



UNIVERSITA' DEGLI STUDI DI BERGAMO  
Facoltà di Ingegneria

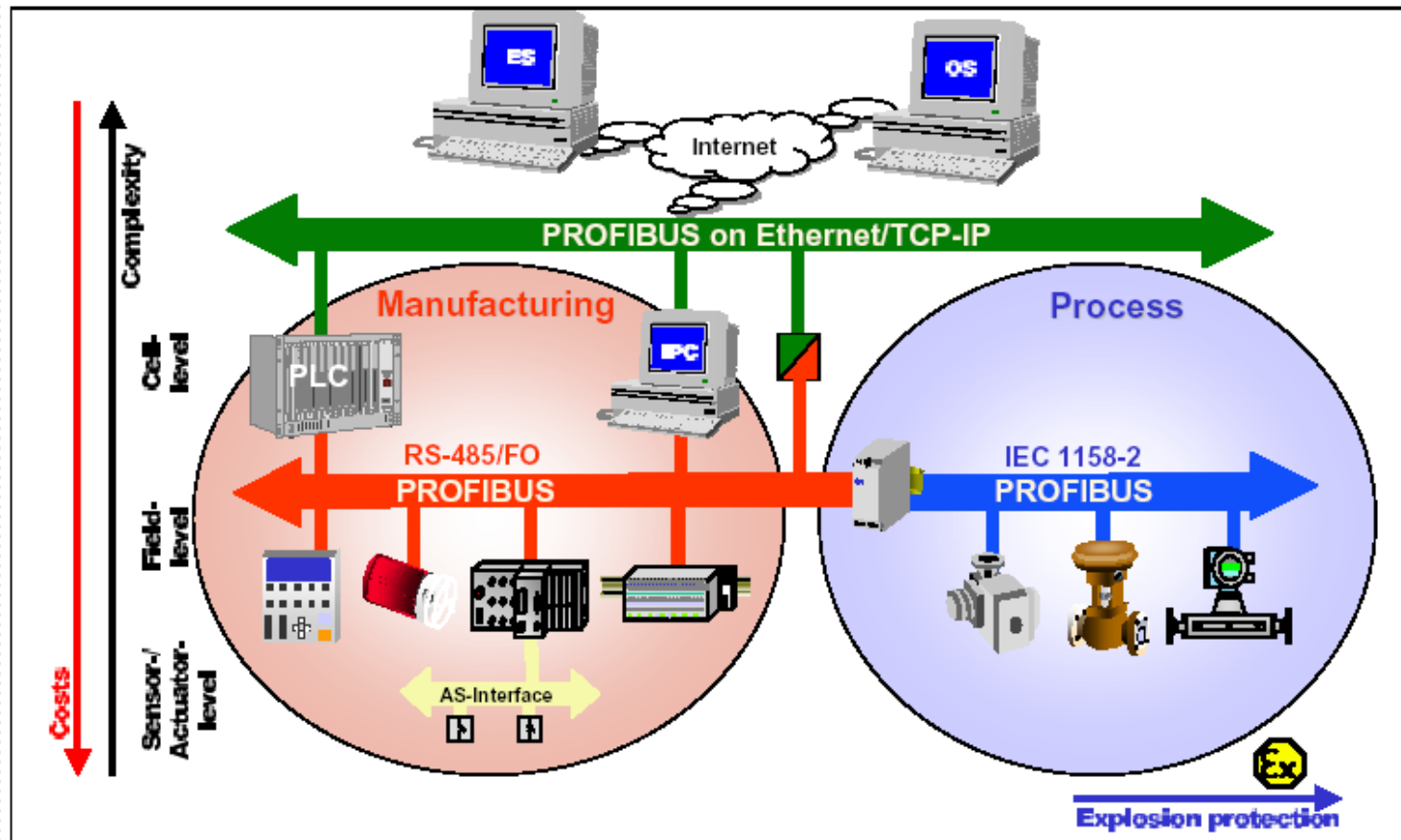
# Informatica Industriale

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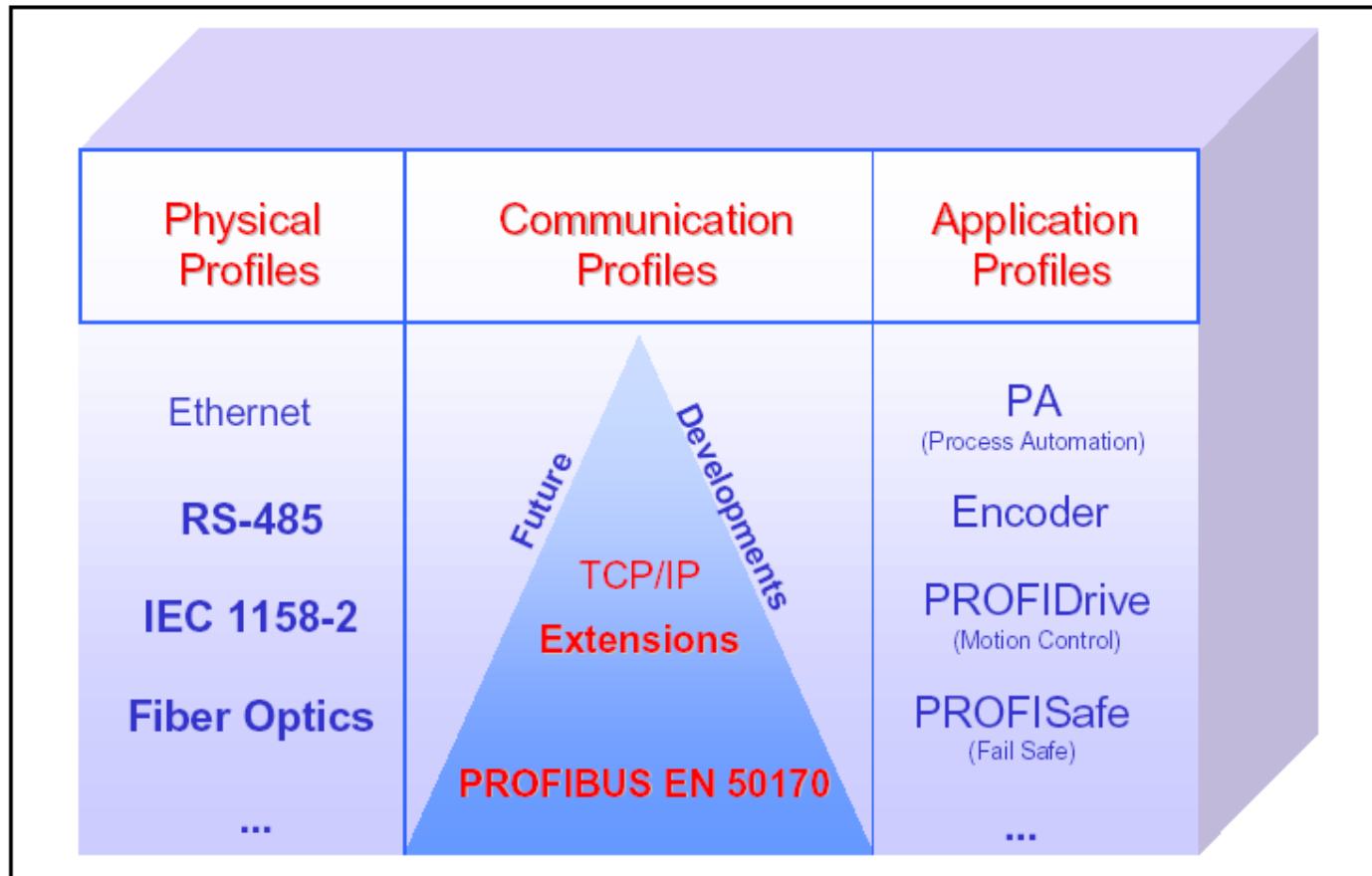
3.2 – Profibus

