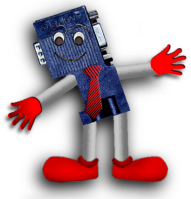
PROFIBUS



- ⇨ **What a fieldbus system needs to offer**
  - ✓ **deterministic (since parallel wiring will be replaced)**
  - ✓ **flexible**
  - ✓ **interoperable (multi-vendor use)**
  - ✓ **cost effective (installation, startup, service)**
  - ✓ **reliable and safe**
  - ✓ **easy to use**

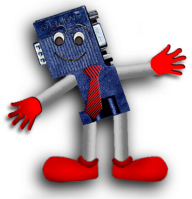
- ⇨ **standardization**

PROFIBUS
EN 50170

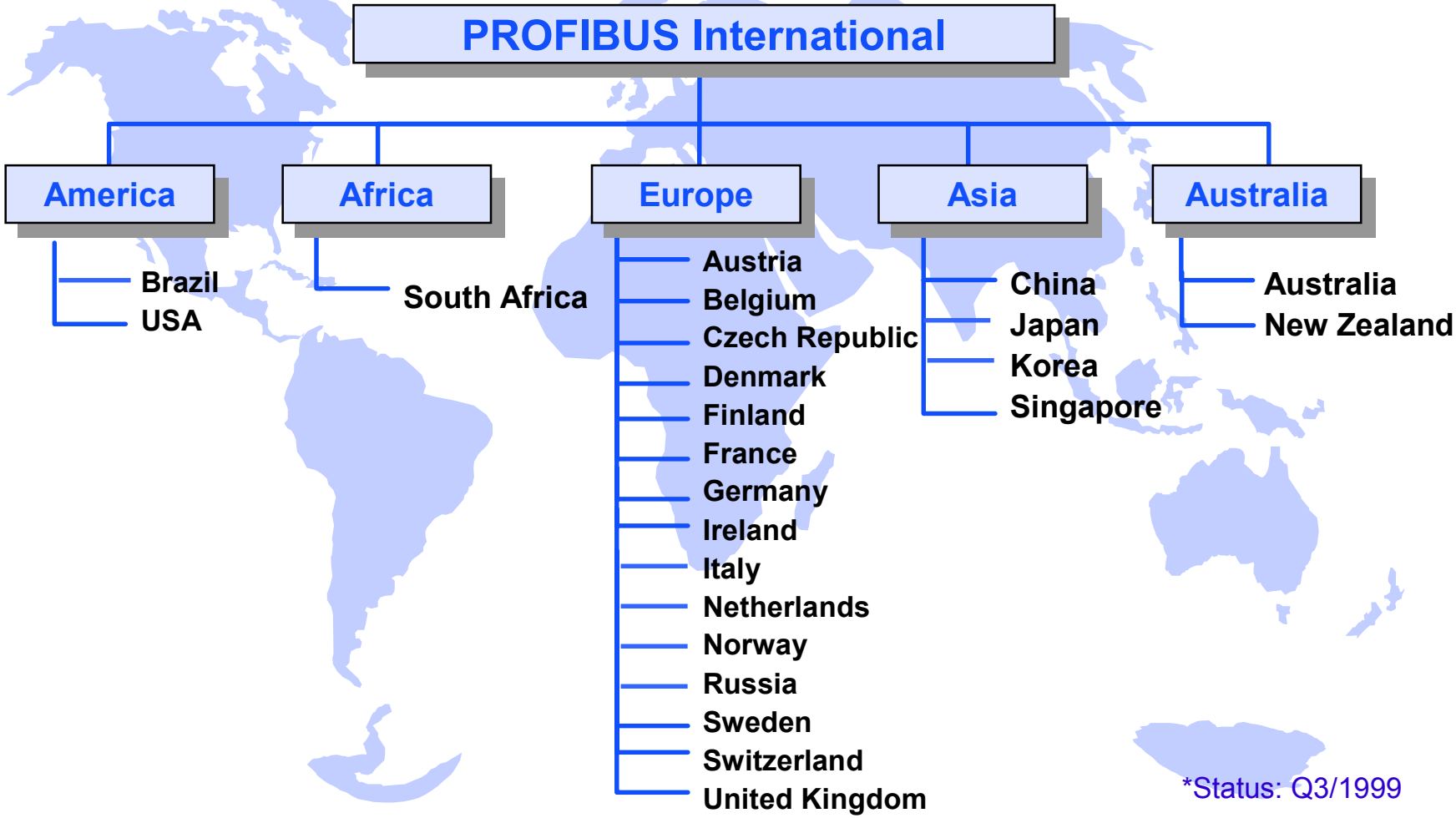
EN 50170 Volume 2

General Purpose Automation	Factory Automation	Process Automation
PROFIBUS-FMS	**PROFIBUS-DP**	**PROFIBUS-PA**
RS 485 / FO	RS 485 / FO	IEC 1158-2
Universal	**Fast**	**Application Oriented**
- Large variety of applications - Multi-master communication	- Plug and play - Efficient and cost effective	- Powering over the bus - Intrinsic safety

INTERNATIONAL

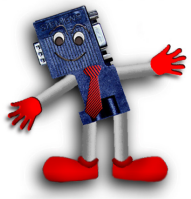


⇨ **More than 900 members - 23 regional user associations**



*Status: Q3/1999

PRODUCT Variety



Drives
- AC Drives
- DC Drives

Controllers
- PLC/NC/RC
- VME, PC
- Workstation

Software Drivers
- DOS/Windows/NT/95
- RT-OS/OS9/VRTX
- VxWorks/PSOS+
- OS2, QNX
- UNIX/VMS

Tools
- Configuration
- Bus Monitor
- Engineering

Decentralized I/O
- Binary I/O
- Analog I/O
- Regulators
- Timer
- Counter
- Ident-Systems

Network components
- Repeaters
- Fiber optics
- Cables

Services
- Development Support
- Implementation Support
- Training

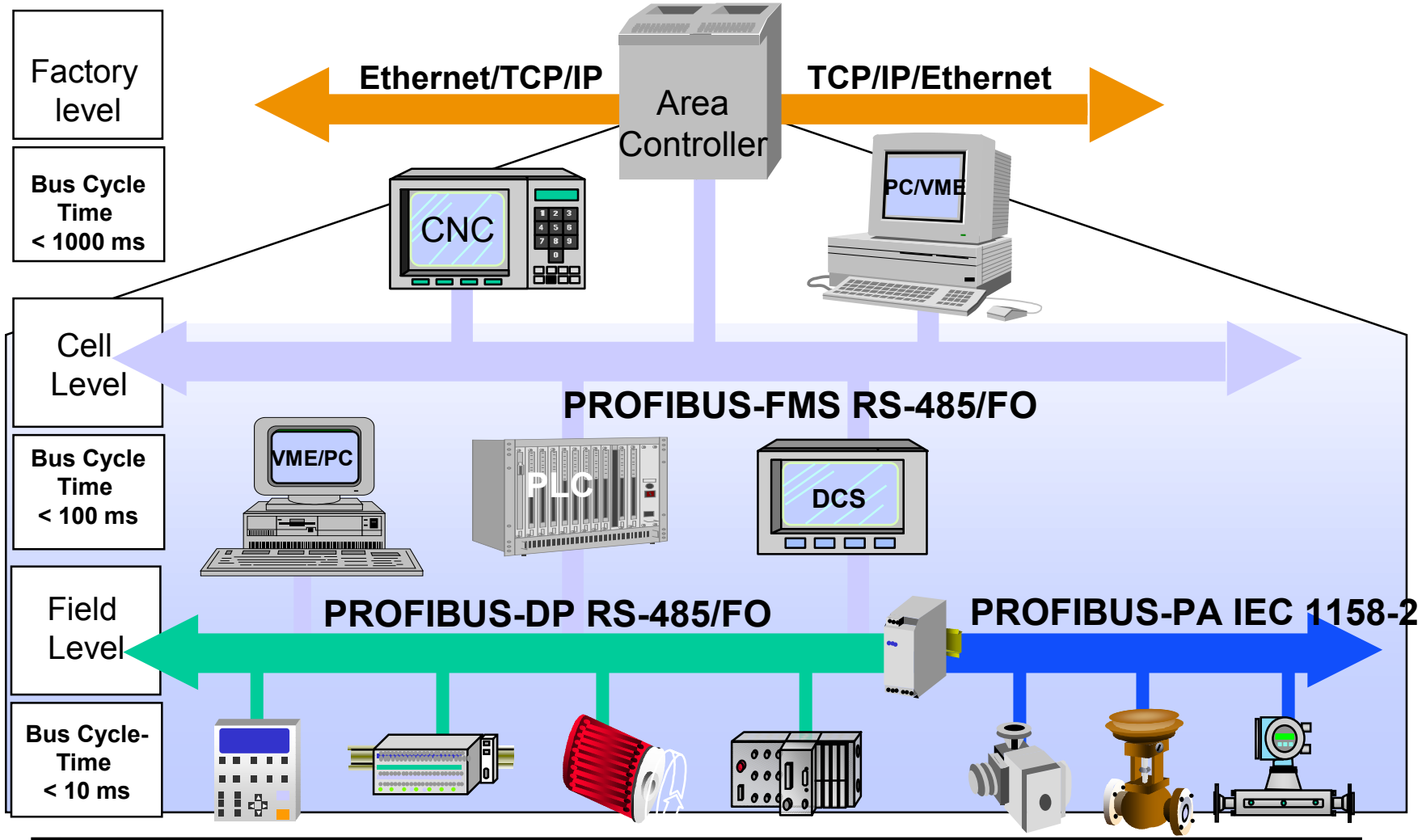
Host Interfaces
- VAX computers
- VME computers

MMI
- Operator Panels
- Text Displays

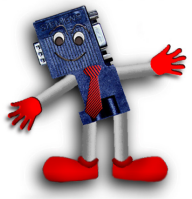
Instruments
- Level
- Flow
- Pressure
- Temperature

