safety concept that will make it possible to transmit standard and safety-related data along one cable. Another aspect is the development of a security solution to protect communication within industrial plants from data spying, manipulation or unauthorized access.

3. Function of Profinet IO

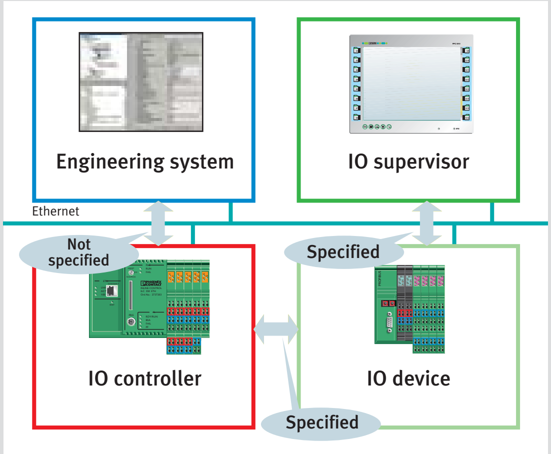
With Profinet IO, the Profinet specification now provides an integration model for simple fieldbus devices that corresponds to the usual viewpoint today of distributed I/Os. The components are addressed in the form familiar from the fieldbus environment, integrated in the particular engineering tool (PC Worx, Step 7 etc.) via the device description, and logically assigned to a controller during planning.

Since all Ethernet devices operate with equal rights in the network, the master/slave process of fieldbus technology becomes a provider/consumer model with Profinet IO. The provider is the transmitter, which sends unsolicited data to the communication partners, the consumers, which then process the data.

In the framework of Profinet IO, a difference is made between the following **device types**:

- **IO controller**
  The IO controller is a device that addresses the particular IO devices connected. It is generally a sequence controller within the distributed function unit that exchanges the input and output signals with the assigned field devices.
- **IO device**
  An IO device is a distributed field device (e. g. remote I/O, drive, valve island, switch) that is assigned to one or more IO controllers and that transmits not only process and configuration data, but also alarms. Data cross traffic between the IO devices is taken care of by the configuration of provider/consumer sub-modules.
- **IO supervisor**
  The IO supervisor can be a programming device or an industrial PC and like the IO controller has access to all process and parameter data .

Application relationships exist between the IO controller, IO supervisor and the IO devices. These relationships in turn contain various communication relationships for the transmission of configuration data (standard channel), process data (realtime



In addition to the engineering systems for network configuration and I/O address allocation, Profinet IO distinguishes between three different device types

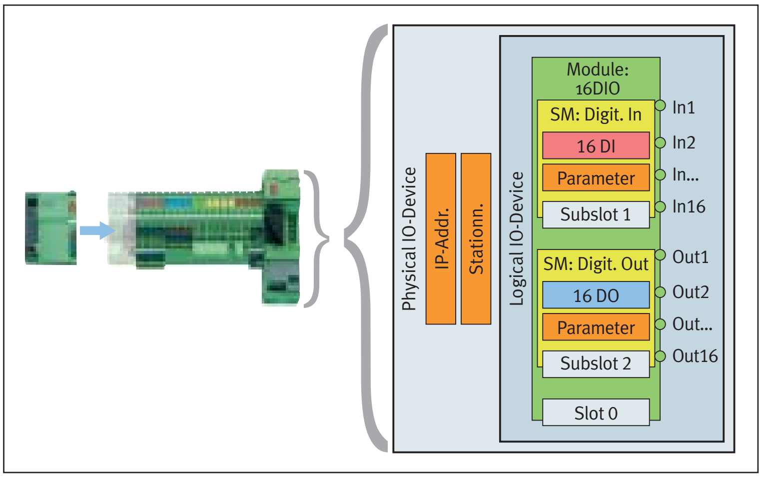
channel) and alarms (realtime channel). The relationships are set up using a **Context Management system** that also serves to set the relevant communication parameters for the communication relationships that are to be set up and for clear identification of the devices.

Profinet IO device model

For addressing, the Context Management system uses a device model which represents the functions of one particular field device as seen from the point of view of Profinet IO. This point of view must be uniform for all field devices to allow communication between different manufacturers' products and different devices. It is also important to note that an IO device in the Profinet IO system does not necessarily correspond to a physical field device, since the device may contain several logical IO devices. The IO device itself defines slots in which modules can be integrated provided they consist of at least one sub-module which represents the actual function.