# Industrial Communication



# PROFIBUS Technology

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# PROFIBUS Technology

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## □ Physical Profiles

- RS-485 → manufacturing automation
- IEC 1158-2 → process automation

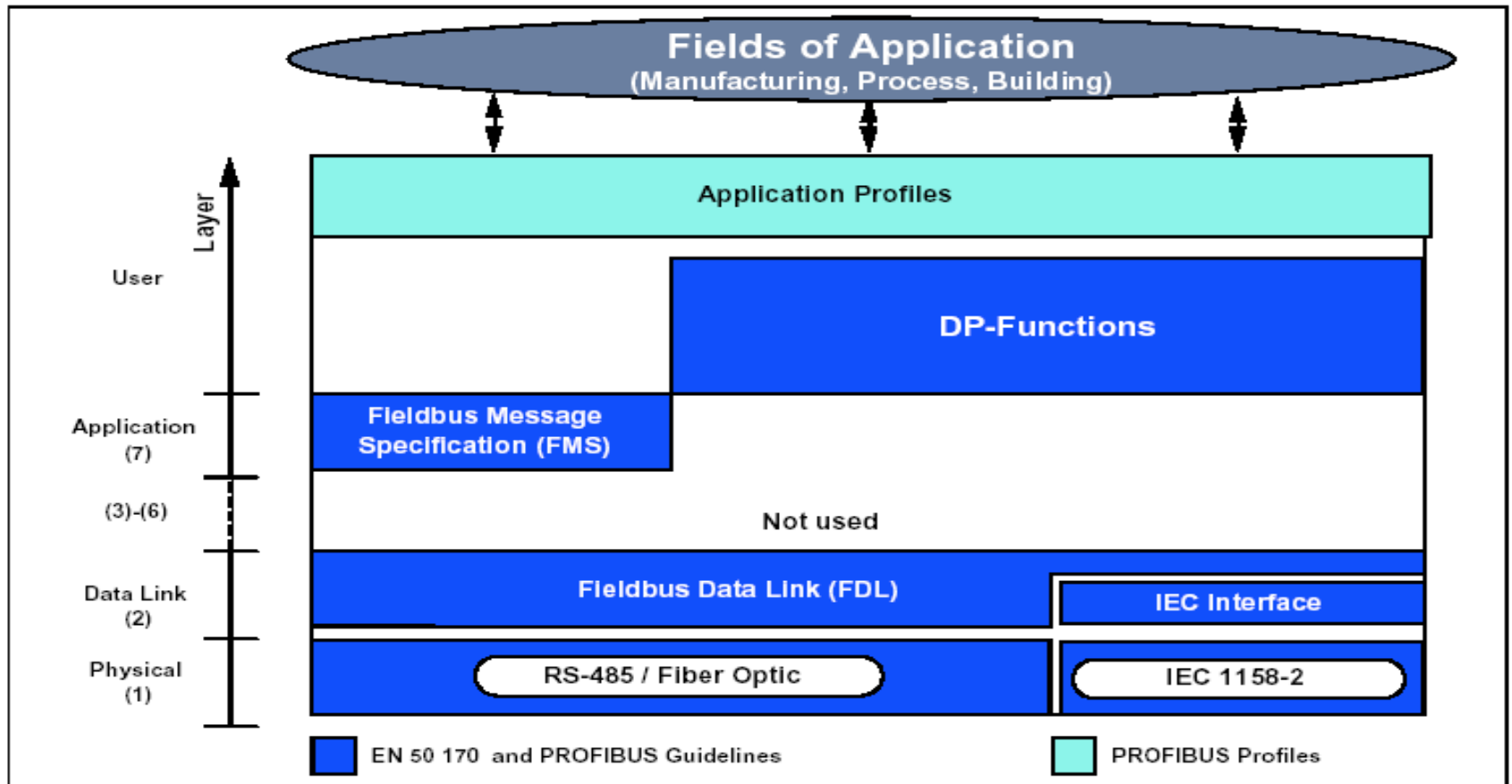
## □ Communication Profiles

- DP (Decentralized Peripherals) → optimized for speed and efficiency (Master-Slave)
- FMS (Fieldbus Message Specification) → sophisticated application functions for communication between intelligent devices (PC – PLC)

## □ Application Profiles

- Interaction Physical/Communication Profiles
- Define the behavior of the field devices

# Protocol Architecture

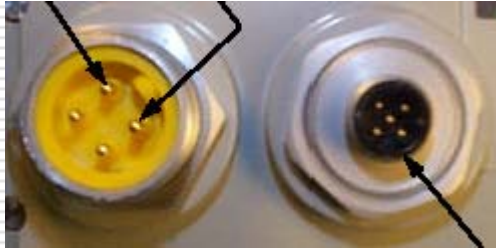


# Protocol Standards

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IEC 61158 document	Contents	OSI layer
IEC 61158-1	Introduction	
IEC 61158-2	Physical layer specification and service definition	1
IEC 61158-3	Data-link service definition	2
IEC 61158-4	Data-link protocol specification	2
IEC 61158-5	Application layer service definition	7
IEC 61158-6	Application layer protocol specification	7

# Physical Profile : RS-485

Cable	Shielded twisted pair – <b>high speed</b>		
Number of Stations	32 stations in each segment without repeater, 126 with repeater		
Connectors	Power 24 V DC		Data A Data B

Baud rate	9.6 kbit/s	19.2 kbit/s	93.75 kbit/s	187.5 kbit/s	500 kbit/s	1.5 Mbit/s	12 Mbit/s
Range/segment	1.2 Km	1.2 Km	1.2 Km	1 Km	400 m	200 m	100 m

# Physical Profile : IEC 1158-2

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Data transmission	Digital, bit- <b>synchronous</b> , Manchester coding
Transmission speed	31,25 kbit/s, Voltage Mode
Cable	Two wire shielded twisted pair cable
Remote powering	Optional, via data lines
Topology	Line and tree topologies, or a combination
Number of stations	Up to 32 stations per line segment, maximum total of 126
Repeater	Can be expanded with up to 4 repeaters