Gateways
- AS-Interface
- Proprietary networks

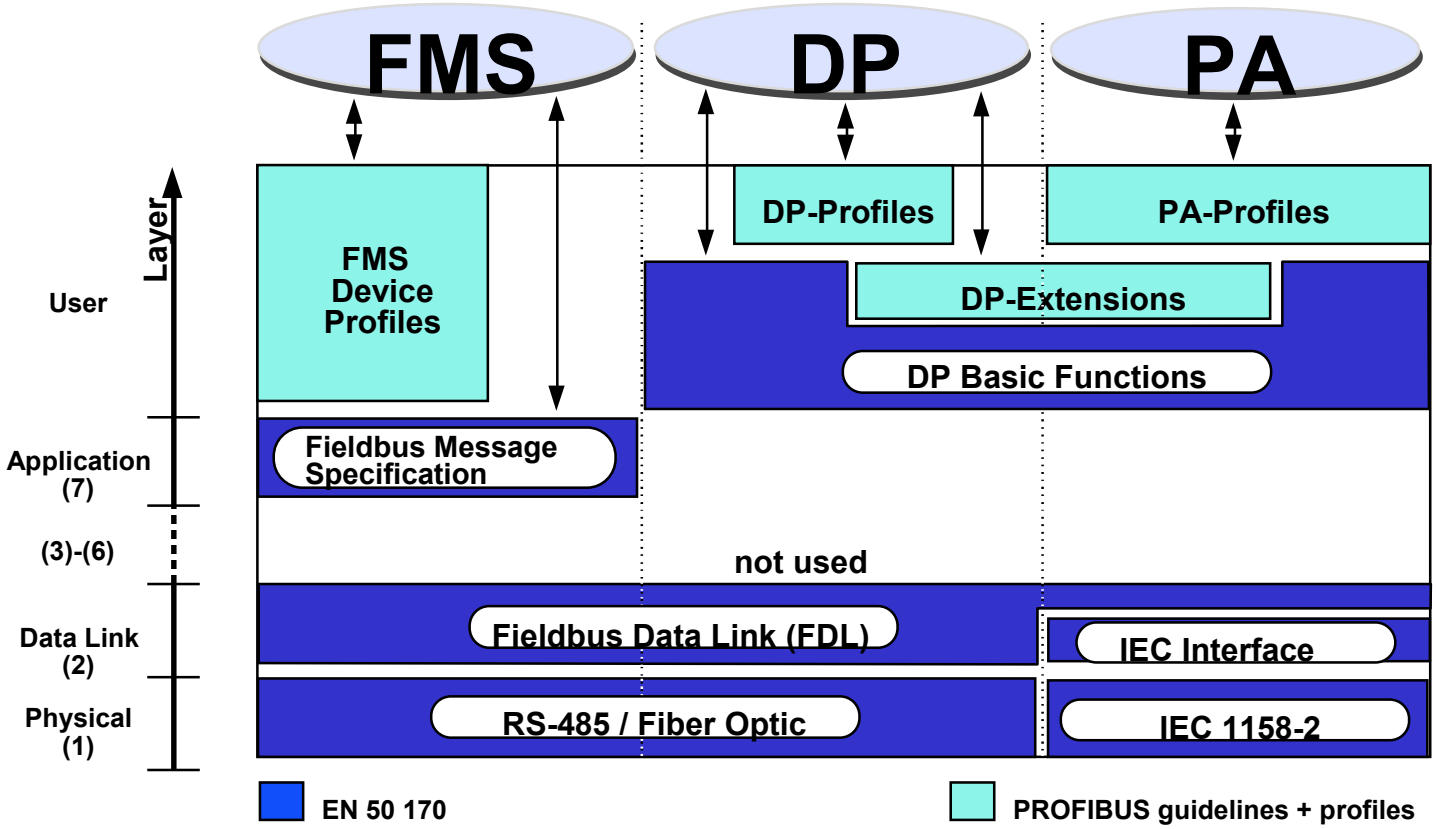
Valves
- Pneumatic Valves
- Magnetic Valves


Factory level
Bus Cycle Time < 1000 ms
Cell Level
Bus Cycle Time < 100 ms
Field Level
Bus Cycle-Time < 10 ms
Ethernet/TCP/IP
Area Controller
TCP/IP/Ethernet
CNC
PC/VME
PROFIBUS-FMS RS-485/FO
VME/PC
PLC
DCS
PROFIBUS-DP RS-485/FO
PROFIBUS-PA IEC 1158-2

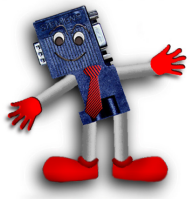
EN 50170 - 2



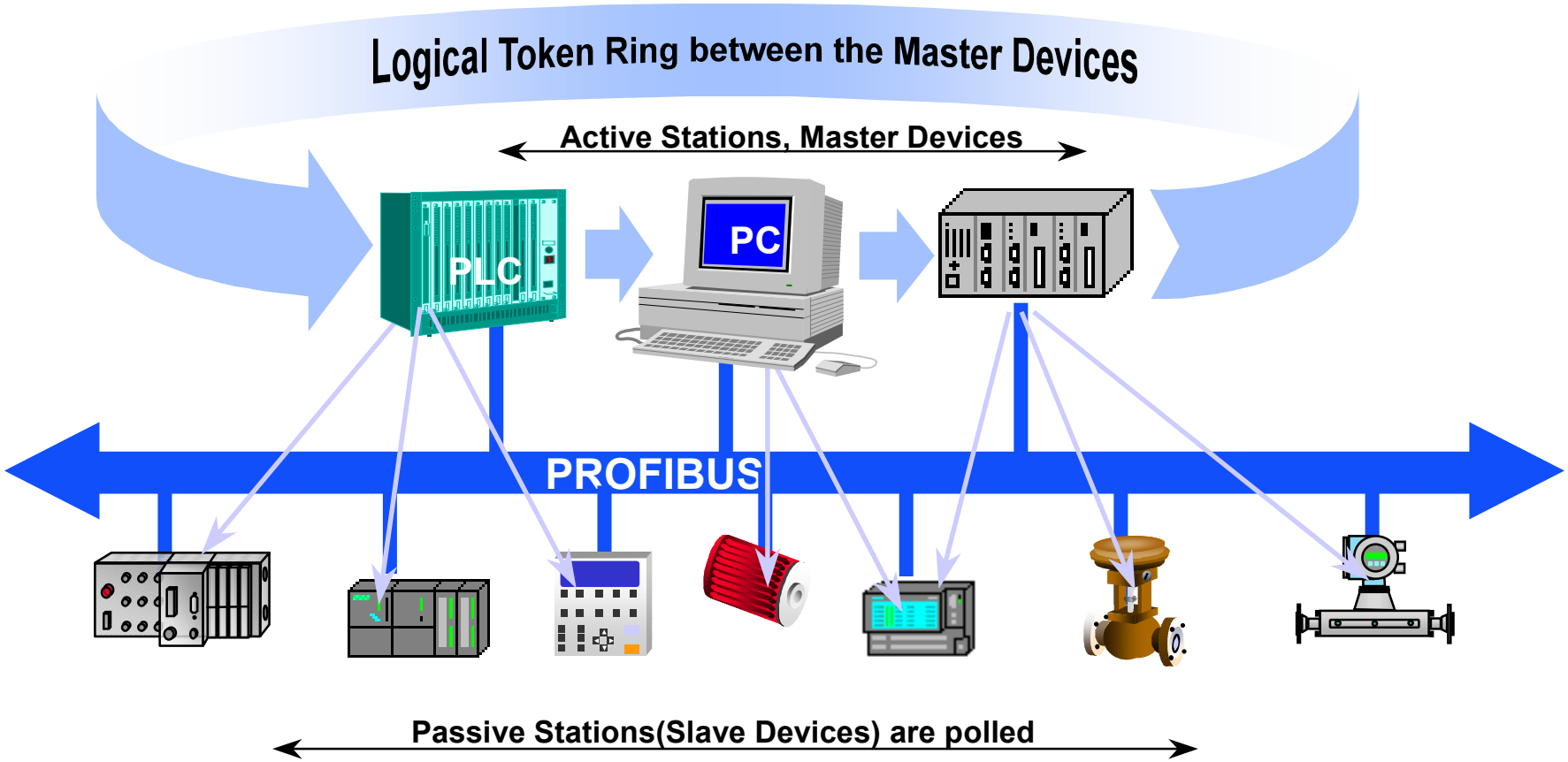
⇨ **The PROFIBUS Protocol is in Accordance with the ISO/OSI Reference Model for Open Systems**



Bus Access

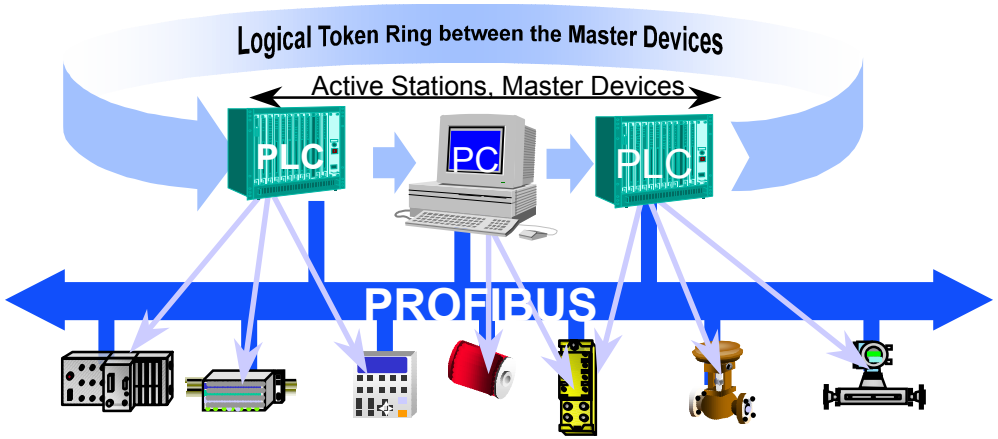


⇨ **The PROFIBUS Bus Access Method combines Multi-Master and Master-Slave communications**

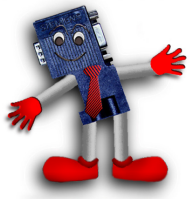


Bus Access

- ⇨ the PROFIBUS Bus Access Protocol (Layer 2) is identical for all three PROFIBUS variations
- ⇨ this enables transparent communication and easy combinations of FMS/DP/PA Network sections
- ⇨ Because FMS/DP use the same Physical Media (RS-485/FO), they can be combined on the same cable



Bus Access



⇨ Hybrid Bus Access Protocol

- ✓ Token-Passing between Masters
  Master - Slave Protocol between Master and Slaves

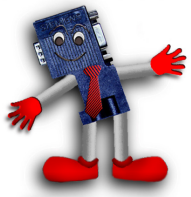
⇨ Master

- ✓ active stations with the right to control the bus for a limited amount of time (Token - Hold - Time)

⇨ Slave

- ✓ Slaves only respond on request of a Master - they have no rights to control the bus

Bus Access



- ✓ in Multi-Master Networks, the Token Passing procedure must ensure that each master has enough time to fulfill its communication tasks
- ✓ the user therefore configures the overall Target Token Rotation Time (TTR) taking into account the communication tasks of all masters
- ✓ each Master calculates the available amount of time for its communication tasks at token receipt according to the following rule:

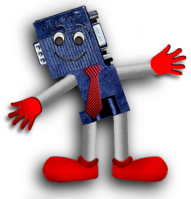
T_{TH} = Token Hold Time

T_{TR} = Target Token Rotation Time

T_{RR} = Real Token Rotation Time

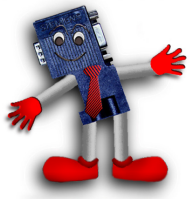
$$T_{TH} = T_{TR} - T_{RR}$$

FMS, DP, PA



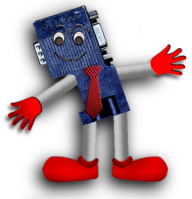
- ⇨ **FMS stands for Fieldbus Messaging System**
  - ✓ **peer to peer communication**
- ⇨ **DP stands for Decentralized Periphery**
  - ✓ **fast data exchange**
- ⇨ **PA stands for Process Automation**
  - ✓ **intrinsically safe environment**