Each IO device is allocated a globally unique device ID. This is made up of the 16 bit manufacturer ID allocated by the Profibus User Organisation and the 16 bit device ID that each manufacturer is free to define.

The device model represents the functions of the field device as seen from the point of view of Profinet IO



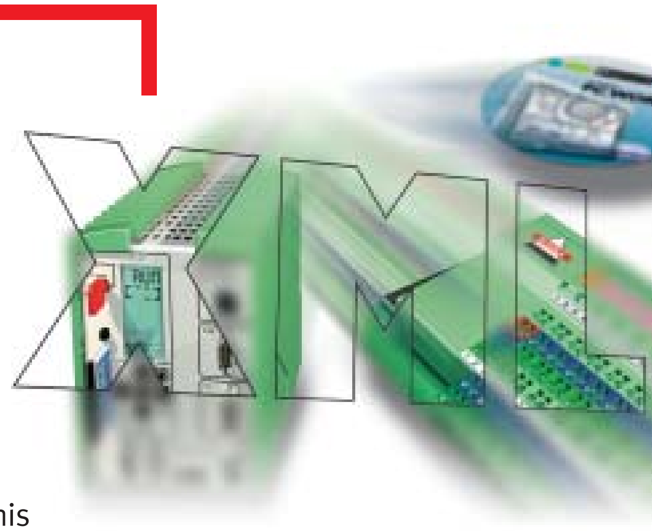
Suitable conductors

Profinet operates in full duplex mode with a data transmission rate of 100 mbps (Fast Ethernet) and can be used in both the production and the office areas. The following conductor types are possible:

1. Electrical conductors with twisted copper cable
The transmission characteristics of the conductors must comply with the CAT 5 requirements and the maximum length between two components must not exceed 100 m.

2. Optical conductors
Multimode FO or single mode FO can be used as the transmission medium, either with glass fibers or of plastic. The maximum length between two components must not exceed 2 km (multimode) or 14 km (single mode).

4. Device description in INTERBUS and Profinet



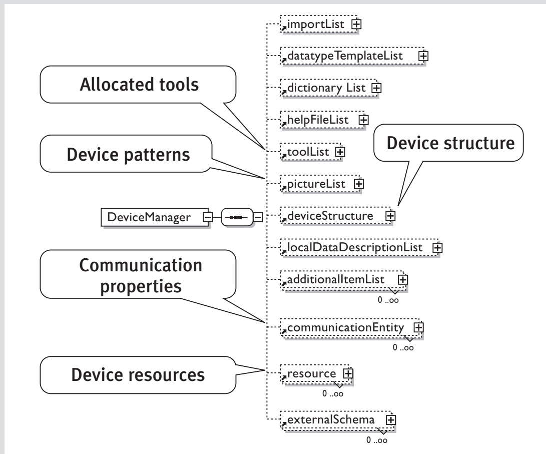
In order to be able to integrate the components needed in an automation solution, a range of information on the device must be provided in the various engineering steps. This is generally made available in the form of a device description. Within the framework of the Profinet system, this description is imported into the particular engineering system as a GSD file (General Station Description) in XML format. Project planning and programming is carried out in the engineering tool and then transferred to the IO controller.

In INTERBUS systems, the components are described in the XML-based FDCML language (Field Device Communication Markup Language) in acc. with ISO 15745-3. FDCML features the following characteristics:

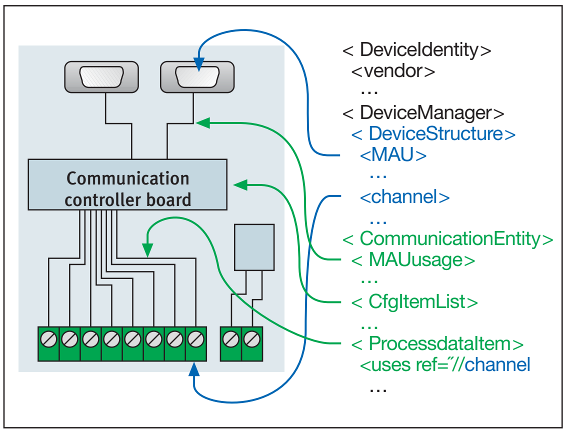
- Can be used for devices with varying compatibility
- System-independent
- Can be extended by typifying generic FDCML elements
- Supports online changeover to a variety of languages
- Can be used for devices that support more than one communication system

The FDCML device model is made up of the following basic elements:

- **DeviceIdentity object**
  The DeviceIdentity object serves for identifying and selecting the device, using the manufacturer's name and device type or device ID, for example.
- **DeviceManager object**
  The DeviceManager object contains all the information needed for the configuration of the system. This could be the electrical connections of the components, for example.

