Overview and Applications of PROFINET

Andy Verwer
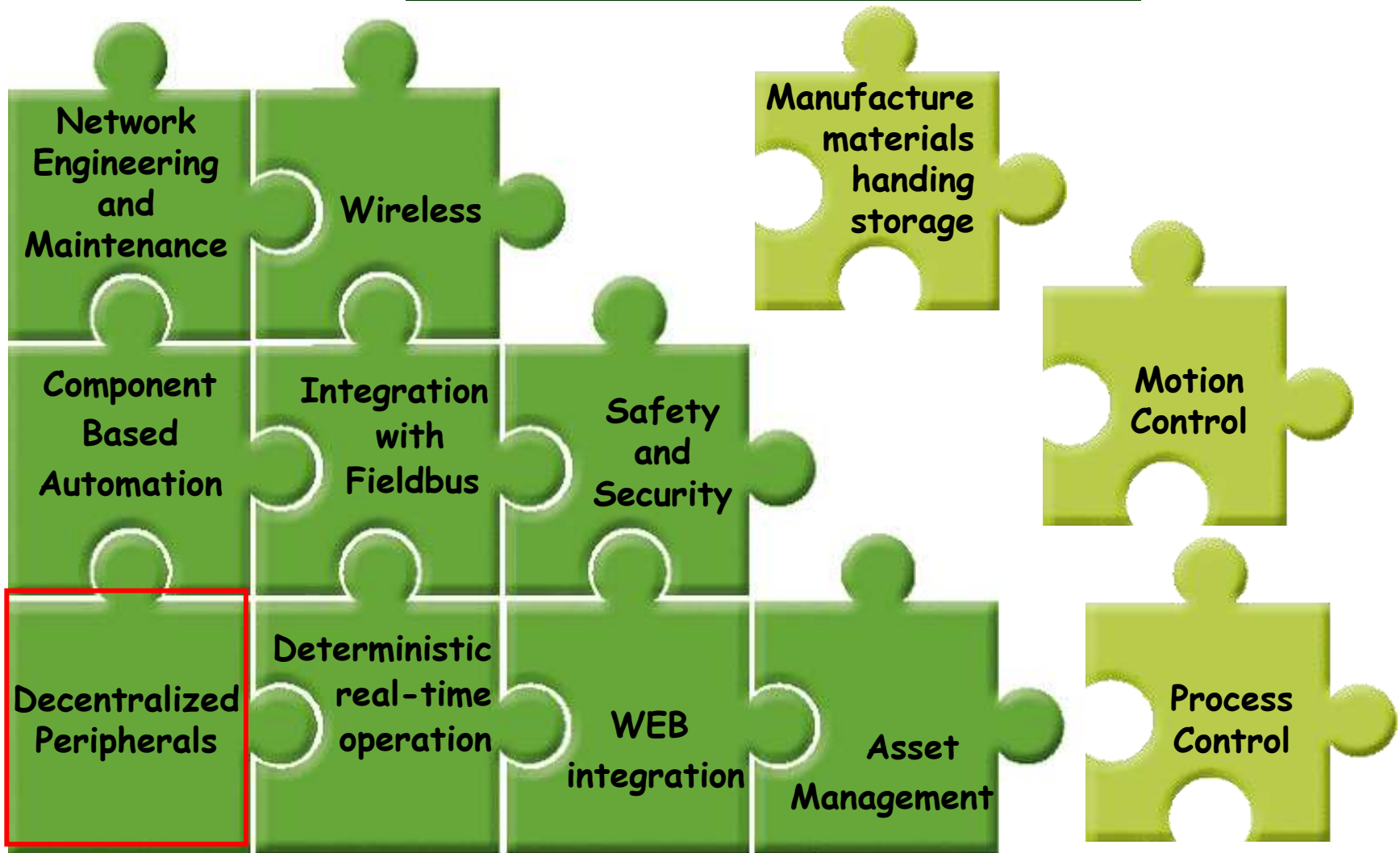Verwer Training & Consultancy Ltd

What exactly is PROFINET?

- PROFINET is an open Industrial Ethernet standard developed by the PROFIBUS Organisation.
- PROFINET
  - is completely standard Ethernet (IEEE802.3).
  - operates at 100Mbit/s over twisted-pair copper or fibre-optic cables,
  - makes use of TCP/IP and other IT standards for non-real-time communications (i.e. configuration and parameters).
  - Provides a "real-time" channel for time-critical communications (i.e. process data)
- PROFINET is NOT PROFIBUS over Ethernet!
- However, PROFINET is well thought out to incorporate the requirements of modern systems based on the lessons learned from PROFIBUS.