FMS/DP In Common



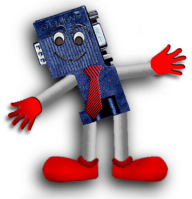
- ⇨ **DP and FMS are based on same Layer 1 and 2:**
  - ✓ **DP and FMS can be operated on the same bus**
  - ✓ **Message header and data length are identical**
  - ✓ **The bus physics are identical**
- ⇨ **One master can service several slaves**
- ⇨ **Several masters can participate on the bus**
- ⇨ **Baudrates from 9.6 kBd up to 12 MBd are possible**

FMS/DP In Common



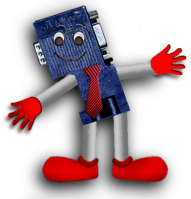
- ⇨ Data transmission can be between 1 and 244 bytes
- ⇨ 126 stations can be connected
- ⇨ System can consist of several segments
- ⇨ 32 stations (RS 485 drivers) per segment
- ⇨ Common components
  - ✓ Cabling, connectors, repeater, fibre optic
- ⇨ Savings in maintenance and spare parts inventory

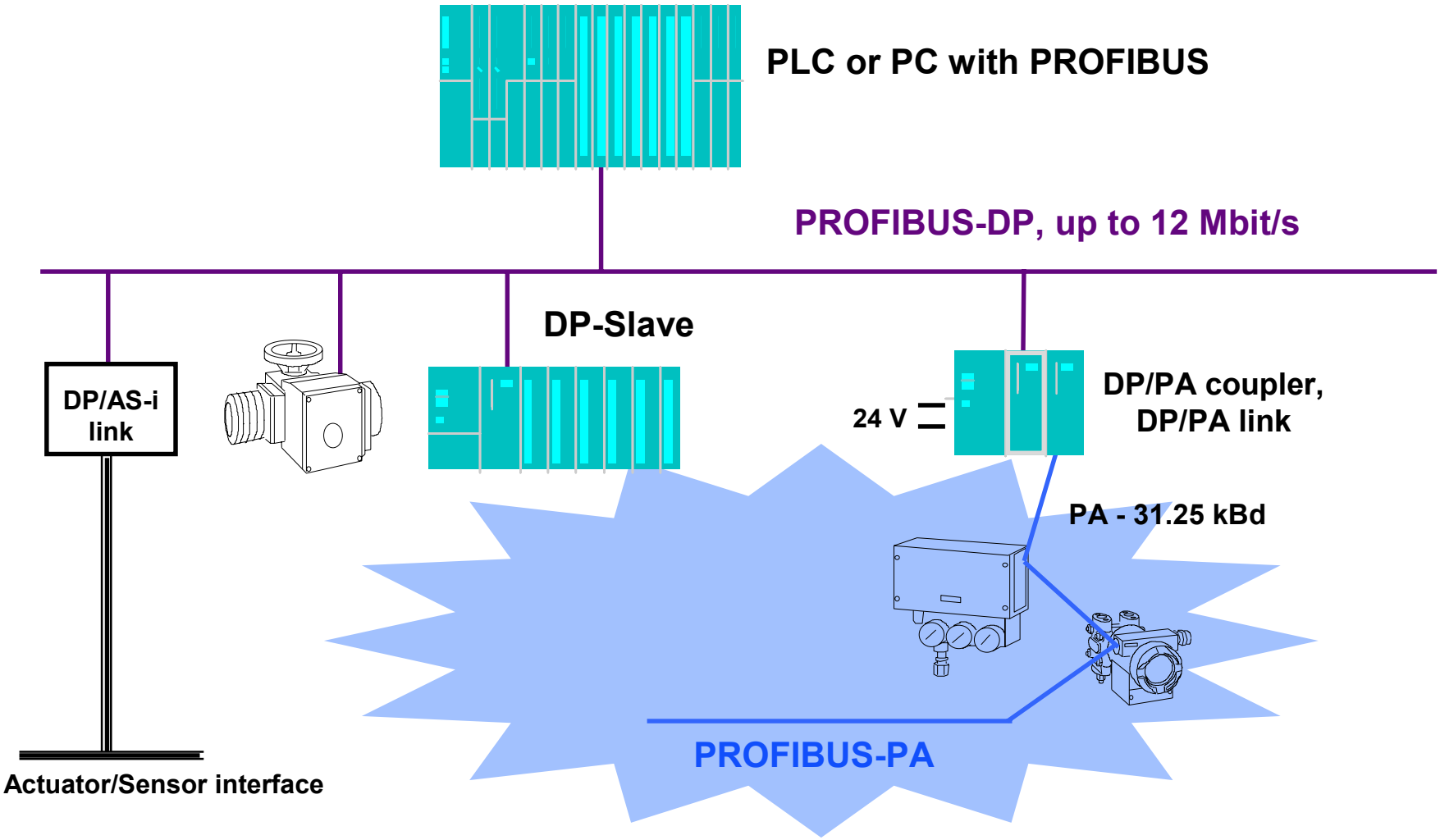
PA/DP In Common



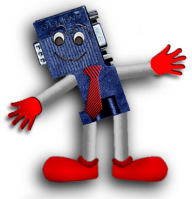
- ⇨ **DP and PA are based on the same protocol definition - DP/V1 (extended DP)**
  - ✓ **DP and PA can use the same master systems**
  - ✓ **Message header and data length are identical**
  - ✓ **Configuration tools are the same**
  - ✓ **Data transmission can be between 1 and 244 bytes**

PA/DP In Common



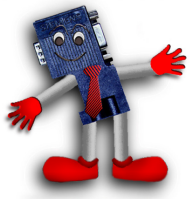


FMS Features



- ⇨ **FMS is optimized for universal, object oriented communication of intelligent master devices at the cell level**
- ⇨ **FMS permits a subset of the MMS-Functions (Manufacturing Message Specification, ISO 9506)**
- ⇨ **A slave can be assigned to several masters**
  - ✓ **Several masters can write to the same slave**
- ⇨ **Communication connections can be temporary or permanent**
- ⇨ **Communication is defined in a communication relation list**

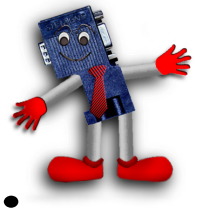
FMS Services



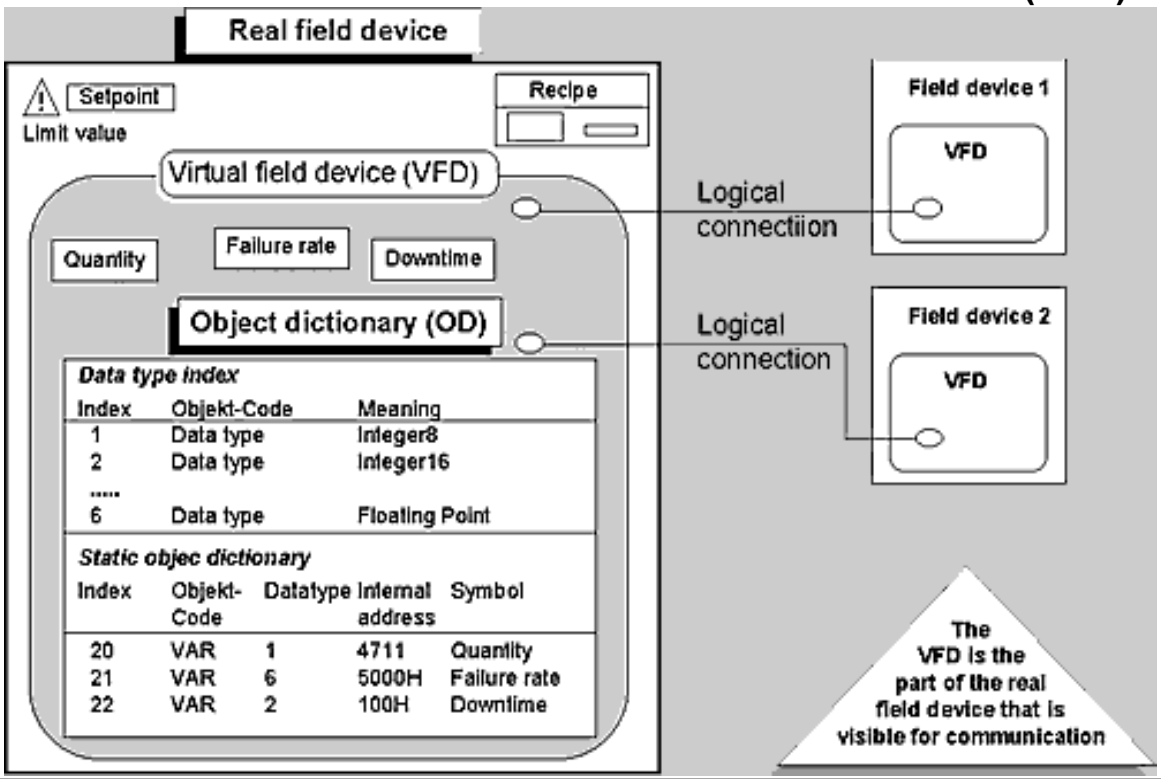
- The FMS application layer (7) consists of the following parts:
  - ✓ The Fieldbus Message Specification (FMS) and
  - ✓ the Lower Layer Interface (LLI)

- FMS services are a subset of the MMS services (MMS=Manufacturing Message Specification, ISO 9506)
  - ✓ have been optimized for field bus applications and have been expanded by functions for communication object administration and network management

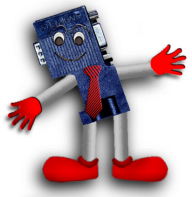
FMS Services virtual field device (VFD).



- ⇨ **The PROFIBUS-FMS communication model permits distributed application processes to be unified into a common process by using communication relationships.**
  - ✓ **The portion of an application process in a field device which can be reached via communication is called a virtual field device (VFD)**



FMS Services



⇨**Context Management** services are for establishing and terminating logical connections.

⇨**Variable Access** services are used to access variables, records, arrays or variable lists.