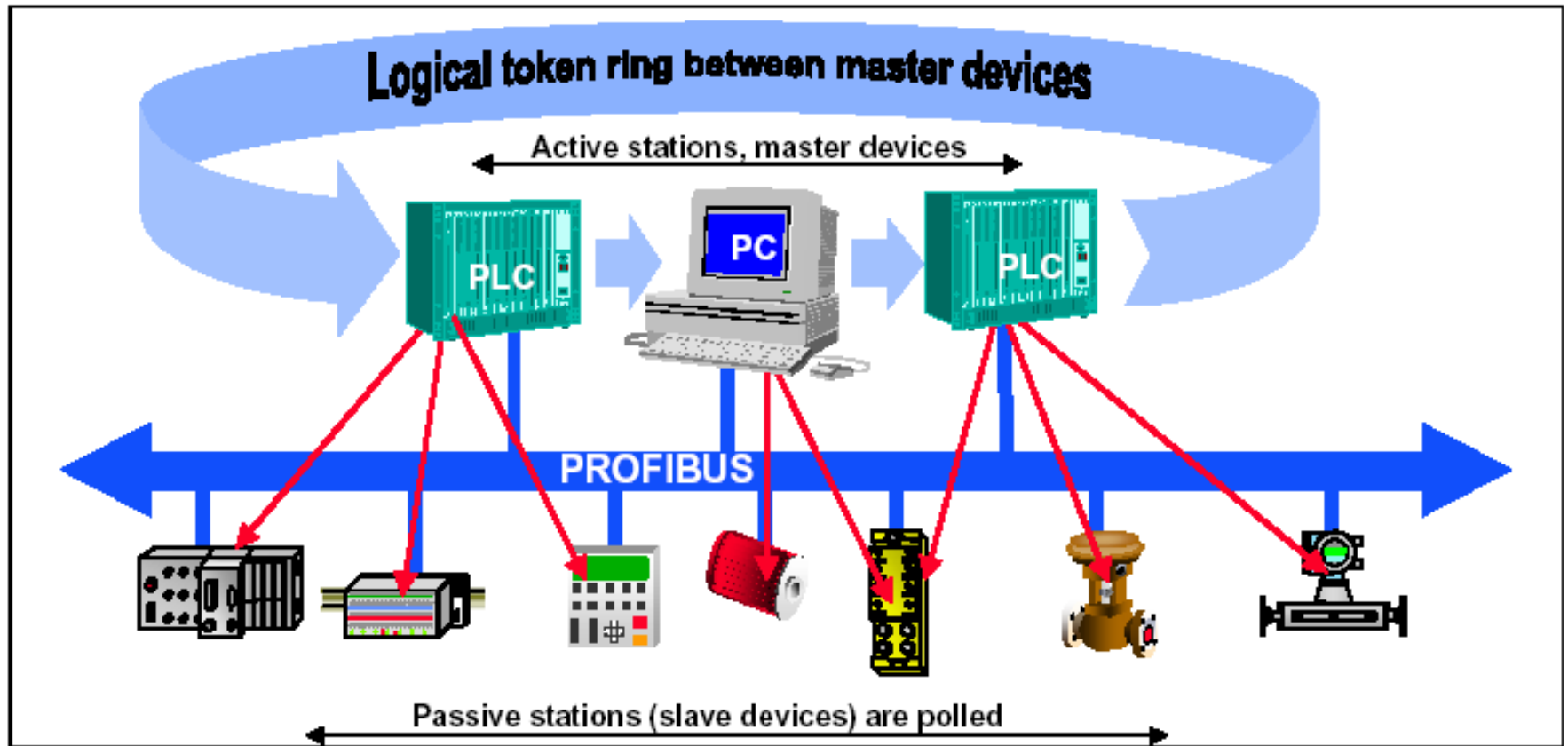


# Medium Access Protocol (MAC)

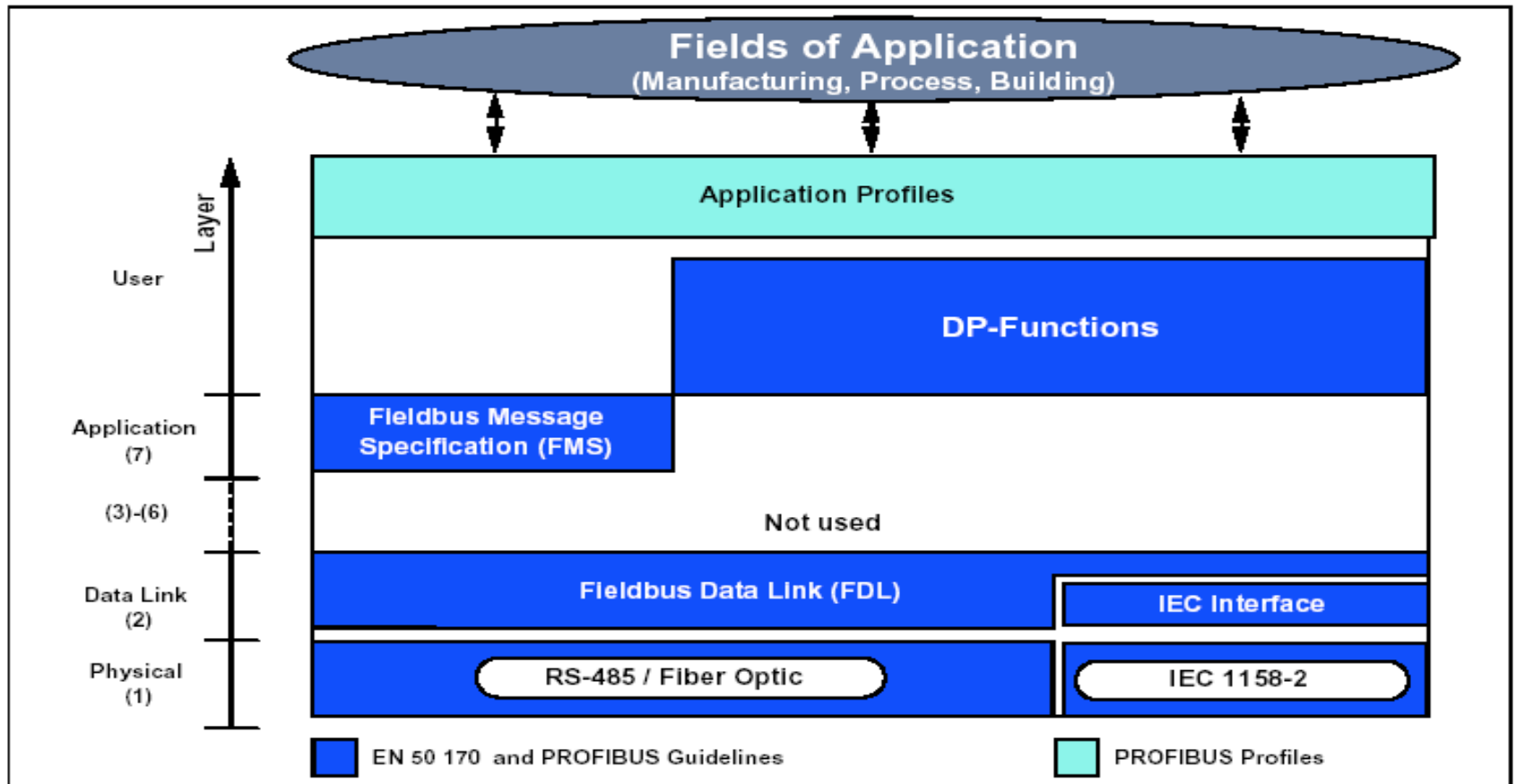
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- ❑ Implemented by layer 2 of ISO-OSI
- ❑ Layer 2 is called ***Fieldbus Data Link (FDL)***
- ❑ MAC specifies the procedure when a station is permitted to transmit data.
- ❑ Master – Master communication → Token
- ❑ Master – Slave communication → Cyclic
- ❑ Broadcast / Multicast communication
- ❑ Data Security → Hamming Distance = 4