PROFINET Scope and Application Areas

Network Engineering and Maintenance

Wireless

Manufacture materials handing storage

Component Based Automation

Integration with Fieldbus

Safety and Security

Motion Control

Decentralized Peripherals

Deterministic real-time operation

WEB integration
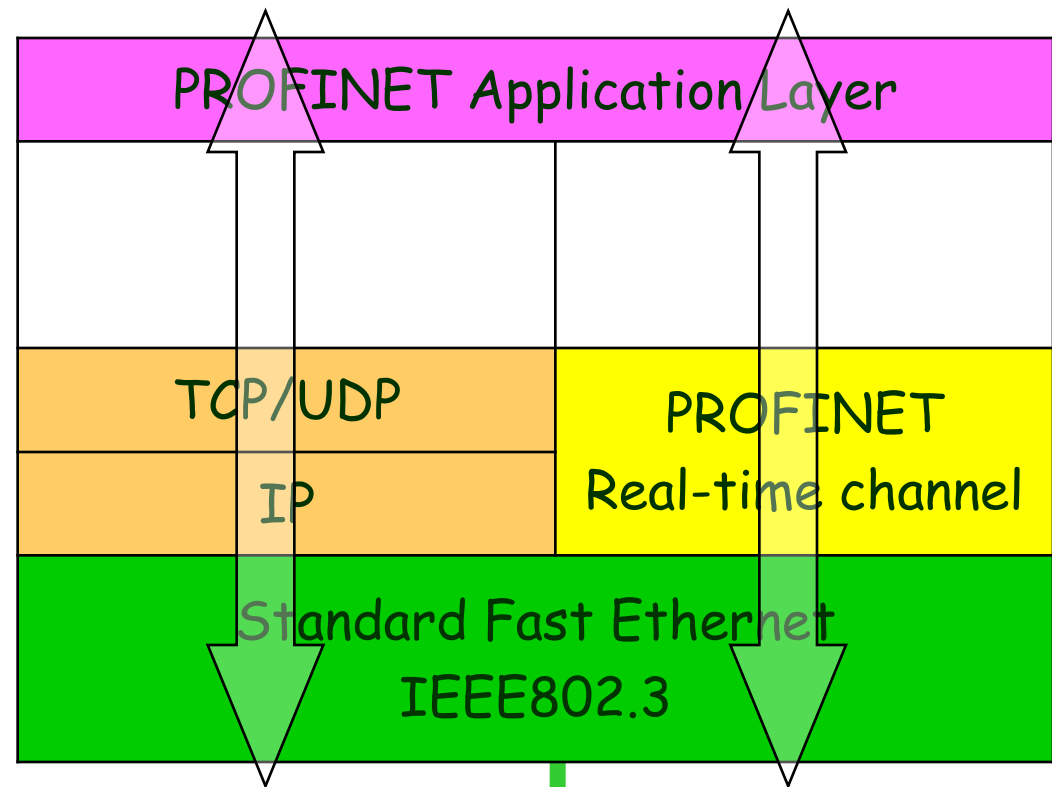
Asset Management

Process Control

PROFINET IO

- PROFINET IO provides decentralised peripherals using Ethernet connection and the PROFINET communication protocol.

- PROFINET IO uses Real-Time and Non Real-Time communications.

- PROFINET makes use of relevant TCP/IP protocols for setup, configuration and maintenance functions:
  - DHCP – Dynamic Host Configuration Protocol,
  - DNS – Domain Name Service,
  - SNMP – Simple Network Management Protocol,
  - ARP – Address Resolution Protocol,
  - HTTP – Web page access, and lots more!
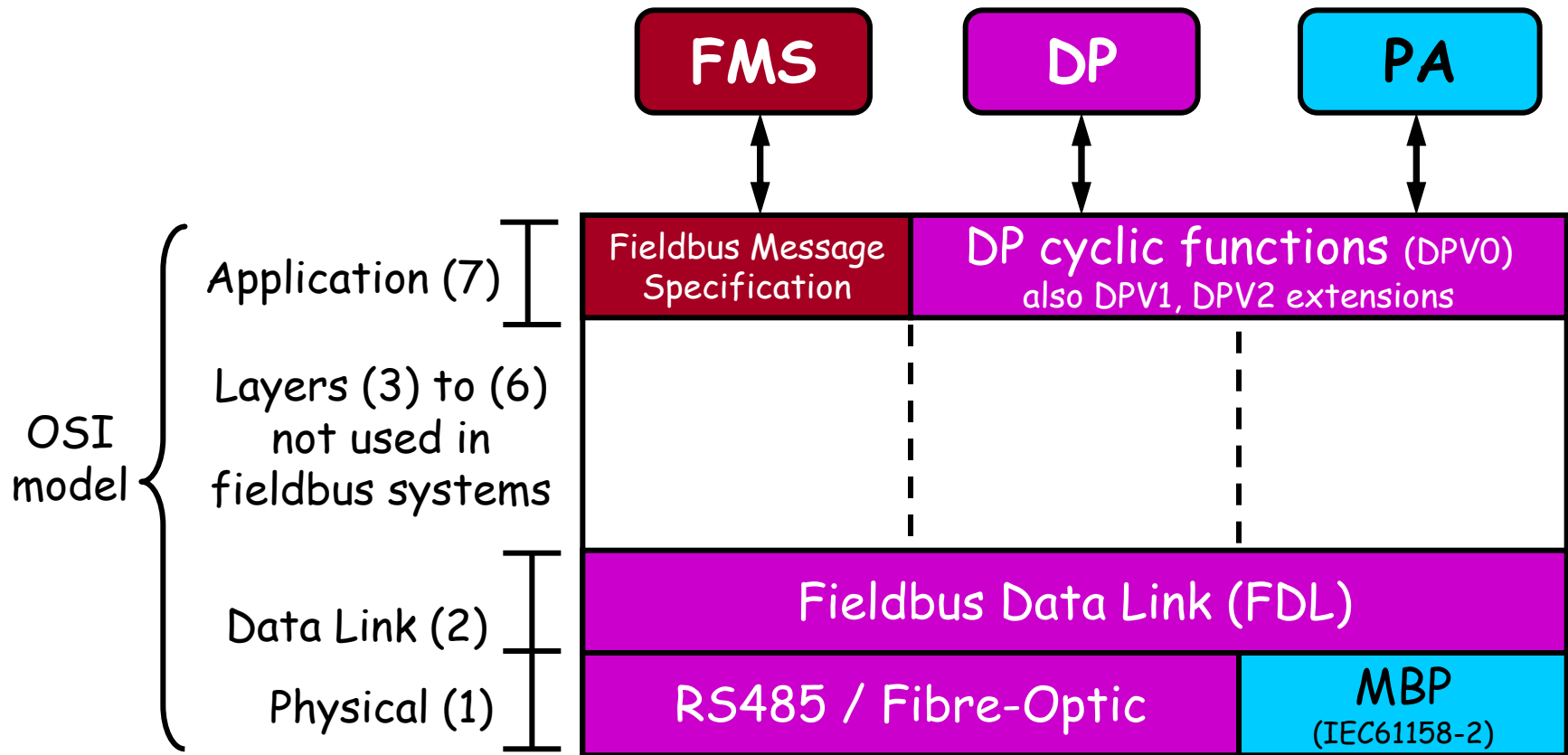
PROFINET