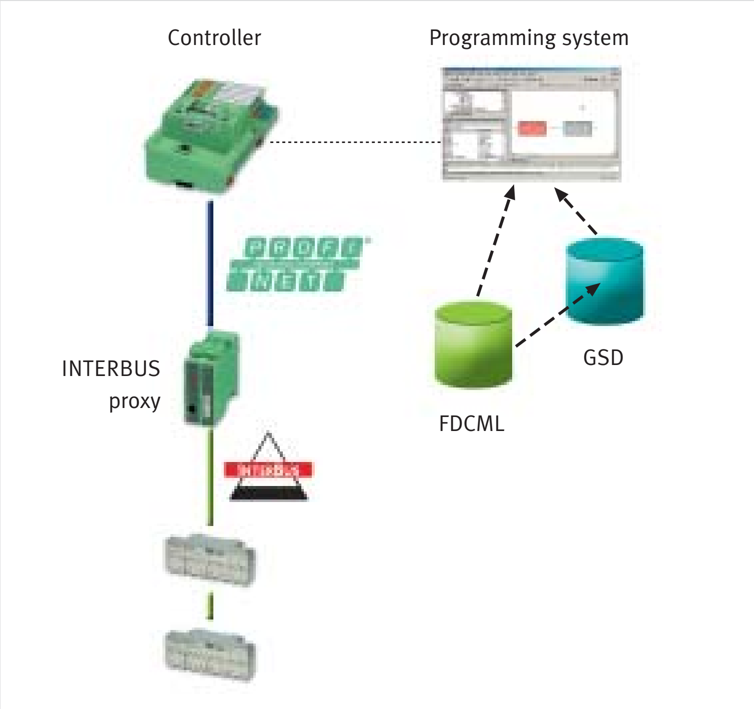


Information on device management in the DeviceManager object



Description of a simple field device in FDCML, the INTERBUS description language

- **DeviceFunction object**
  The DeviceFunction object describes the device function and parameters, thus providing suitable viewpoints for configu-ration, parameterization or visualization.
- **ApplicationProcess object**
  The ApplicationProcess object provides suitable viewpoints for programming or integration in programming environments.



FDCML, the device description language, is suitable for use for both INTERBUS and Profinet IO networks

If one compares GSD in XML format and FDCML, the two device description languages, it is worth noting that GSD in Version 1.0 cannot be used for describing modular stations that are made up of modules from different manufacturers as is generally the case in INTERBUS systems.
The GSD concept is based on a modular slave and all the modules used originating from one manufacturer, so that it is only necessary to keep one GSD file in XML format per IO station.

Work kept to a minimum

In comparison, FDCML is designed for the description of every single device or module. Since the relationships of modular stations can also be described, the possibilities for description with GSD in XML format are also available with FDCML. FDCML is therefore suitable for Profinet networks, since the device information necessary for the configuration of Profinet IO systems can be described in the FDCML device structure. The work involved in describing a component is thus considerably reduced for the device manufacturer, since the description need only be generated once in FDCML. GSD files from IO stations are then generated from the FDCML editor at the touch of a button.

XML – eXtensible Markup Language

XML is nowadays the basis for many applications. This meta language is an abbreviated version of the international SGML standard (Standard Generalized Markup Language), on the basis of which one can develop such tagging languages as HTML oneself. Since SGML is very complex and parts of the standard are seldom used, the World Wide Web Consortium (W3C) created a simplified language in the form of XML. The basic idea of XML is that the documents generated follow certain basic patterns in their structure in order to make the data contained in them easier to reuse.

5. Concepts for the integration of INTERBUS in Profinet IO

The combination of INTERBUS and Profinet IO only contributes towards increasing productivity if the overall solution is seamless and uniform without losing the specific advantages of the Fieldbus and Ethernet system. It is for this reason that the integration of INTERBUS in Profinet IO is based on the proxy concept familiar from the Internet. Transition between networks is realized with gateways that take on the role of a representative, thus guaranteeing that devices and objects connected to INTERBUS are integrated seamlessly in the Profinet concept.