# Medium Access Protocol (MAC)



# DP Communication Profile



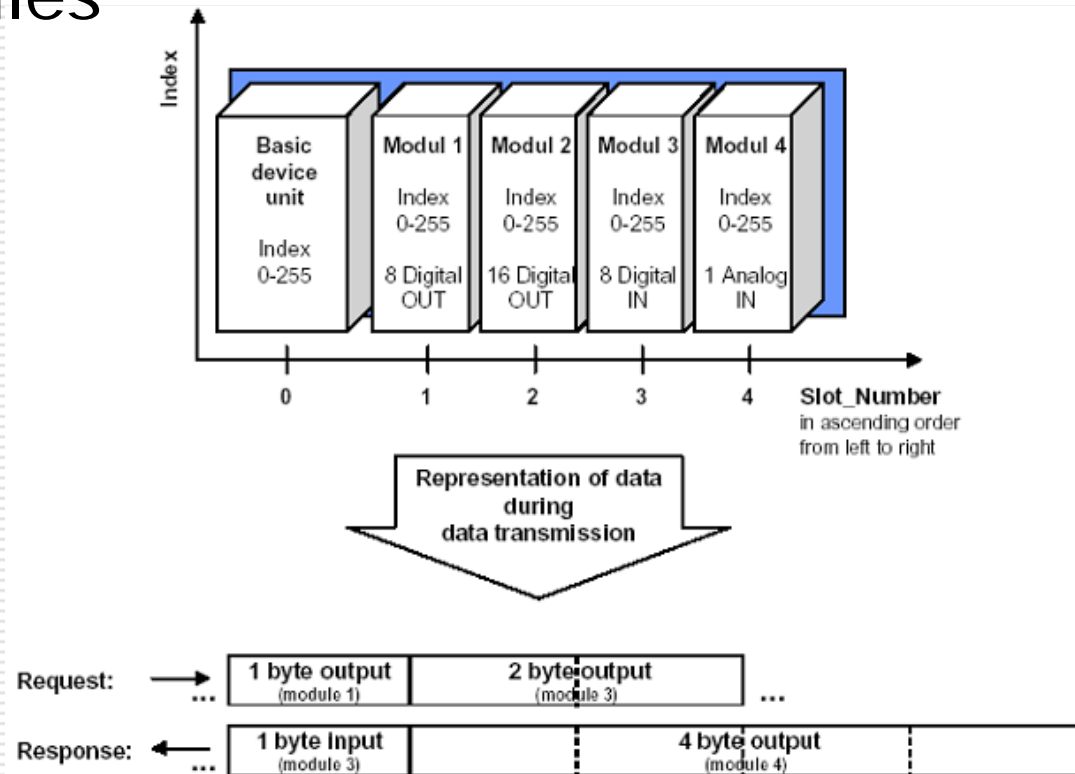
# DP Communication Profile

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- ❑ DP : Decentralized Peripherals
- ❑ The Master cyclically reads/writes information from/to the slaves
- ❑ Master Class 1 (**DPMC1**) → PLC
- ❑ Master Class 2 (**DPMC2**) → Config. Tools

# DP Communication Profile

- ❑ Slaves are **physical building blocks** structured internally in modules
- ❑ Data blocks enabled for read/write belong to modules
  - Slot numbers address the modules
  - Index numbers address the data blocks



# DP Communication Profile

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## □ Cyclic communication

- It is used for data that has to be updated continuously through recurring read and write requests to the slaves.
- It includes process inputs and outputs, which are typically scanned by a class 1 master such as a PLC

## □ Acyclic communication

- It is used for data that only has to be communicated infrequently. It includes the host reading and writing parameters in the field instruments and downloading and entire device configuration, typically from a class 2 master such as a host configuration tool

# DP Communication Profile

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- **Acyclic** transmission between master class 1 (central controller) and slave:
  - Master class 1 reads data from slave
  - Master class 1 writes data to slave
  - Alarm transmission from slave to master class 1
  - Master class 1 acknowledge alarm to slave
  - Status transmission from slave to master class 1

# DP Communication Profile

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- **Acyclic** transmission between master class 2 (engineering tool) and slave:
  - Establish connection for data transport
  - Terminate connection for data transport
  - Master class 2 reads data from slave
  - Master class 2 writes data to slave