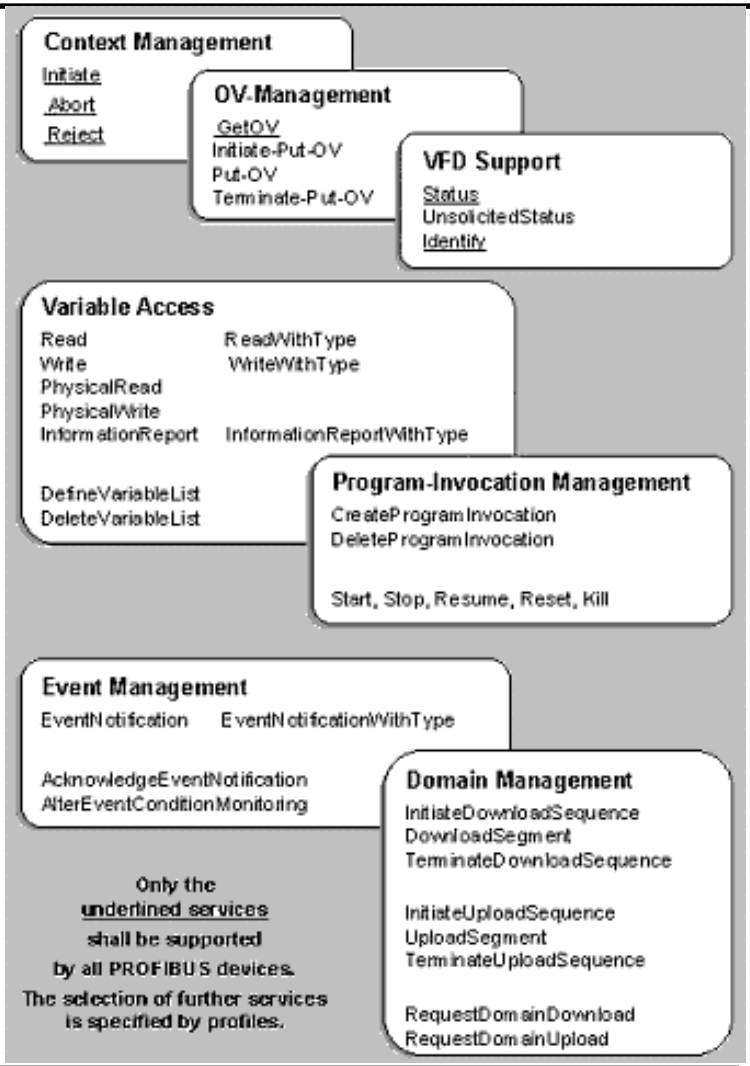
⇨**Domain Management** services are used to transmit large memory areas. The data must be divided into segments by the user.

⇨**Program Invocation Management** services are used for program control.

⇨**Event Management** services are used to transmit alarm messages. These messages can also be sent as broadcast or multicast transmissions.

⇨**VFD Support** services are used for identification and status polling. They can also be sent spontaneously at the request of a device as multicast or broadcast transmissions.

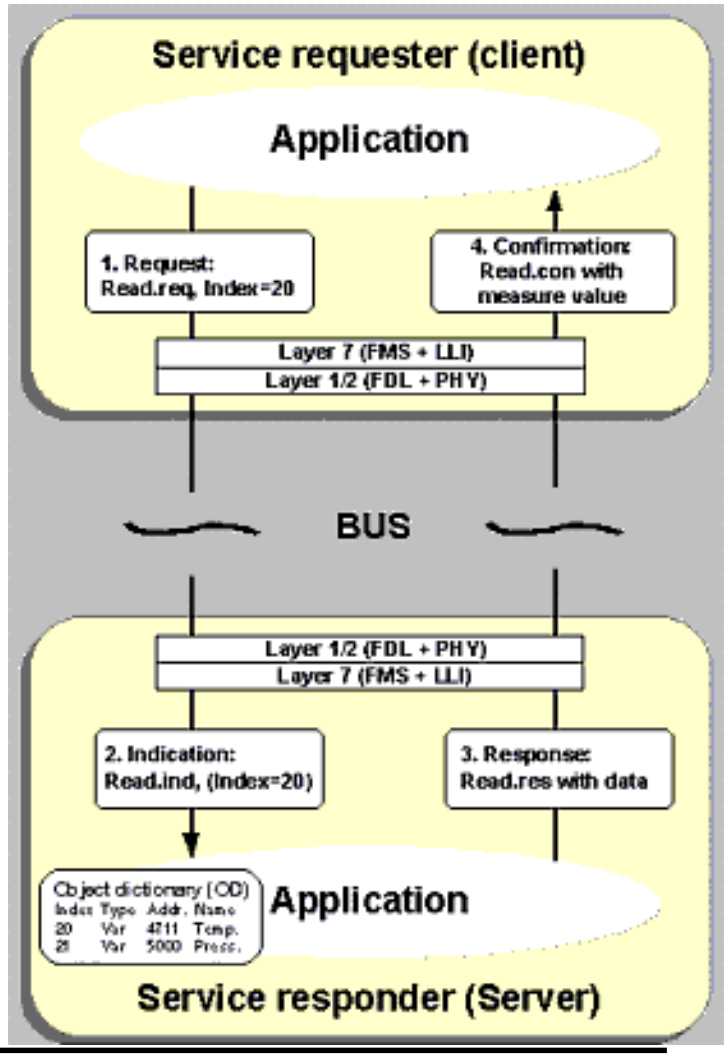
⇨**OD** Management services are used for read and write access to the object dictionary.



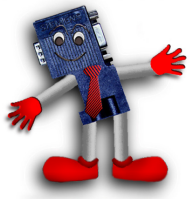
FMS Services

- **Confirmed services** can only be used for connection-oriented communication relationships. The execution of a service is shown in Figure

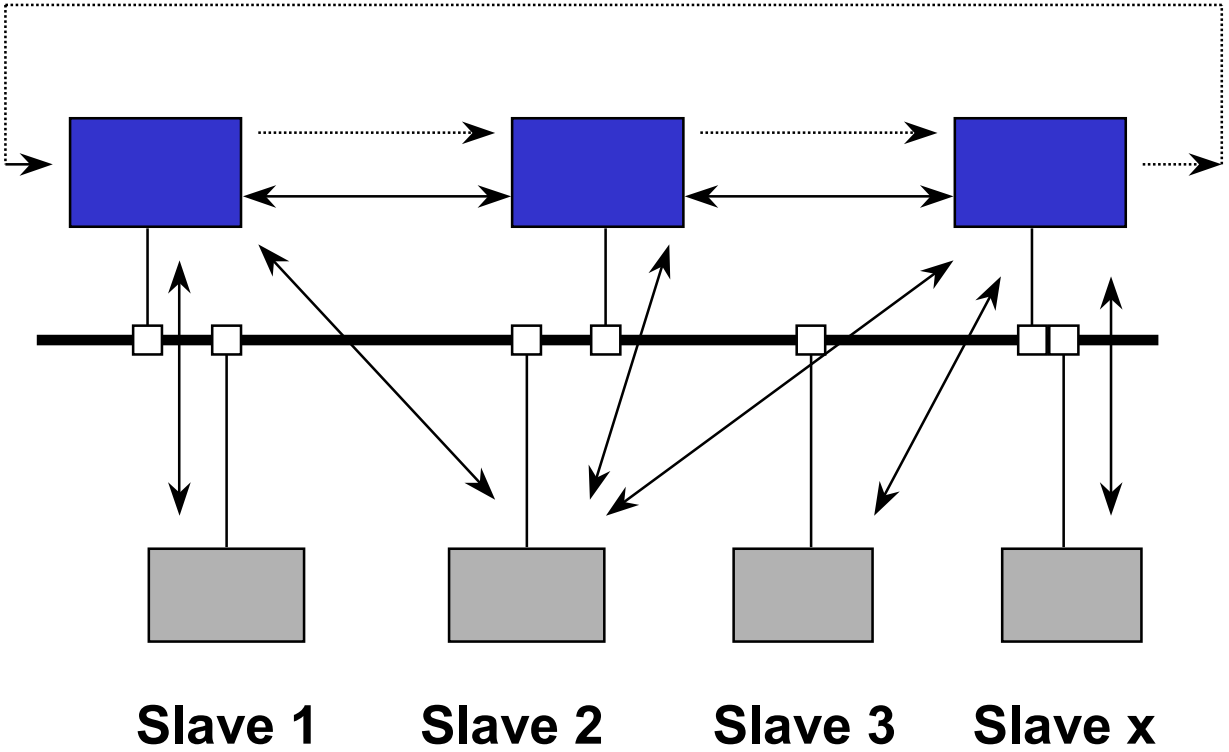
- **Unconfirmed services** can also be used on connectionless communication relationships (broadcast and multicast). They can be transmitted with high or low priority.