Taking the Profinet IO device model, the following concepts for the integration of INTERBUS in the Ethernet standard are possible:

■ Transparent integration

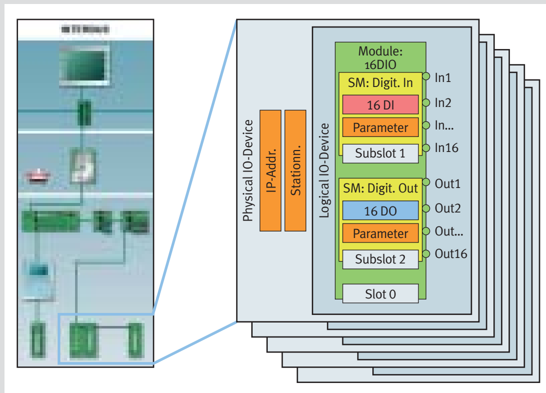
Each INTERBUS device is mapped to a virtual IO device. The advantage of this is that all the devices connected to the fieldbus system are directly visible in Profinet IO. It is, however, necessary to send a separate Ethernet frame with at least 64 bytes for each IO device, even though INTERBUS devices generally only have very little process data. In the case of large-scale lower level systems, this leads to a high network load in the Profinet system and thus to reduced protocol efficiency. The transparent model is therefore not absolutely suitable for the integration of INTERBUS.

■ Compact integration

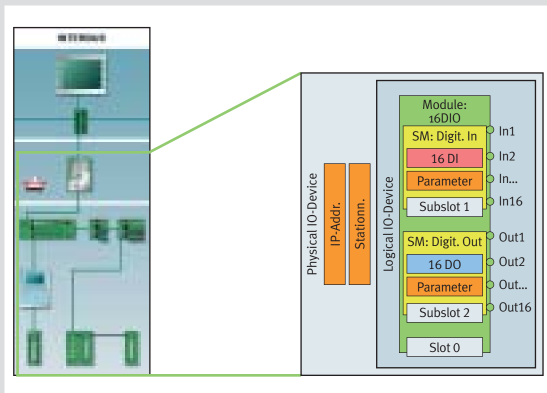
The entire INTERBUS system is mapped to one IO device with just one module and one sub-module. Since it is possible to transmit the entire process image available via INTERBUS with one Profinet IO telegram, the network load in the Profinet system is low. The structural representation of the INTERBUS system, however, is not possible, since the INTERBUS devices are no longer visible in the Profinet IO. In addition, it is necessary to plan the INTERBUS proxy with a special engineering tool.

■ Modular integration

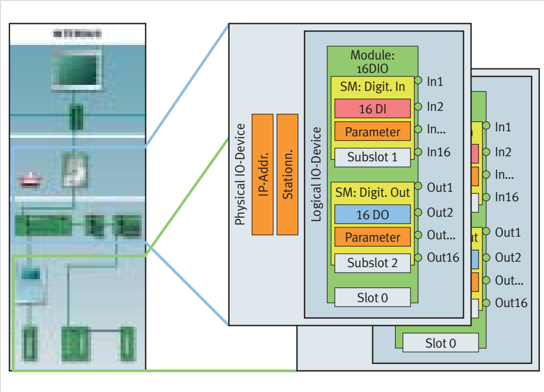
Each INTERBUS device is mapped to its own module in just one IO device. It is thus possible to transmit the data of all modules in one Ethernet frame, resulting in high protocol efficiency in the Profinet system. The characteristics of the INTERBUS devices continue to be available in the particular sub-module. Another advantage is the fact that no extra configuration tool is needed for the INTERBUS proxy, since configuration of a modular device is supported by all programming systems.



Transparent integration: Each INTERBUS device is mapped to an IO device



Compact integration: The entire INTERBUS system is mapped to an IO device



Modular integration: Each INTERBUS device is mapped to a module in one IO device

After weighing up the pros and cons of the individual integration models, the INTERBUS Club and its members have pledged support of the specification of the modular concept in a first step. This is described briefly below.