PROFINet stack
(OSI model):

Non time-critical
communication

Real-time
communication

PROFINet stack (OSI model)	Non time-critical communication	Real-time communication
7 - Application Layer	PROFINET Application Layer	
6 - Presentation Layer		
5 - Session Layer		
4 - Transport Layer	TCP/UDP	PROFINET Real-time channel
3 - Network Layer	IP	
2 - Data Link Layer	Standard Fast Ethernet IEEE802.3	
1 - Physical layer		

Network

PROFIBUS OSI Model

	FMS	DP	PA

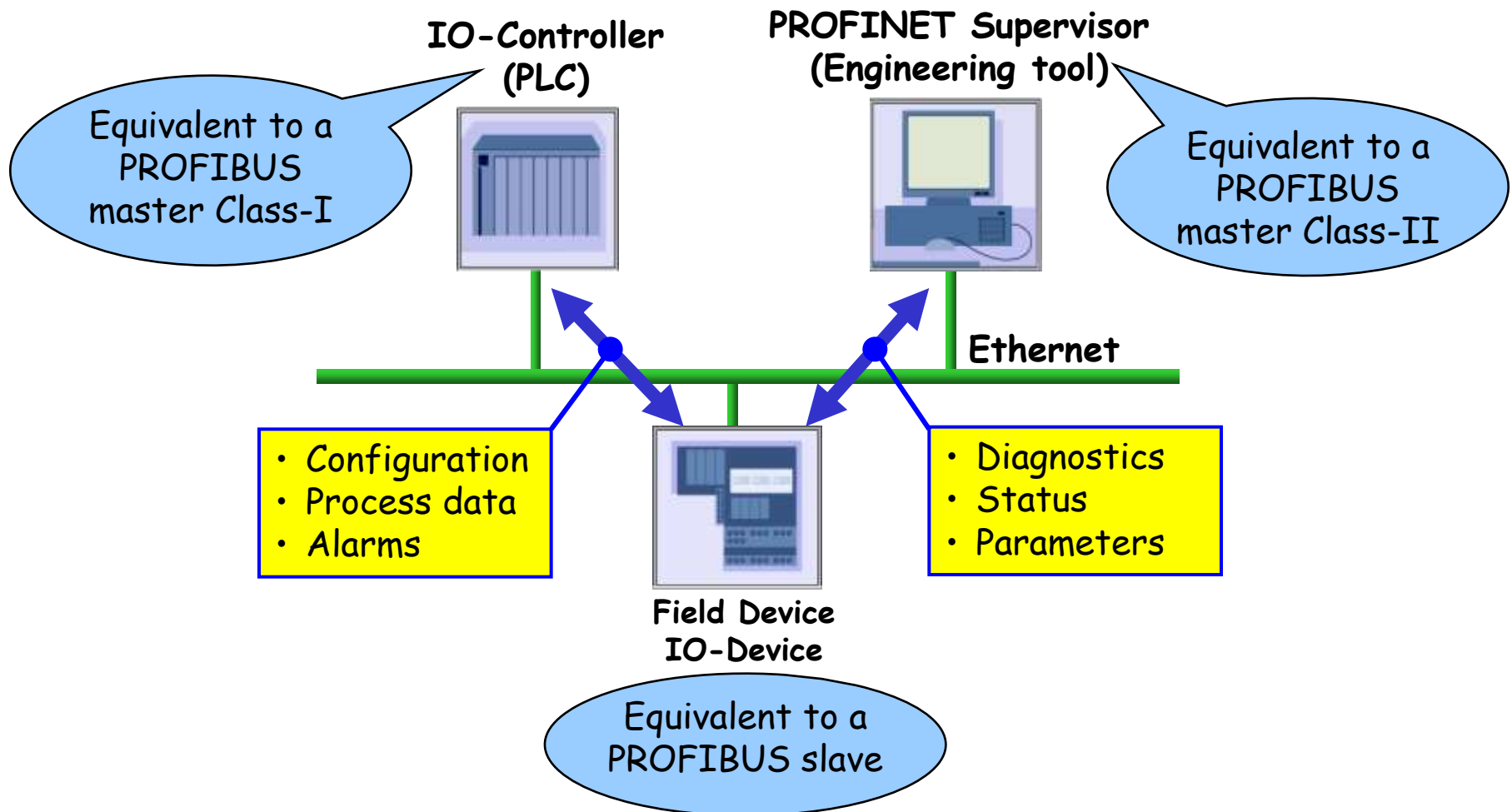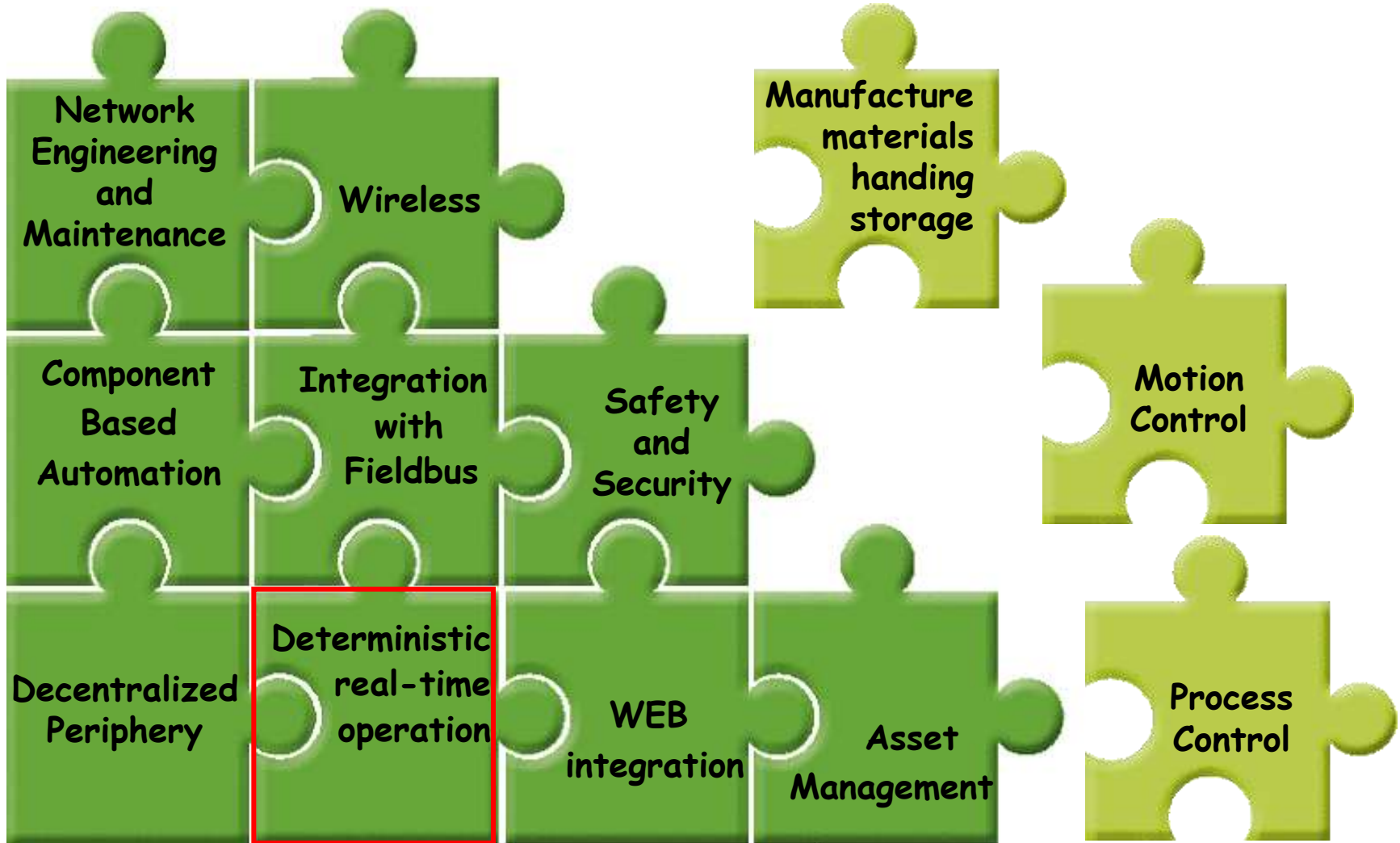| OSI model | Application (7) | Fieldbus Message Specification | DP cyclic functions (DPV0) also DPV1, DPV2 extensions | |
	Layers (3) to (6) not used in fieldbus systems			
	Data Link (2)	Fieldbus Data Link (FDL)		
	Physical (1)	RS485 / Fibre-Optic		MBP (IEC61158-2)

PROFINET IO

- The TCP/IP channel is used for non-time critical tasks.
  - Downloading of configuration, parameters,
  - Diagnostics,
  - Device management information, etc.
- The Real-Time channel is used for time-critical data:
  - Cyclic process data,
  - Alarms and critical messages,
  - Communication monitoring.
- The PROFINET application layer protocol is defined in the International Fieldbus standard IEC61158 (type 10).

PROFINET Devices

IO-Controller (PLC)

PROFINET Supervisor (Engineering tool)

Equivalent to a PROFIBUS master Class-I

Equivalent to a PROFIBUS master Class-II

Ethernet

- Configuration
- Process data
- Alarms

- Diagnostics
- Status
- Parameters

Field Device IO-Device

Equivalent to a PROFIBUS slave

PROFINET I/O

- The PROFINET IO device model is similar to that used in PROFIBUS.

- Based on a slots with plug-in modules.