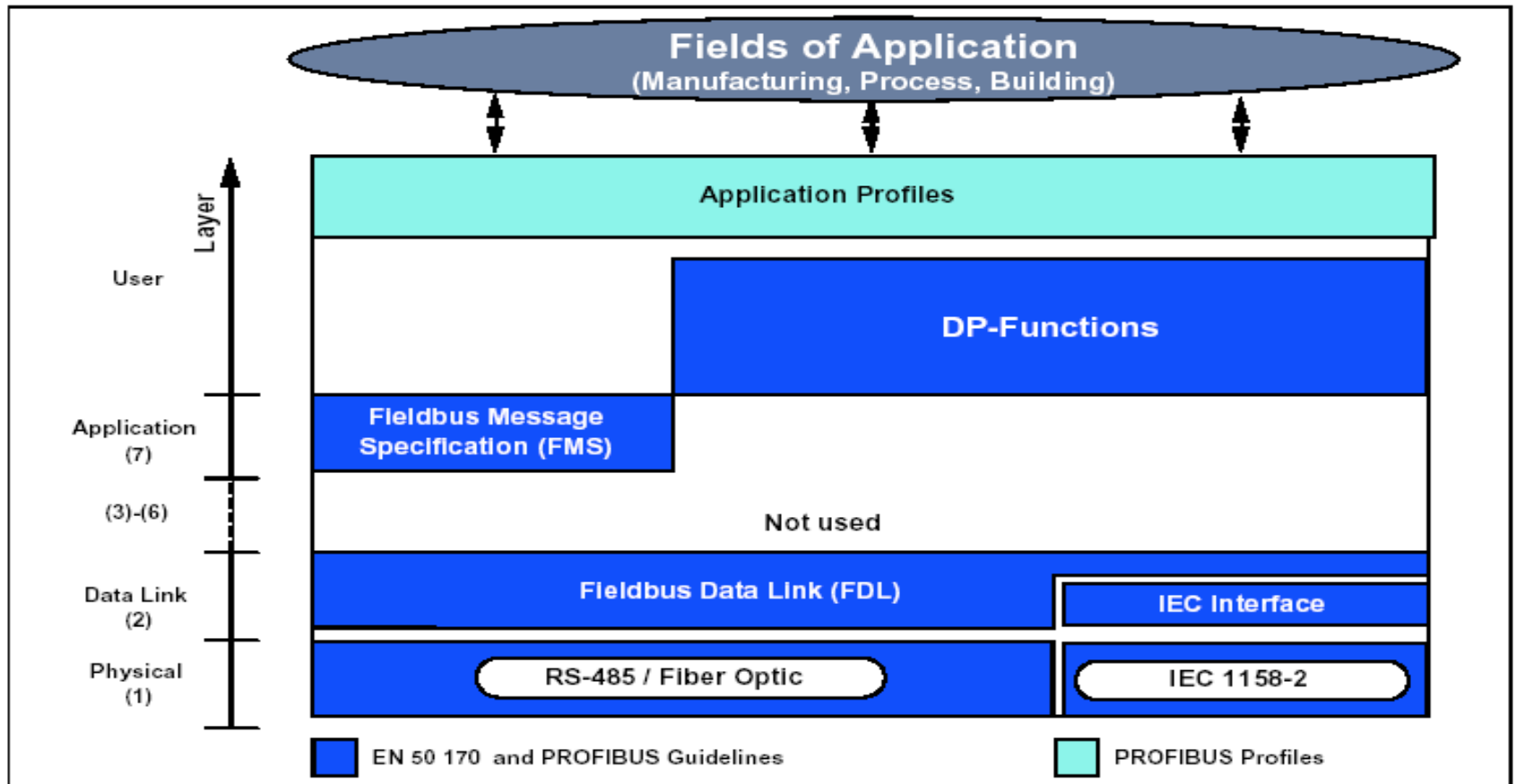


# DP Communication Profile

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- **Cyclic** transmission :
  - Check consistency between master and slave exchange configuration
  - Select parameters for cyclic exchange
  - Indicate diagnostics
- Three states communicated cyclically to the slaves at fixed time intervals:
  - Stop → no data transmission
  - Clear → DMP1 reads input of the slaves
  - Operate → DPM1 writes output of the slaves