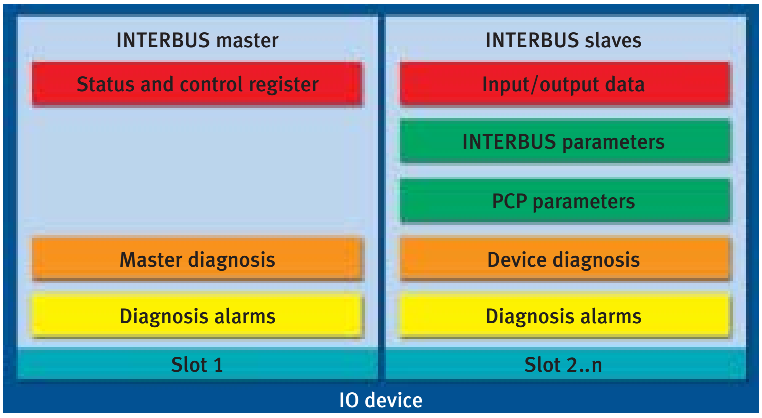
The function of modular integration

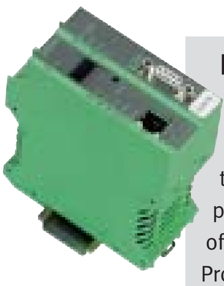
Within the framework of modular integration, slot 1 of the Profinet IO device model is reserved for the INTERBUS master. Via the cyclic process data channel that is used for status messages and control registers it is possible to call up the status of the INTERBUS system and to carry out special actions such as enabling and disabling devices. All events that do not concern a special slot are mapped to the channel diagnosis of slot 1, e.g. general parameterizing errors. Each diagnosis event is sent to the controller in the form of a corresponding diagnosis alarm.

All INTERBUS slaves connected to the master use slots 2 and those following, the order of which must correspond to the structure of the INTERBUS system. Empty slots are therefore not permitted. The cyclic process data of a slot is directly assigned to the input and output data of the individual INTERBUS slaves, while the Profinet IO parameters are used for setting device-specific data (e.g. ID code or process data length) as well as mapping device-specific PCP parameters. Diagnosis messages from the INTERBUS system are available as Profinet IO channel diagnosis and are forwarded to the controller as diagnosis alarms and the controller then displays the diagnosis event in plain text.

The device model functions like an INTERBUS controller board, but in this case is not connected to the backplane of the control system. It instead makes contact via a serial Profinet connection.

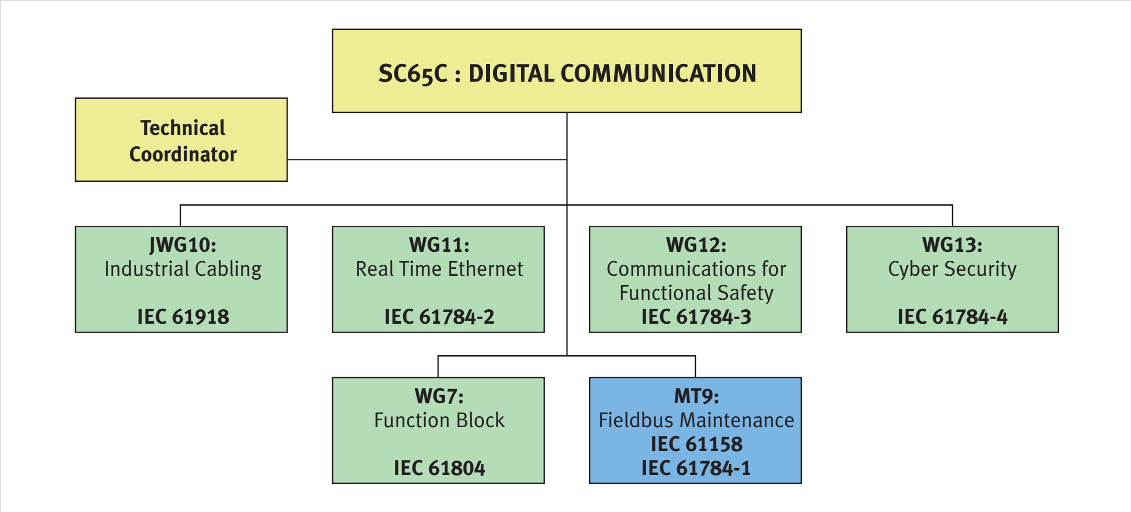
Within the framework of modular integration, slot 1 is reserved for the INTERBUS master, while the slaves are arranged on slots 2 and following





Profinet/INTERBUS proxy FL PN/IBS

Phoenix Contact is one of the first automation manufacturers to offer a Profinet/INTERBUS proxy that unites the advantages of the INTERBUS system with the Profinet world. Transparent access to the data of the INTERBUS components allows existing fieldbus applications to be easily integrated in the complete solution. The DIN rail mountable FL PN/IBS proxy supports full duplex operation with 100 mbps and is characterized by optimized time behavior, since the process data of all components is grouped in an efficient manner.