- However the base module has a PROFINET interface rather than PROFIBUS

Slot 1   Slot 2   Slot 3   Slot 4   Slot 5
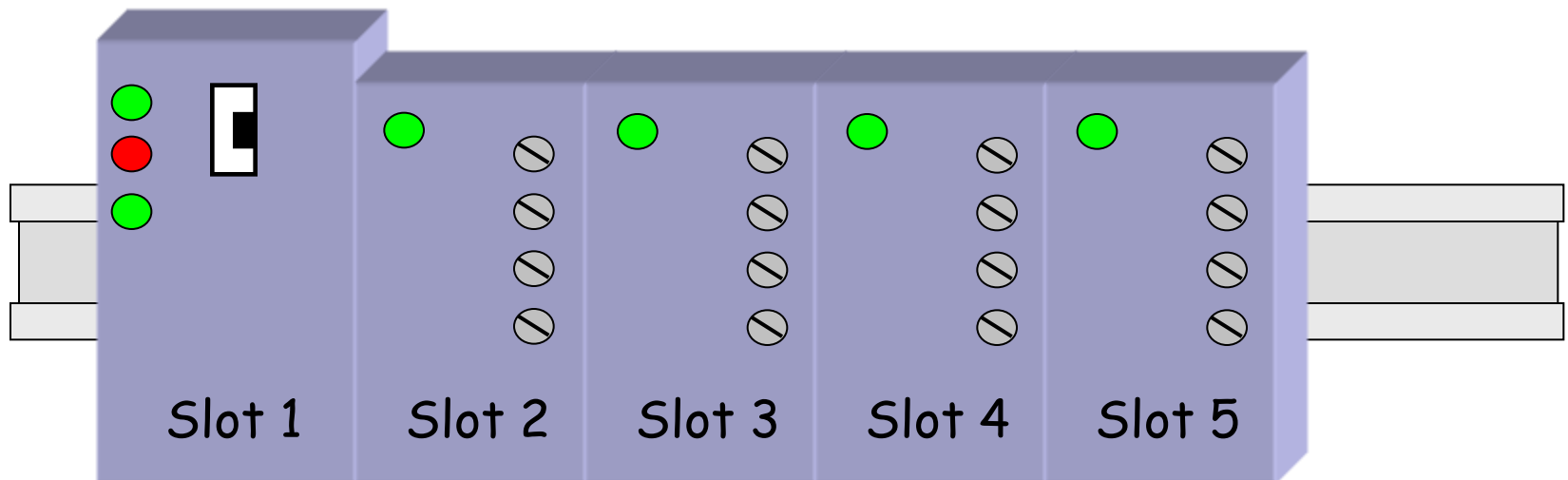
PROFINET IO

- Many features that have been developed for PROFIBUS devices have been directly incorporated into PROFINET:
  - Standardised module and channel-related diagnostics,
  - Alarm and status information,
  - Identification and Maintenance (I&M) functions,
  - Time stamping,
  - Highly deterministic process cycle timing (Isochronous),
  - Device description file (GSD) with configuration data for the device and available modules – PROFINET uses XML.