# FMS Communication Profile

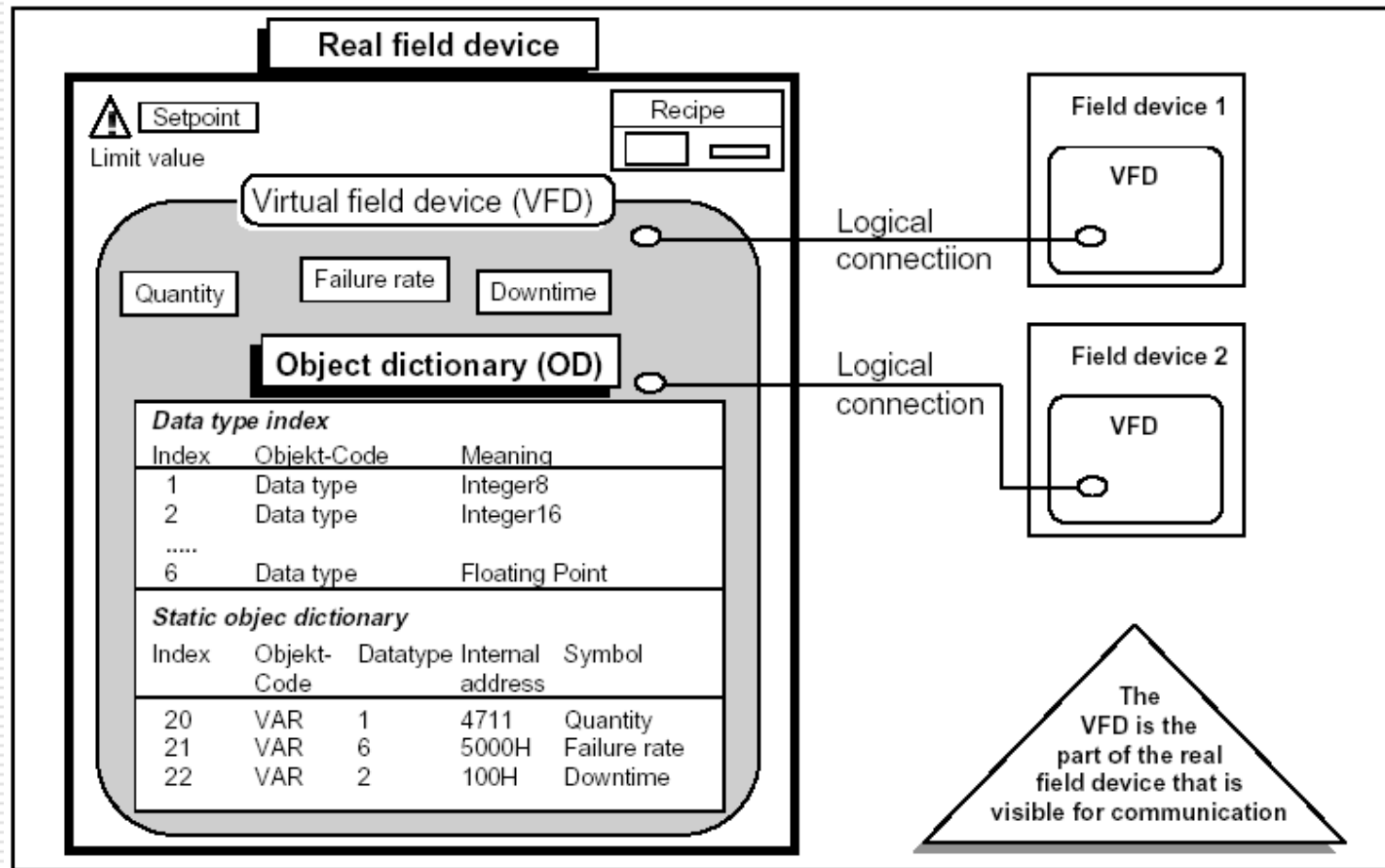


# FMS Communication Profile

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- ❑ For communication at cell level
- ❑ Layer 7 ISO OSI
  - Field Message Specification (FMS)
  - Lower Layer Interface (LLI)
- ❑ Virtual Field Device (VFD)
  - A logical subdivision of the information that is accessible from a device
  - Simple variable, Array, Record, Domain, Event
  - The information in the devices is accessed in the form of objects. The objects for configuring the device are listed in an object dictionary (OD)
  - Each object is identified by an index. For example, every function block and every parameter has an index.