Work groups within IEC SC65C "Digital Communications"

6. International standardization of INTERBUS and Profinet

Despite a certain delay between development activities and standardization, the international standardization of communication systems and components gives both the users and the manufacturers a sense of security. This is due to the fact that the standards guarantee that the devices of various manufacturers interact seamlessly in an automation solution.

It is for precisely this reason that the INTERBUS Club has been pursuing an active policy of standardization for many years, a policy reflected in the ratification of the system in DIN E 19258 (May 1994), EN 50254 (December 1998) and IEC 61158 (January 2000). Linking INTERBUS and Profinet is currently at the focus of standardization activities, most of which take place in IEC SC65C "Digital Communications" and the accompanying K956 "Fieldbus" in Germany.

INTERBUS has received joint standardization with the fieldbus systems of Foundation Fieldbus, ControlNet, Profibus, P-Net, Swiftnet and WorldFIP in IEC 61158, last updated in March 2003. Since the IEC 61158 includes different fieldbus specifications, so-called "Communication profiles for IEC 61158" were defined and published in IEC 61784-1 as an international standard. The communication profiles represent subsets of the generic IEC 61158 specification, corresponding to the particular communication systems (e.g. INTERBUS, Profibus etc.). In March 2004, the EN IEC 61158 series of standards and EN IEC 61784-1 were ratified by CENELEC, the European standards organization, and thus automatically adopted by the CENELEC member states for their standards.

Ethernet concepts integrated

Work on the IEC 61158 showed that Ethernet-based solutions were increasingly being used in industrial data communication alongside "classical" fieldbus systems. It is for this reason that Profinet, Ethernet IP and Fieldbus Foundation HSE, the concepts found to be relevant to Ethernet during work on the standard, were included in IEC 61158 Edition 3. In IEC SC65C, a new project, IEC 61784-2, on the subject of

"Additional Profiles for ISO/IEC 8802-3 based communication networks in real time applications" was initiated. The corresponding activities take place in the working group 11 (IEC SC65C/ WG 11) "Real Time Ethernet (RTE)", that will define communication profiles until August 2007. In addition to this, the RTE extensions of the communication systems already included in the IEC 61158 standard (e. g. Profinet IO), and other Ethernet-based solutions, such as Ethernet Powerlink for which the basic specification must be made available as a PAS (Publicly Available Specification), are to be integrated in the next edition of IEC 61158, that is to be completed by the end of 2007.

INTERBUS Club and the Profibus User Organisation are carrying out the necessary specification work on the Profinet protocol in joint working groups. In this conjunction, the INTERBUS specification will be extended against the background of achieving an optimum link to the Profinet protocol. The combination of both these standardized systems provides the user with a stable and broad technological base on which to build communication solutions with a secure future.

7. Continuous further development of both systems

Future oriented and competitive sectors such as the automobile industry are following the prognosis of the INTERBUS Club and will in future also implement the Profinet system in their automation solutions.

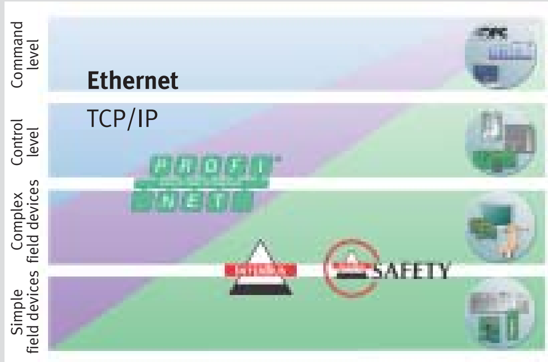
At the end of November 2004, Audi, BMW, DaimlerChrysler and Volkswagen, who had united to form the automation initiative of German automobile manufacturers (AIDA), declared that Profinet, the protocol standard with integrated personal security would be used for simple and uniform connection of the automation components whenever both technical advantages and economic benefits were to be expected. This decision will send out a signal to other sectors, who have in the past, adapted the automation concepts used and proven in the automobile industry to their own machines and plants.
The INTERBUS Club and its members are currently working in various Profinet working groups on standards for safety-related data transmission and motion control applications, as well as safety mechanisms to protect against unauthorized access or manipulation of the network. Due to the wealth of experience made by the INTERBUS Club in the development of INTERBUS Safety, the safe fieldbus system, it is to

be expected that there will soon be an accepted solution for personal security available.