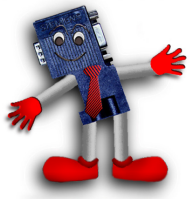
FMS Features



⇨ **FMS access procedure**



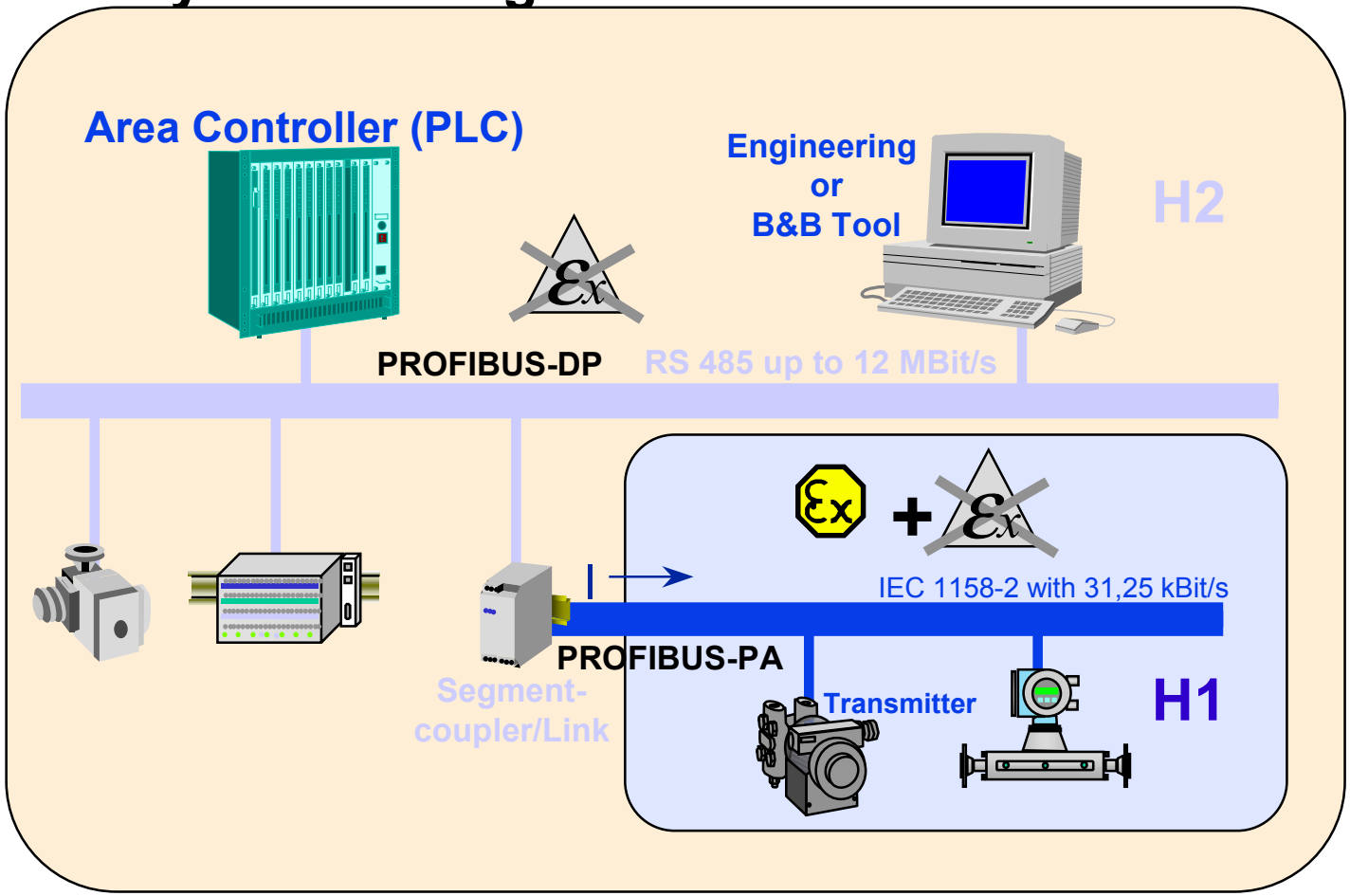
PA Features



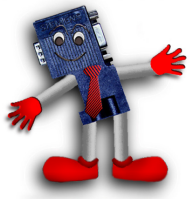
- ⇨ **Based on the extended PROFIBUS-DP Protocol and IEC 1158-2 Transmission**
  - ✓ **Suitable to replace today's 4...20 mA Technology**
  - ✓ **Only two wires for data and power**
  - ✓ **Connects Instruments to the control system via a serial bus**
  - ✓ **Functional improvements plus reliable serial digital transmission**
  - ✓ **Control, regulation and monitoring via a simple twisted pair cable**
  - ✓ **A single engineering tool for all devices**

PA Features

Typical System Configuration with PROFIBUS-PA



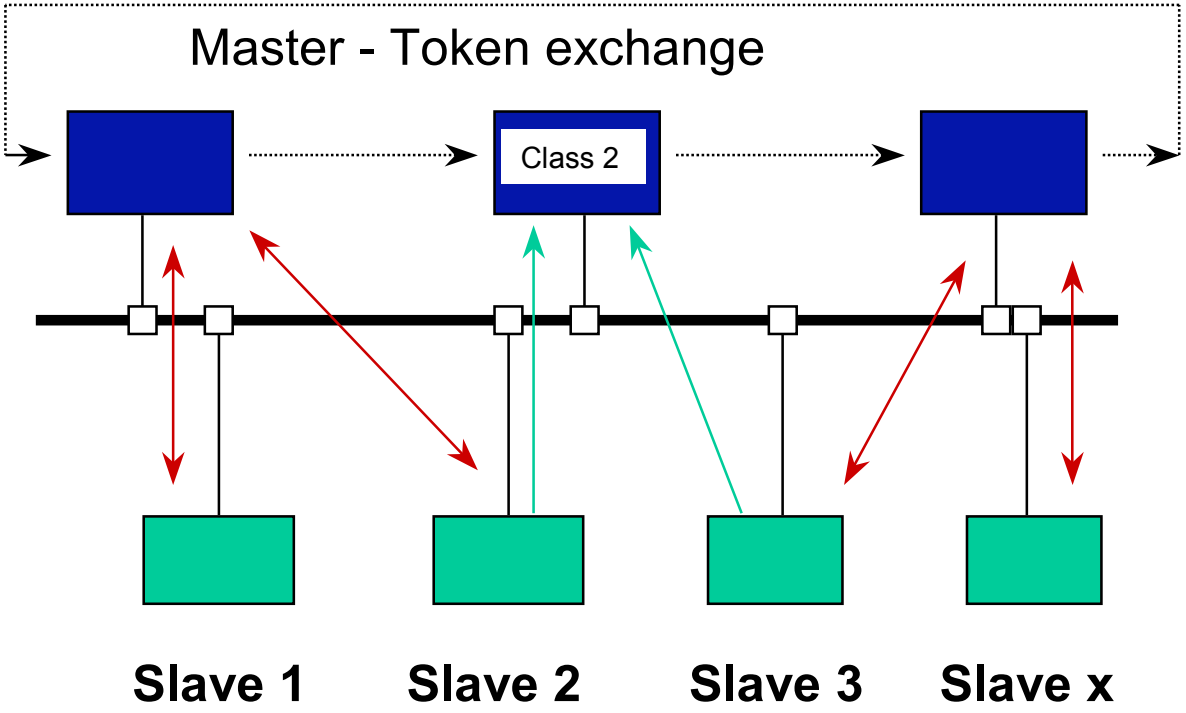
DP Features



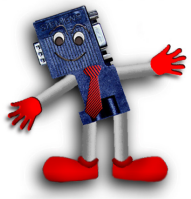
- ⇨ DP communication is permanent and cyclic
- ⇨ the transmitted data is specified during the configuration (optimized data exchange)
- ⇨ only one master can write outputs (safety aspect)
- ⇨ data can be read by controlling and Class 2 master
- ⇨ acyclic data via DPV1 functions
- ⇨ alarm acknowledgment
- ⇨ fastest fieldbus system (up to 12 MBaud)
- ⇨ up to 244 byte input AND 244 byte output data per station

DP Features

⇨ DP- Access Procedure

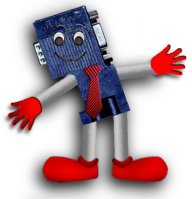


Reliability-DP/FMS



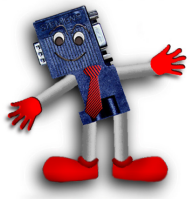
- ⇨ **Hamming Distance HD = 4**
- ⇨ **HD 4 means, that up to 3 transmission failures at a time can be detected (done by the ASICs)**
  - ✓ **By detecting a faulty telegram, it will be resent automatically without affecting other existing stations**
- ⇨ **HD 4 is a term used to describe the reliability of the data transmission on the Profibus network.**
  - ✓ **Special Start and End Sentinels**
  - ✓ **Parity Bit for Each Byte**
  - ✓ **Slip Free**
  - ✓ **According to IEC 870-5-1**
  - ✓ **Delimiter Synchronization**

PROFIBUS Wiring



- ⇨ **PROFIBUS DP/FMS wiring can be done with:**
  - ✓ **twisted shielded pair copper cable**
  - ✓ **fiber optic components**
  - ✓ **infrared components**
- ⇨ **detailed installation guideline is available PTO order no. 2.112**

PROFIBUS Wiring

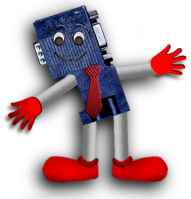


- twisted shielded pair cable
  - ✓ line parameters are defined in EN 50170
  - ✓ standard cable available from Belden and Siemens
  - ✓ standard connectors available

Baudrate	Max. Segment length	Max. Expansion
9.6	1000m / 3278feet	10,000m / 32786feet
19.2	1000m / 3278feet	10,000m / 32786feet
93.75	1000m / 3278feet	10,000m / 32786feet
187.5	1000m / 3278feet	10,000m / 32786feet
500.0	400m / 1311feet	4,000m / 13114feet
1,500.0	200m / 655feet	2,000m / 6557feet
3,000.0	100m / 327feet	1,000m / 3270feet
6,000.0	100m / 327feet	1,000m / 3270feet
12,000.0	100m / 327feet	1,000m / 3270feet

max. expansion is done with 9 repeaters in a row

PROFIBUS Wiring

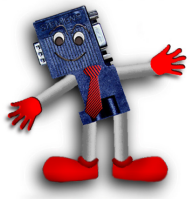


⇨ **fiber optic components**

- ✓ **plastic and glass fiber optic is available**
- ✓ **optical plugs and modules are available**

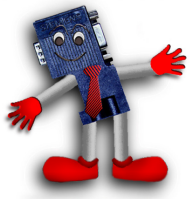
- **noise immune**
- **potential difference independent**
- **longer distances (up to 20 miles)**
- **redundant operating is possible**
- **line, ring and star configuration**

PROFIBUS Wiring



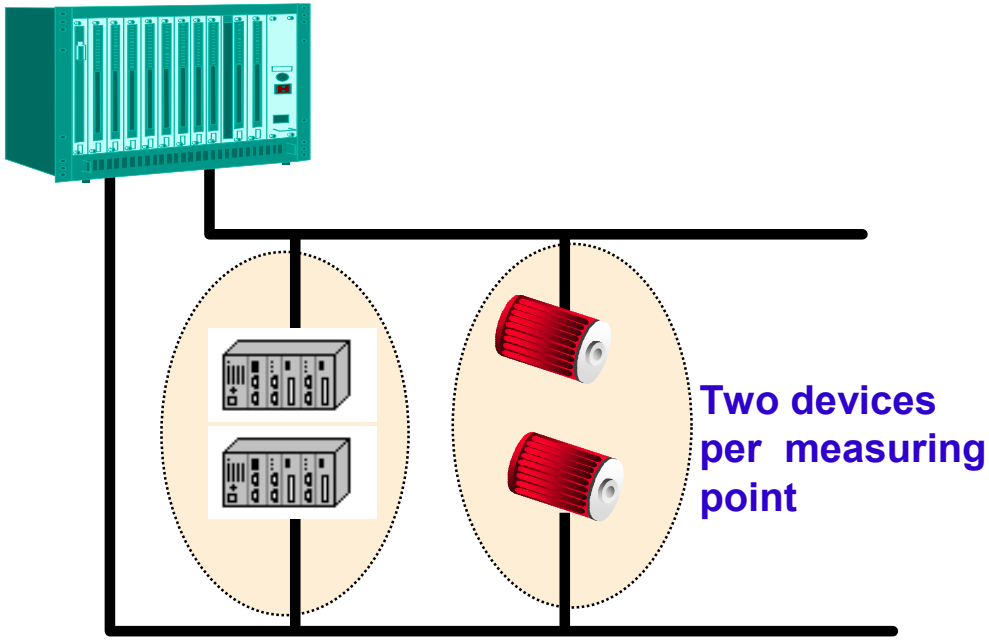
- infrared components
  - ✓ wireless linking of devices in close-up ranges
  - ✓ communication with moving devices
  - ✓ communication with changing devices
  - ✓ noise immune
  - ✓ ground independent