# FMS Communication Profile



# FMS Communication Profile

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## □ FMS Services

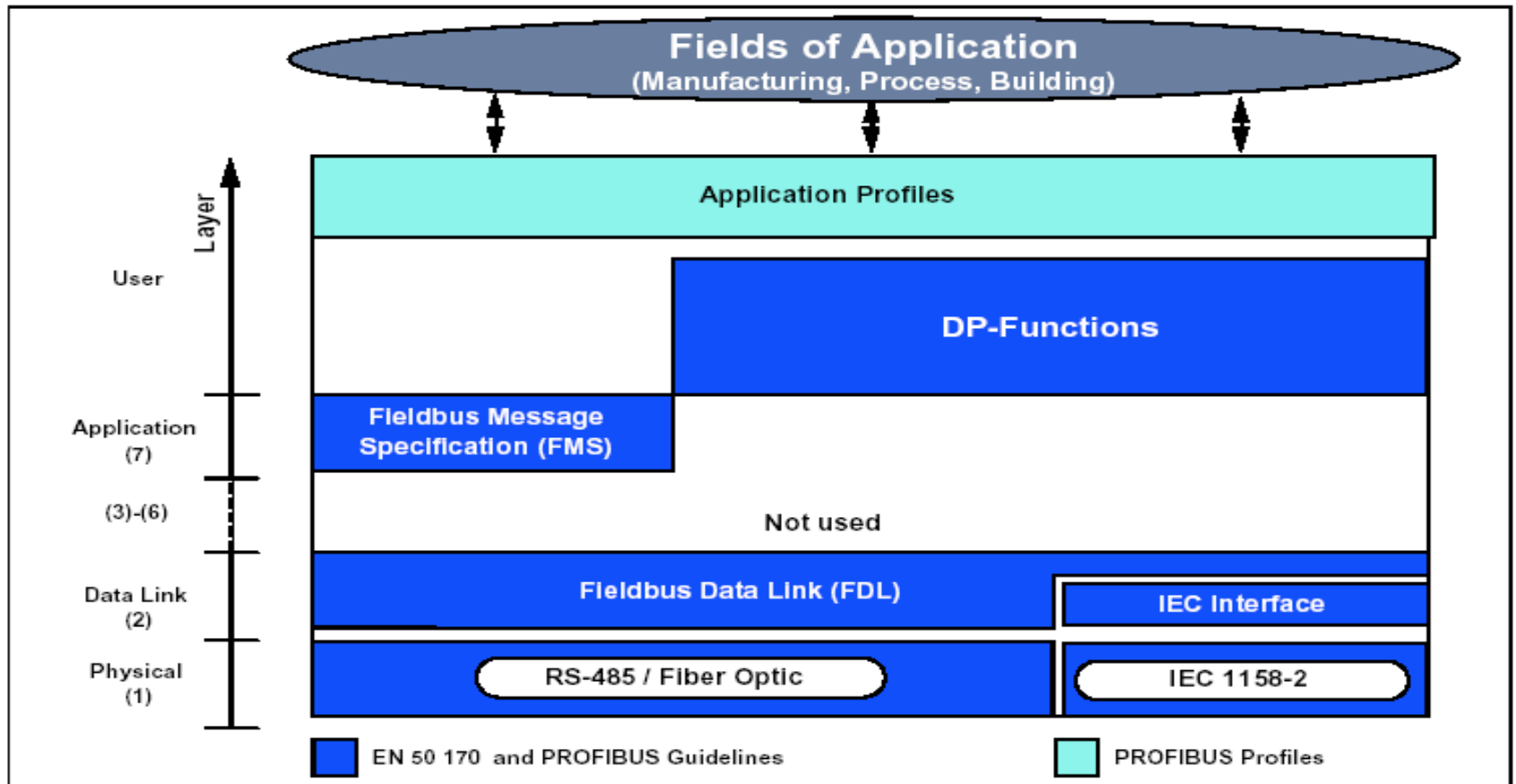
- Context Management (establish/release a connection)
- Variable Access (read/write a variable, define/delete a variable list)
- Program Invocation Management (create, delete, start, stop, resume, reset, kill a program)
- Event Management (report /acknowledge an event, disable/enable an event)

# FMS Communication Profile

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- Lower Layer Interface (LLI)
  - Mapping of layer 7 to layer 2
  - Connection-oriented communication →  
Confirmed services
  - Connectionless communication →  
Broadcast / Multicast