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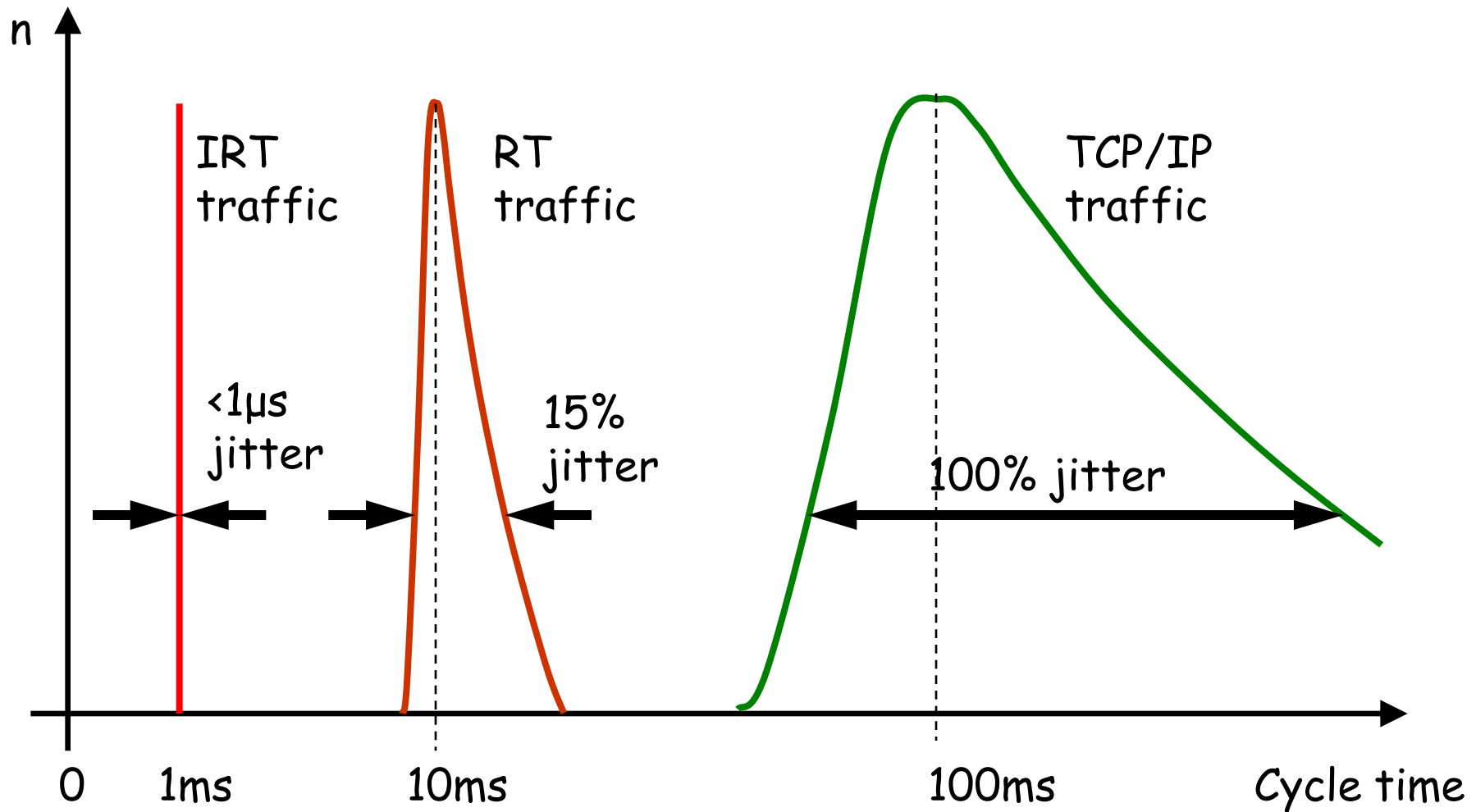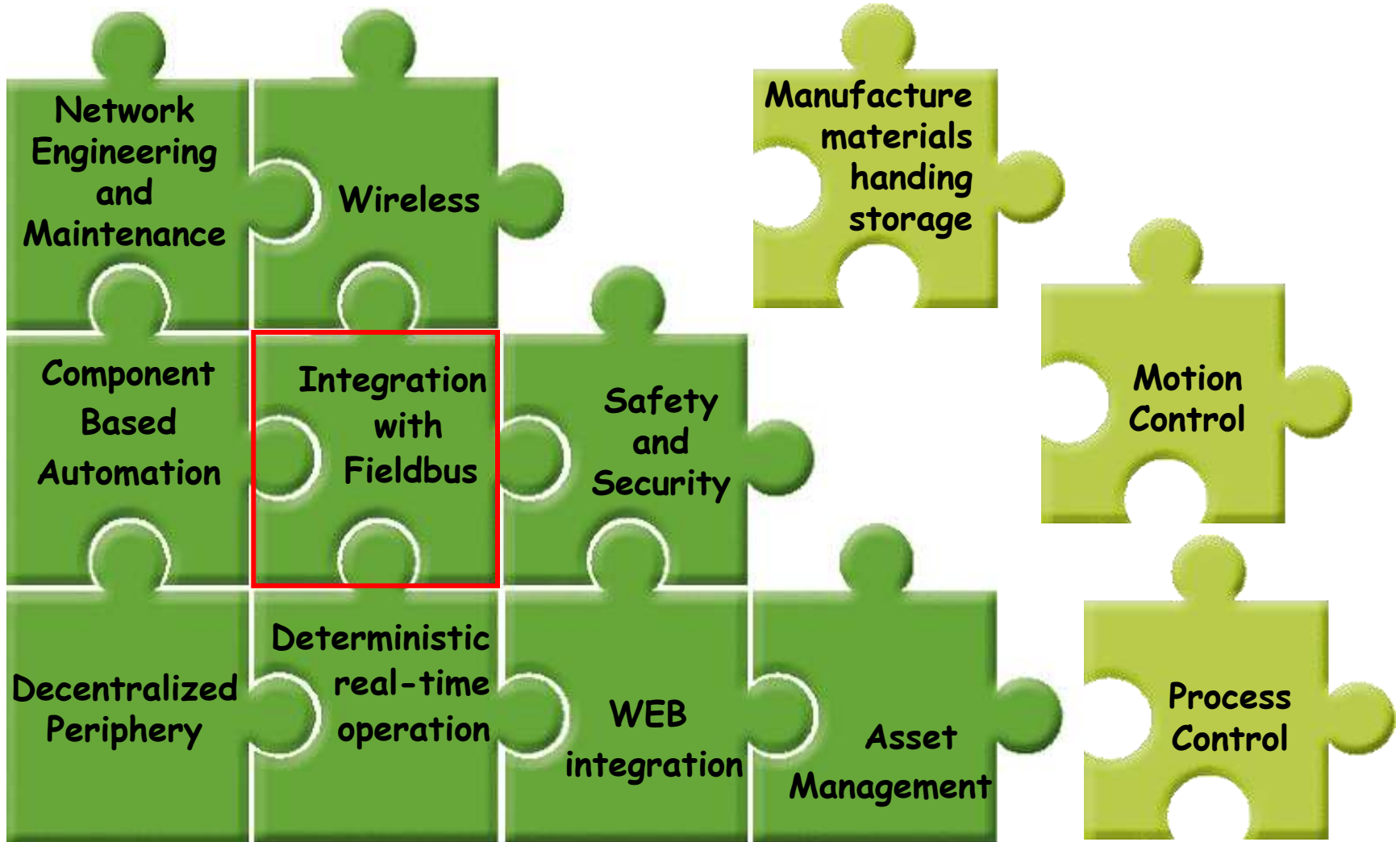
Process Control

Real-Time Operation

- What does "Real-Time" mean?
  - A real-time control system responds in a deterministic manner within a time which is short compared to the plant response time.
  - i.e. it depends on the application!
- Standard communications (IT)
  - requires a response in the order of ~100ms.
- Factory automation
  - requires a response time in the order of ~10ms.
- Motion control
  - requires a response time in the order of ~1ms with a jitter <1μs.