PROFIBUS Wiring



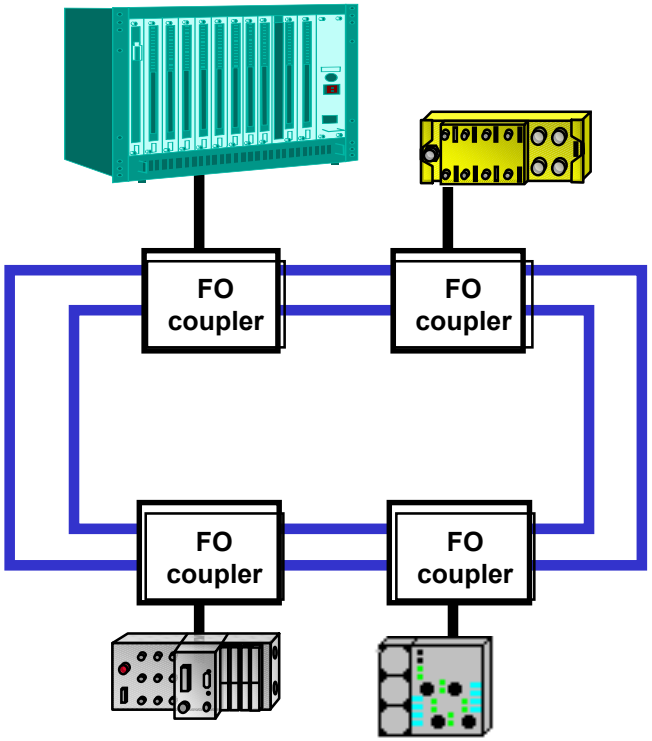
⇨ Redundancy Improves System Reliability

System redundancy



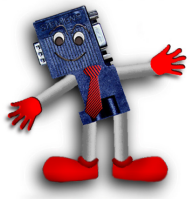
Several interfaces enable redundant systems

Media redundancy



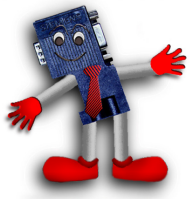
Fiber optic segments enable redundant wiring

DP Details

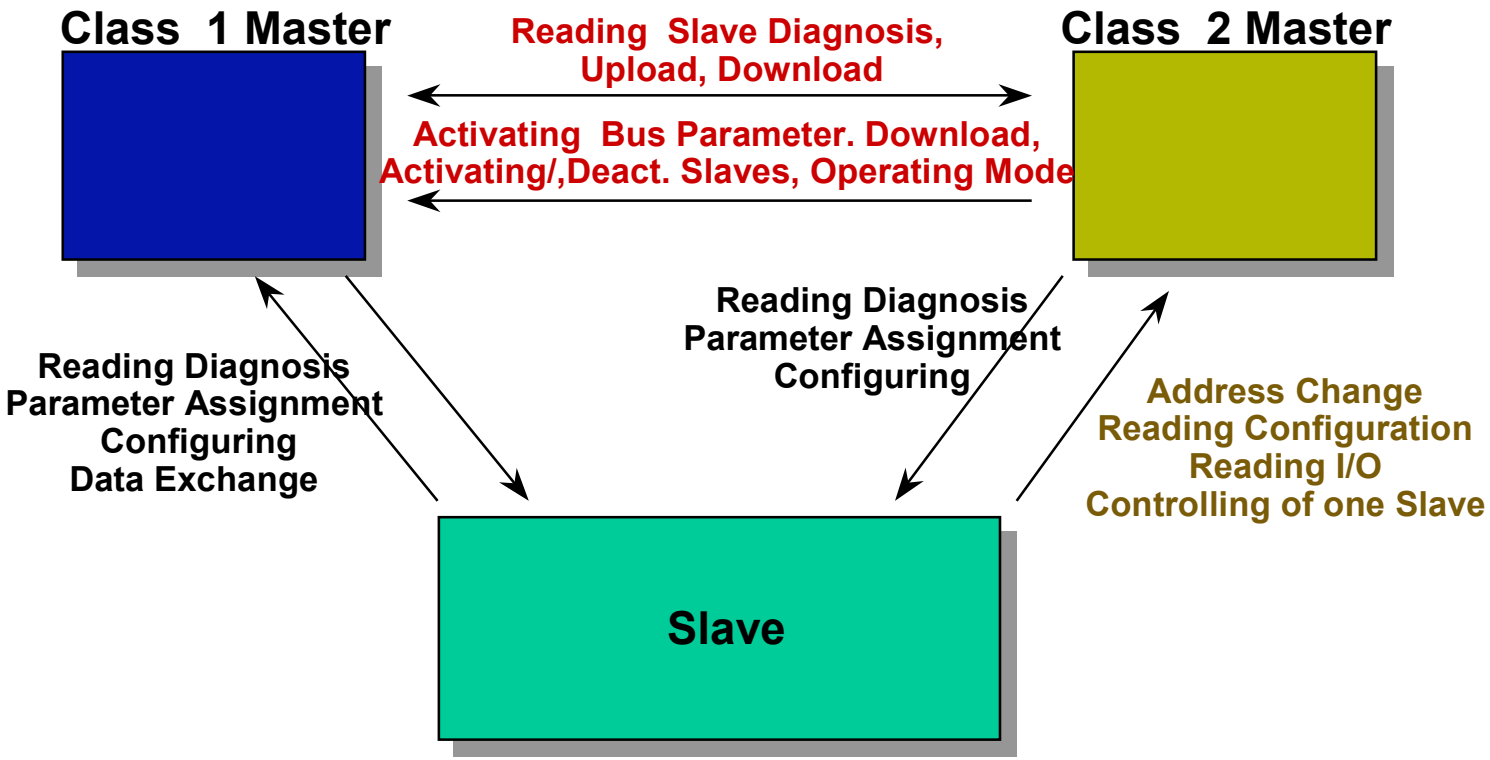


- class 1 master -
  - ✓ central controller which exchanges data with the connected I/O devices (slaves)
  - ✓ determines the baudrate
  - ✓ handles the Token
  - ✓ several class1 masters are permitted, typical devices are PLC, PC
- class 2 master -
  - ✓ diagnostic and startup tool, typically a configuration tool
  - ✓ can control one slave at a time
- slave station -
  - ✓ passive station which acknowledges messages or answers per request

DP Details



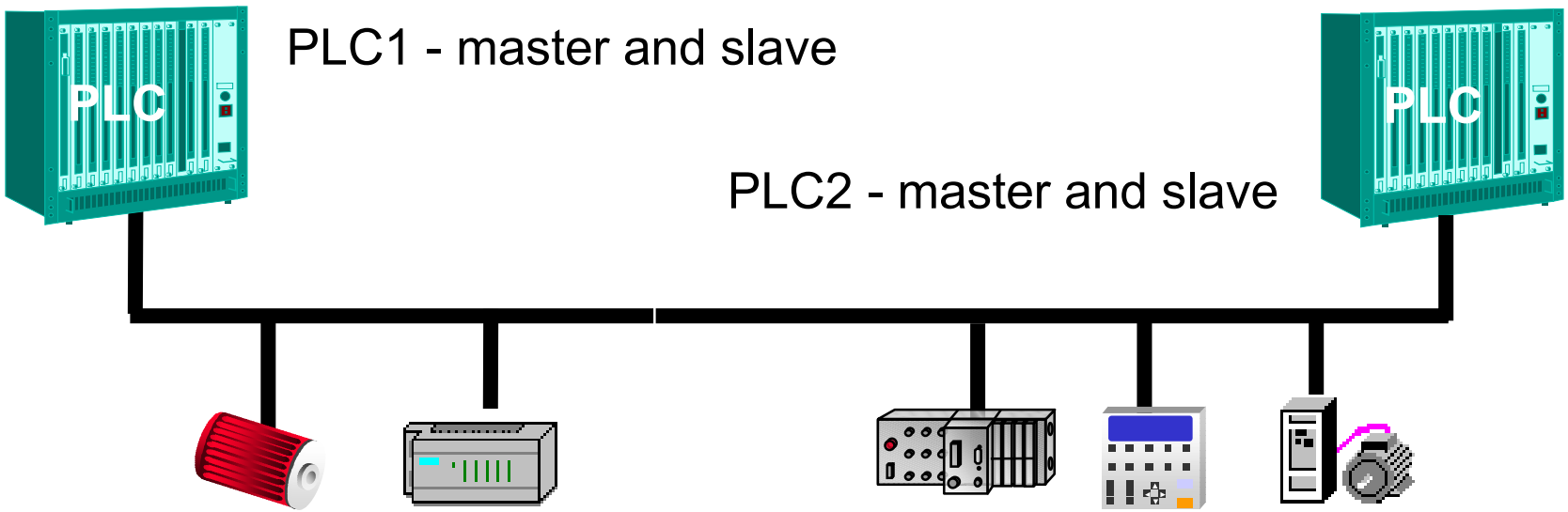
⇨ **master- master, master- slave communication**



a device can consist of multiple functions, e.g.... class1 and class2, class1 and slave

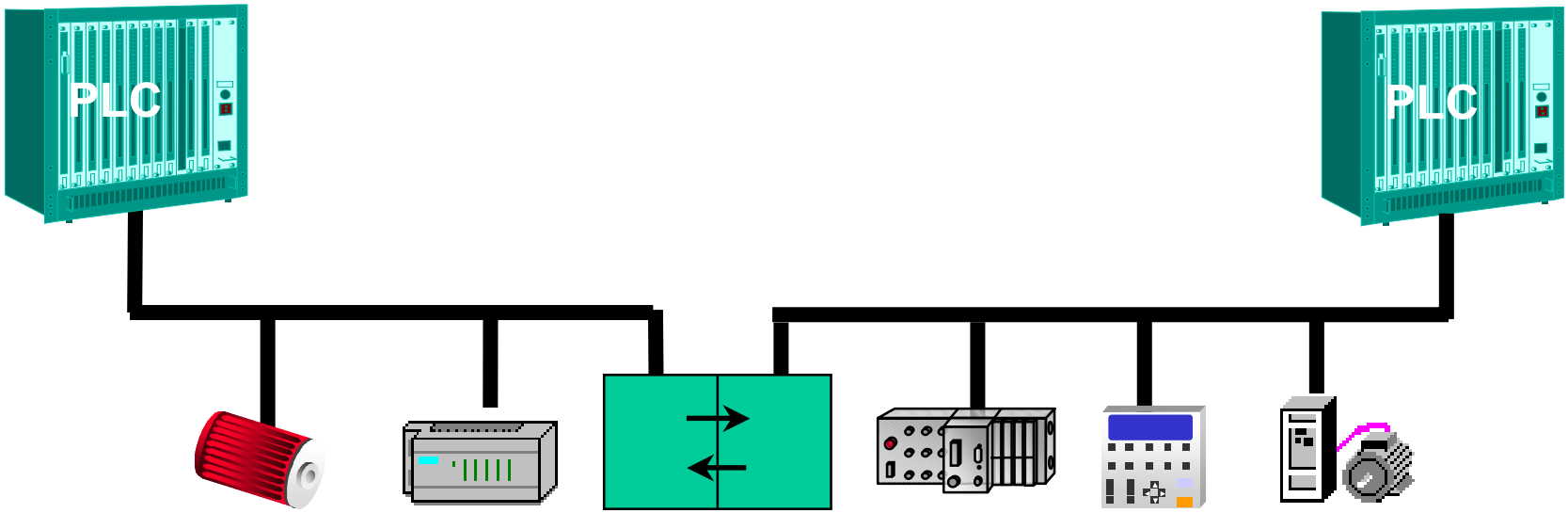
DP Details

- A device can consist of multiple functions, e.g... class1 and class2, class1 and slave, which allows:
  - ✓ a simple master master communication via the master - slave combination
  - ✓ whenever one master has the token the other PLC can be a slave to this master