# Application Profiles



# Application Profiles

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- ❑ Describe the use of Communication and Physical Profiles for a certain range of applications (*process automation, building automation*) or for certain device types (*encoders, drives*).
- ❑ General Application Profiles
  - PROFISafe
  - Time Stamps
  - Slave Redundancy
- ❑ Specific Application Profiles



# PROFISafe

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- ❑ Defines how fail-safe devices (emergency stop pushbuttons, light arrays, overfill cutouts, etc.) can communicate over PROFIBUS with fail-safe controllers.
- ❑ PROFIsafe is a software solution, which is implemented in the devices as an additional layer "**above**" **layer 7**. It implements safe communications over a special format of user data and a special protocol.
- ❑ Uses **acyclic communication** and can be used with RS485 and fiber optic. This ensures both **fast response times** (important for the manufacturing industry) and **intrinsically safe operation** (important for process automation).
- ❑ **Takes into account a number of error possibilities that can occur in serial bus communications**, such as the delay, loss or repetition of data, incorrect sequences, addressing or corrupt data.

# Time Stamps

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- Timing functions such as diagnostics or fault location require the ability to **provide events and actions with a time stamp**, which enables precise time assignment.
- Precondition is a **time-of-day management** in the slaves through a time-of-day master service.
- "**Alerts**" are divided into high priority "**alarms**" (these transmit a diagnostics message) and low priority "**events**".

# Slave Redundancy

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- ❑ The installation of field devices with redundant communication behavior is desired in many applications.
- ❑ In normal mode, communications are sent exclusively over the primary slave; only this slave is configured, it also sends the diagnostic data of the backup slave.
- ❑ **In the event that the primary slave fails the backup slave takes over its functions**, either because it has detected the failure itself or because requested to do so by the master.

Designation	Profile contents	Current status of PNO guideline	
PROFIdrive	The profile specifies the behavior of devices and the access procedure to data for variable-speed electrical drives on PROFIBUS.	V2 V3	3.072 3.172
PA devices	The profile specifies the characteristics of devices of <i>process engineering in process automation</i> on PROFIBUS.	V3.0	3.042
Robots/NC	The profile describes how <i>handling and assembly robots</i> are controlled over PROFIBUS.	V1.0	3.052
Panel devices	The profile describes the interfacing of simple <i>human machine interface devices (HMI)</i> to higher-level automation components.	V1.0D	3.082
Encoders	The profile describes the interfacing of rotary, angle and linear <i>encoders</i> with single-turn or multi-turn resolution.	V1.1	3.062
Fluid power	The profile describes the control of hydraulic drives over PROFIBUS. In cooperation with VDMA.	V1.5	3.112
SEMI	The profile describes characteristics of devices for semiconductor manufacture on PROFIBUS (SEMI standard).		3.152
Low-voltage switchgear	The profile defines data exchange for low-voltage switchgear (switch-disconnectors, motor starters, etc.) on PROFIBUS DP.		3.122
Dosage/weighing	The profile describes the implementation of weighing and dosage systems on PROFIBUS DP.		3.162
Ident systems	The profile describes the communications between devices for identification purposes (bar codes, transponders).		3.142
Liquid pumps	The profile defines the implementation of liquid pumps on PROFIBUS DP. In cooperation with VDMA.		3.172
Remote I/O for PA devices	Due to their special place in bus operations, a different device model and data types are applied to the remote I/Os compared to the PROFIBUS PA devices.		3.132

# PROFIdrive

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- Defines device behavior and the access procedure to drive data for electric drives on PROFIBUS.
  - **Class 1 : Standard drives** controlled by means of a main setpoint value (rotational speed)
  - **Class 2 : Standard drives with control functions**
  - **Class 3 : Positioning drives** integrate an additional position controller
  - **Class 4-5 : Central Motion Control** enables the coordinated motional sequence of multiple drives
  - **Class 6 : Electronic Shafts** enable distributed automation clocked processes

# Process Automation Devices

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- The PA profile supports interchangeability and interoperability of PA field devices from different vendors. It uses the internationally recognized **function block model to describe the device functions and parameters**.
  - **Physical Block (PB)** : Contains general device information such as device name, manufacturer, version, serial number
  - **Transducer Block (TB)**: Contains application-specific data such as correction parameters
  - **Analog Input Block (AI)** : Provides the value measured by the sensor, with status and scaling
  - **Analog Output Block (AO)** : Provides the analog output with the output value specified by the control system
  - **Digital Input (DI)** : Provides the control system with the value of the digital input
  - **Digital Output (DO)** : Provides the digital output with the value specified by the control system
- The blocks are implemented by the manufacturers as **software in the field devices** and, taken as a whole, represent the functionality of the device.

# System Profiles

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- Master Profiles describe classes of controller which support a variety of functionalities:
  - Cyclic communications
  - Acyclic communications
  - Diagnostics, interrupt handling
  - Time-of-day management
  - Slave-to-slave communication

# Device Management

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- ❑ The **communication features** of a PROFIBUS device are described in a device master data file (**General Slave Data, GSD**) in a defined data format; the GSD is a readable ASCII text file created by the device manufacturer and is included in the delivery of the device.
- ❑ The **application features** of a PROFIBUS device are described in the **Electronic Device Description (EDD)** file. It is a readable ASCII text file provided by the device manufacturer.
- ❑ For complex applications all device-specific functions (parameterization, diagnostics, etc.) are mapped as software components (Microsoft ActiveX) in a so-called **Device Type Manager (DTM)**. The DTM (which, in contrast to the GSD and EDD, is a software) then acts as the "driver" of the device.



# Evolution