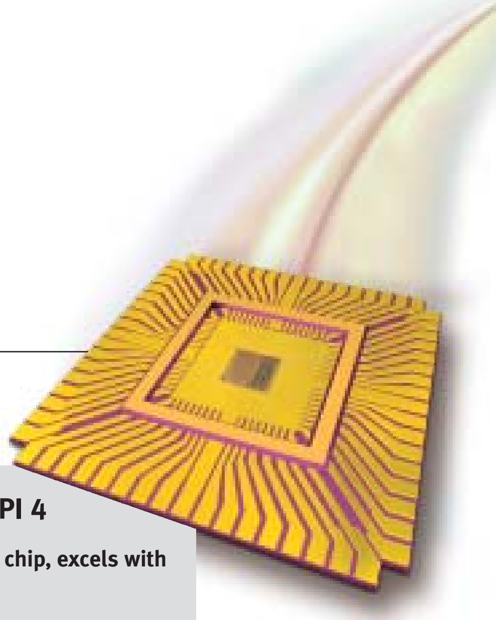
INTERBUS system further optimized

The Ethernet chip necessary to implement the IRT realtime channel in Motion Control devices will be on the market in 2005. Against the background of the economic benefit called for by AIDA, it must be noted that such hardware support would increase the price of the field devices. The INTERBUS Club therefore assumes that fieldbus systems will continue to be used in the medium term for networking local subsystems and simple field devices, since the use of Ethernet protocols is still too complex and too expensive in these areas.

The INTERBUS Club supports this prognosis with the continuous further development of the INTERBUS system. At the end of 2005, with the introduction of the SUPI 4, we will have a new slave protocol chip that secures the technological availability of INTERBUS, optimizes the features of the network, cuts interface costs and creates system reserves. INTERBUS Safety, the fieldbus system certified by the TÜV Rheinland and BGIA, and for which the first components are now on sale, is currently being used in various applications with success. The specification of an INTERBUS/Profinet proxy is also under review and is to be published at the end of March 2005 to allow interested manufacturers to develop a corresponding device.



Automation solutions can be divided into four levels, which place specific requirements on industrial communication



INTERBUS Safety

INTERBUS Safety, the safe fieldbus system, convinces with:

- **Easy integration**
  Safe and non-safe devices can be operated on one bus line
- **Simple handling**
  The familiar procedure of the standard INTERBUS system is kept
- **Localized diagnosis**
  Detection and passing on of short circuits and cross circuits, disturbances in the supply voltage, as well as actions affecting the network wiring
- **Short reaction times and fixed switch-off times**
  Fluctuation-free cycle times of 2 to 5 ms and switch-off times that can be set
- **High security**
  To cat. 4 in acc. with EN 954-1 and SIL3 in acc. with IEC 61508

INTERBUS protocol chip SUPI 4

SUPI 4, the new INTERBUS protocol chip, excels with the following features:

- Downward compatibility with SUPI 2 and SUPI 3
- Low current consumption due to 3.3 V technology and special internal switch-off functions
- Improved driver support
- Additional diagnosis options to support startup
- Increase of the transmission rate to up to 16 mbps incl. automatic baud rate detection
- Improved fiber optics transmission
- Integration of additional data registers and of the PCP layer 2

INTERBUS

Best of Automation

Fax INTERBUS Club Deutschland e.V., Blomberg, Germany

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Please send me the following further information:

- ☐ Brochure “Basics; Standard INTERBUS System”
- ☐ Brochure; “Basics; INTERBUS Safety”
- ☐ Flyer “INTERBUS Protocol Chip SUPI 4“
- ☐ Other: ______________________________

Company

First name/Surname

Dept.

Address/P.O. Box

Zip Code/City/State

Phone

Fax

e-mail

Place, date

Company stamp, signature

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