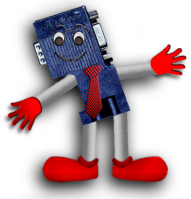


DP Details

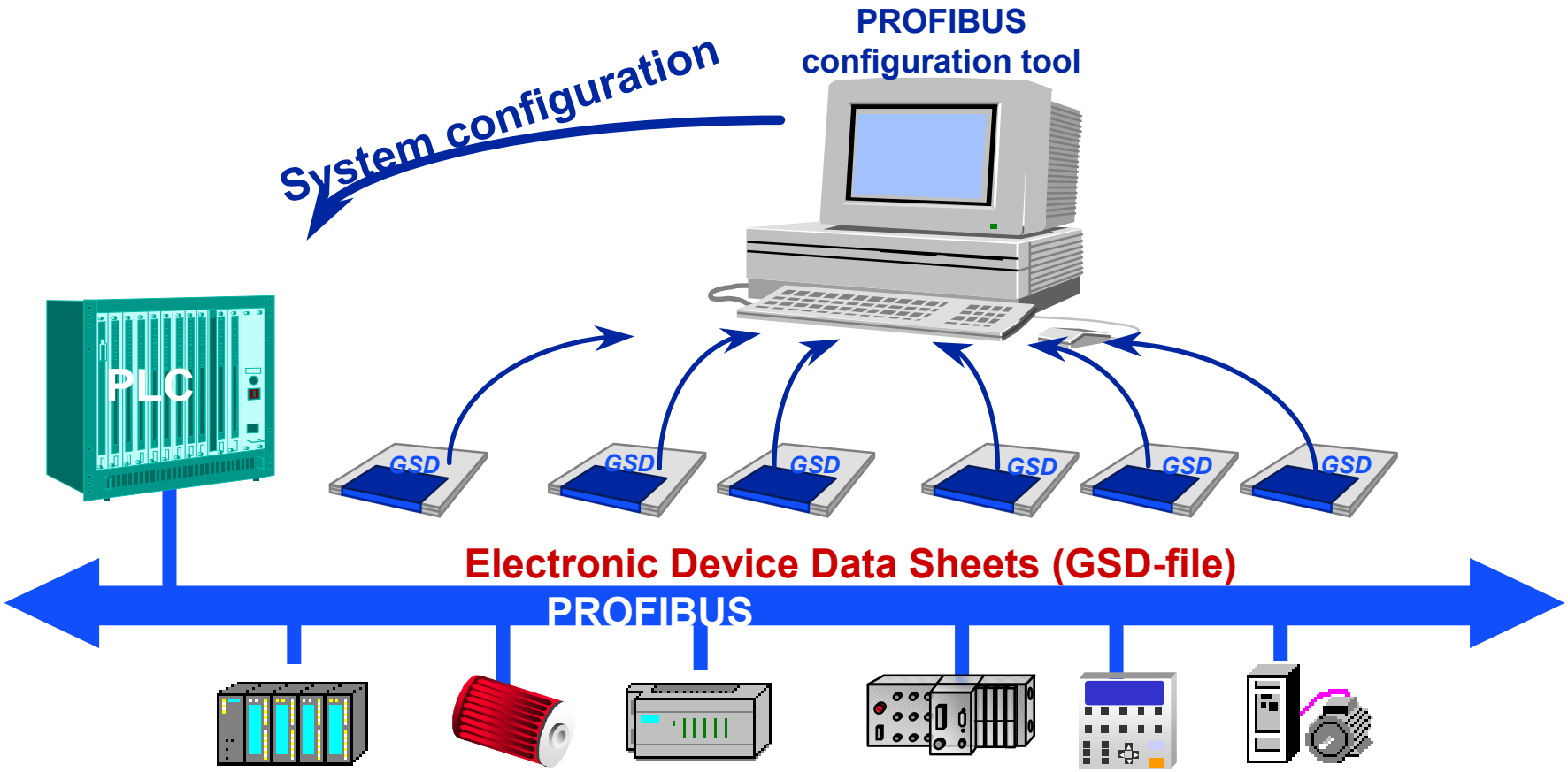
- ⇨ **Master - Master communication by using a DP-DP gateway**
  - ✓ **combination of two mono master systems**
  - ✓ **simple data exchange between the two masters up to 244 byte**



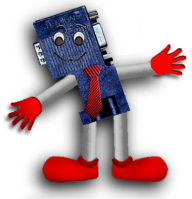
Interoperability



⇨ **Open Configuration permits Plug and Play**

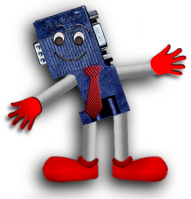


Device Description



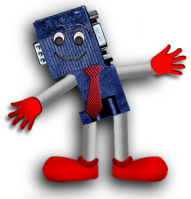
- ⇨ **GSD file**
  - ✓ **each slave or master class 1 device on PROFIBUS DP needs to have a device description file, the characteristic of each PROFIBUS-DP device is described in the GSD-File**
  - ✓ **the GSD-file contains all device specific parameters e.g.:**
    - × **Supported Baudrate**
    - × **Supported Message Length**
    - × **Number of input / output data**
    - × **Meaning of diagnostic messages**
    - × **Options for modular devices e.g. which are available**
  - ✓ **text file (ASCII-format)**
  - ✓ **each configuration tool relates to the GSD information**

Device Description



- ✓ GSD-Files are created by the device vendors
- ✓ the PROFIBUS Trade Organization provides an GSD-Editor which makes it very easy to create GSD-Files
- ✓ the GSD-Editor contains a GSD-Checker which guarantees the conformance of the GSD-Files to the PROFIBUS standard
- ✓ a library of GSD-Files is provided at the PROFIBUS web page: http://www.profibus.com

Device Description



#Profibus_DP	(M)
:<PRM-Text_Def_List>	(O)
PrmText = … … .. EndPrmTExt	
;<Ext-User_Prm_Data_Def_List>	(O)
ExtUserPrmData = … … … . EndExtUserPrmData	
;<Unit_Definition_List>	(M)
GSD_Revision=1 Vendor_Name= … … .. … … .	
;Slave specific data	(M)
Freeze_mode_supported= … … .. … …	
;User_Prm_data	
… … .	
;Unit_diagnostic	
… … ..	
;<Module_Definition_List	(M)
Module = … … . EndModule	

Parameter text (O)

ext. user parameter data (O)

mandatory general data (M)

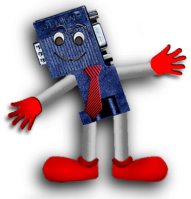
generic slave data (M)

device related slave data (O)

I/O definition (M)

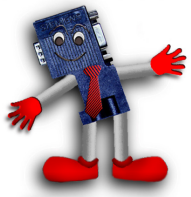
DP Interactions

DP Extended



- **Why DP extended?**
  - ✓ **the requirements of the process industry are included**
  - ✓ **selecting and changing parameters of a field device from several DP-Masters, e.g.. CPU, PG or HMI Devices**
    - × **provides for higher flexibility in operation**
  - ✓ **Interrupts from Field Devices, e.g.. for diagnostics, have to be accepted by the DP-Master**
    - × **allows for greater security**
  - ✓ **time stamping of events, e.g.. for interrupts, accurate history of special events**
  - ✓ **additional data formats are necessary for transmitting data, e.g.. floating-point-radix**

DP Extended



New extended PROFIBUS-DP-Standard

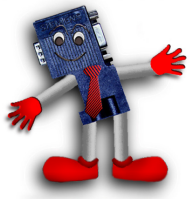
DP-Extension

- Additional acyclic messages between Master and Slave by reading and writing of data blocks
- Acknowledgment of field device interrupts
- Time synchronization for an exact time stamping
- Extension of data types, floating-point-radix

PROFIBUS-DP-Standard !

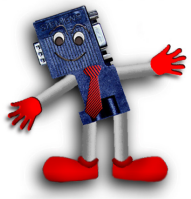
➔ every station that handles the DP-extensions must meet the previous PROFIBUS-DP-Standard-Functions!

DP Extended



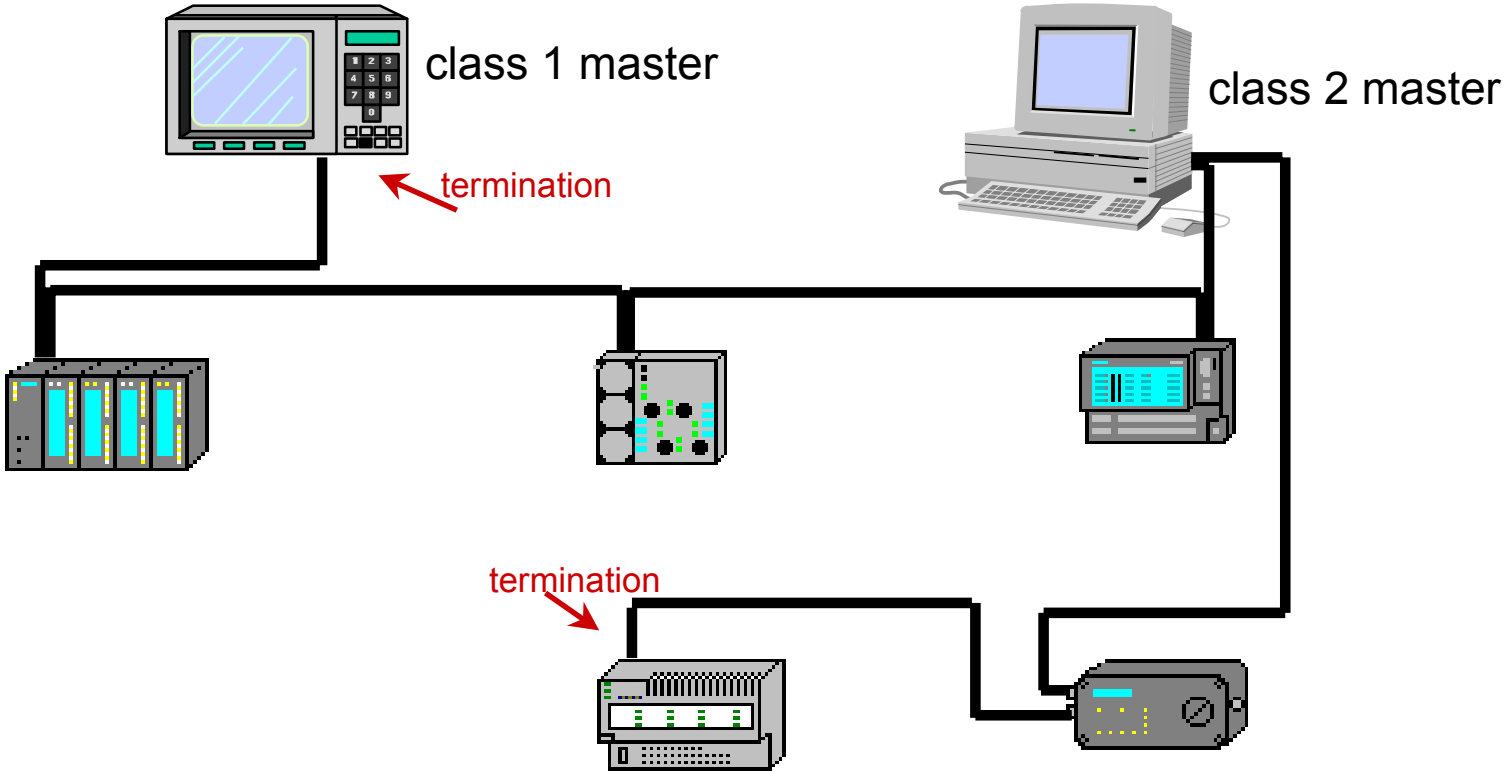
- Acyclic communication connections between Class 1 Master and Slave via Slave SAP 51
  - ✓ Read data set (DDLM_Read)
  - ✓ Write data set (DDLM_Write)
  - ✓ Acknowledge alarms (DDLM_Alarm_Ack)
  - ✓ Only the master that parameterized and configured the slave can utilize the SAP 51 for these services also
  - ✓ Alarm can only be acknowledged by the Class 1 Master via SAP 51 (access protection)

DP Extended

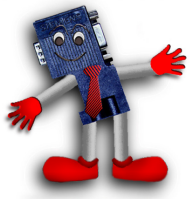


- Acyclic communication relations between Class 2 Master and Slave via SAP 0…49
  - ✓ Initiate (MSAC2_Initiate) - SAP 49
  - ✓ Abort (MSAC2_Abort)
  - ✓ Read Data Set (MSAC2_Read)
  - ✓ Write Data Set (MSAC2_Write)
  - ✓ Data Transport (MSAC2_Data_Transport)

Network Setup



PIC certification



⇨ How to certify a device!

- Vendor applies for an ID number from PROFIBUS International (PI) for his device
- Vendor develops the PROFIBUS device and writes a GSD file

Applies for Certification test at any PROFIBUS Test Lab

Test passed ?

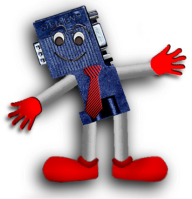
NO → **refused**

YES

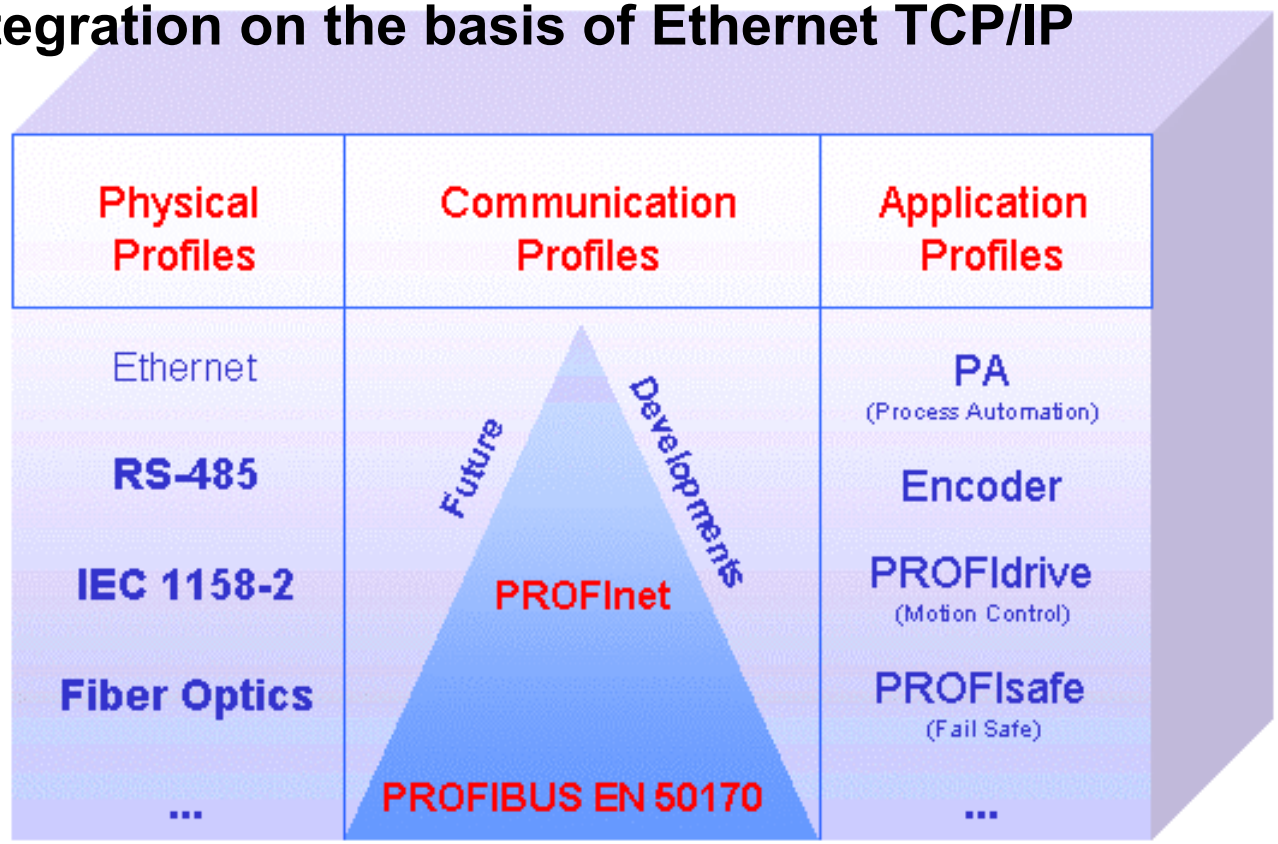
Vendor receives two test reports and can apply for a certificate via PI

CERTIFICATE

Profibus & Ethernet

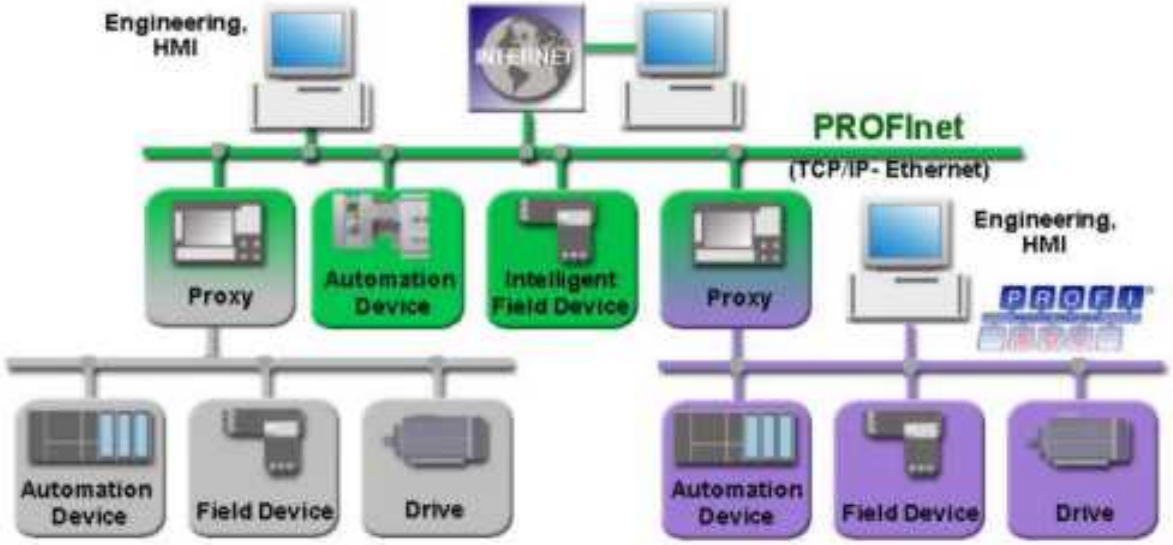


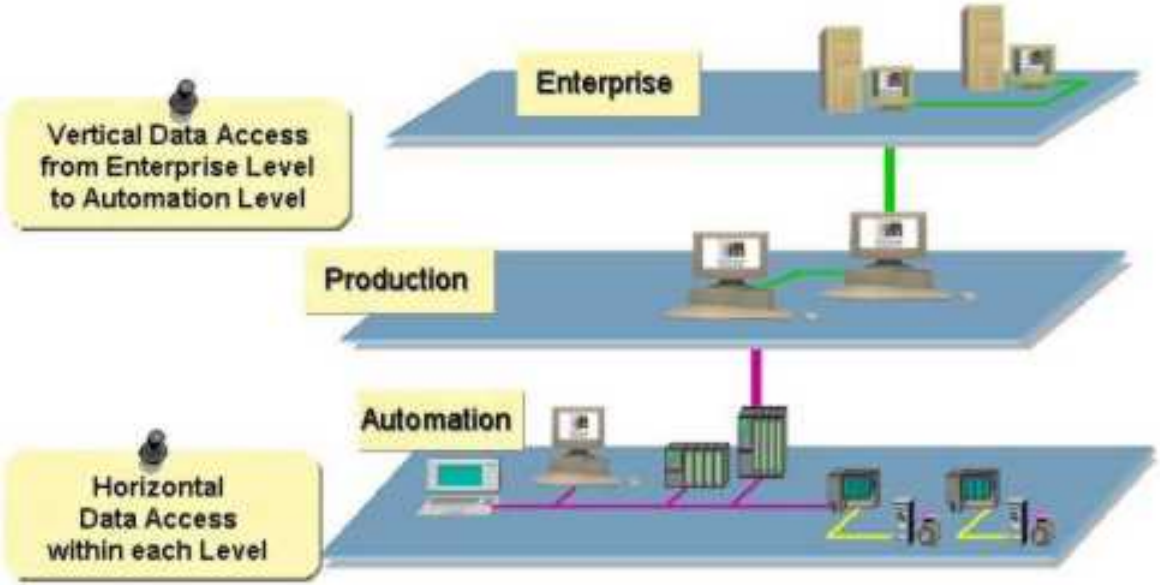
- ⇨ **The PROFIBUS User Organization is currently working on the implementation of universal concepts for vertical integration on the basis of Ethernet TCP/IP**



PROFInet

- Automation object model according to the Microsoft COM/DCOM standard
- Communication: TCP(UDP)/IP and DCOM wire protocol devices
- Object handling in engineering and HMI: Microsoft OLE, ActiveX
- Integration of existing unchanged PROFIBUS bus segments and PROFIBUS based devices




Vertical Data Access
from Enterprise Level
to Automation Level
Enterprise
Production
Automation
Horizontal
Data Access
within each Level