Real-Time Operation

- PROFINET makes use of:
  - TCP/IP for standard communications, achieving response times reliably less than 100ms.
  - A Real-Time, RT, channel for I/O communications, achieving reliable cycle times < 10ms with <1ms jitter.
  - Isochronous Real-Time, IRT, channel for highly deterministic performance (e.g. servos robotics NC), achieving reliable cycle times < 1ms with <1μs jitter.
- RT and IRT communications are totally compatible with TCP/IP.
  - Since the information is transmitted as a standard Ethernet package.

Real-Time Operation

- PRIFINET IRT complies with IEEE 1588 – "Precision clock synchronization protocol for networked measurement and control systems".

- However this not always good enough!

- PROFINET extensions to IEEE 1588 provide better accuracy with:

  - Automatic determination and compensation of the network transmission time.

  - Resulting in less than $1\mu s$ jitter at 100Mbit/s.

Isochronous Real-Time Performance

n

IRT traffic

<1µs jitter

RT traffic

15% jitter

TCP/IP traffic

100% jitter

0   1ms   10ms   100ms   Cycle time

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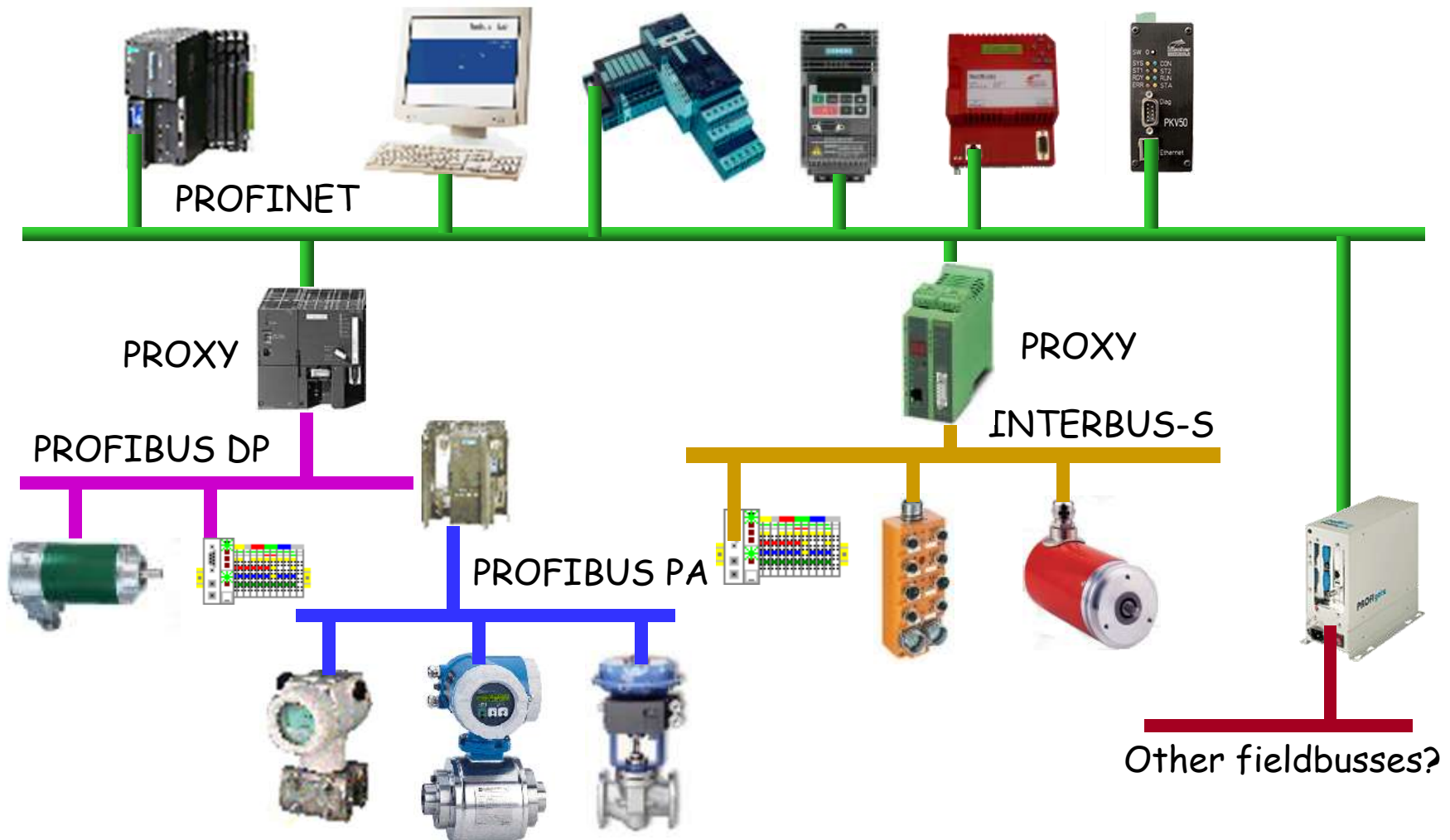WEB integration
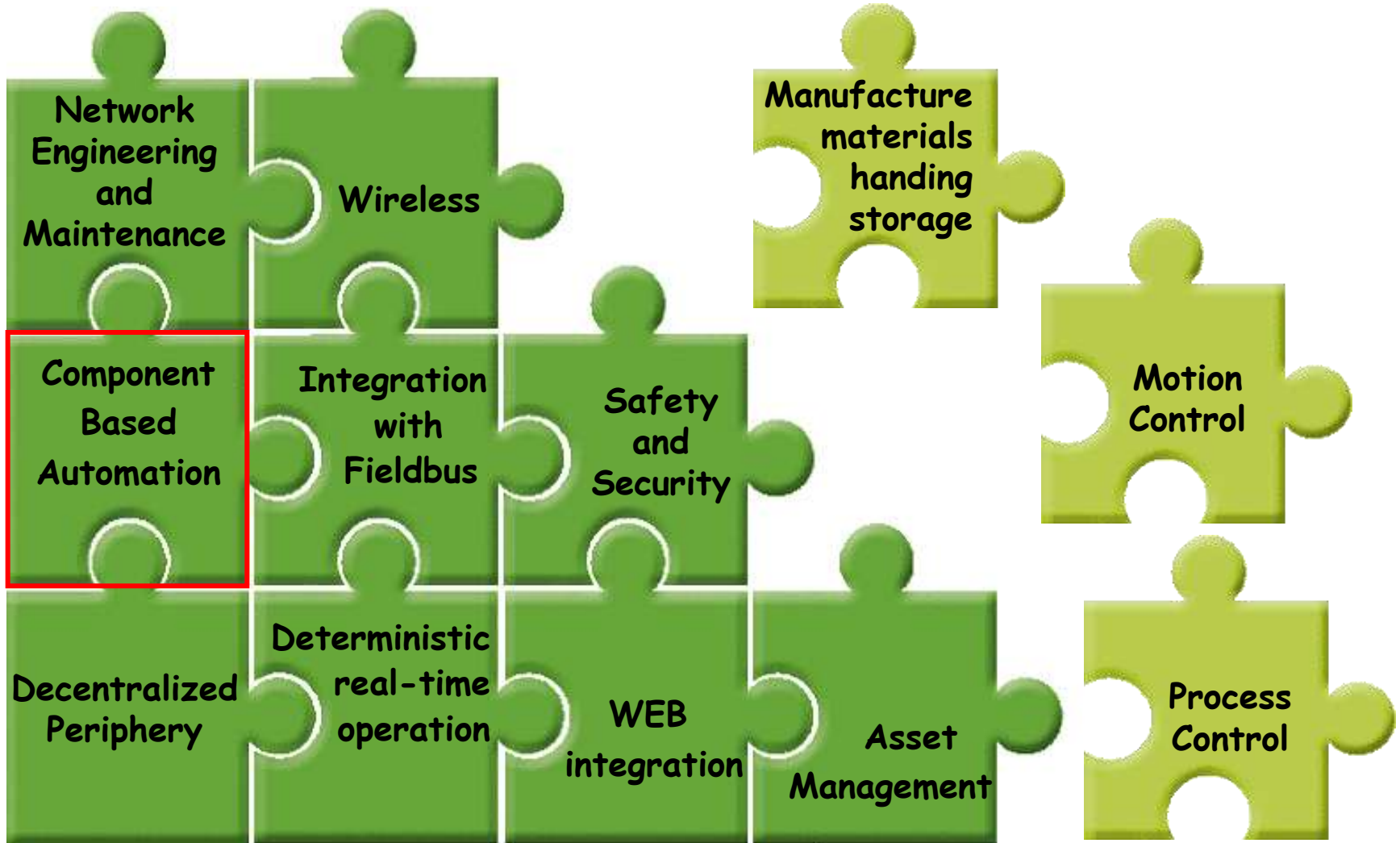
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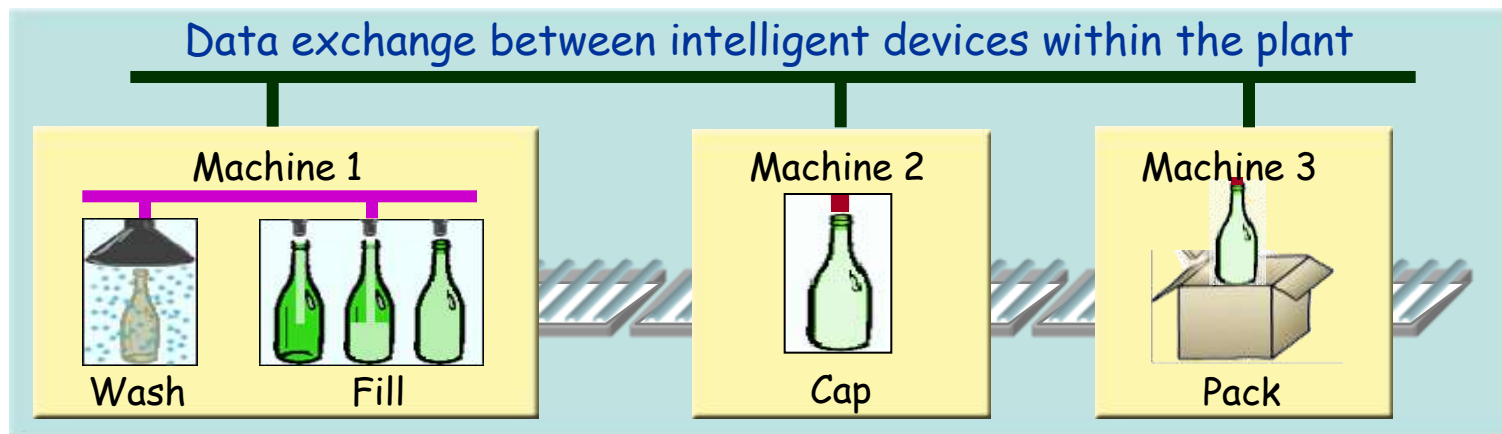
Integration with Fieldbus

- Over 30 million PROFIBUS devices are currently installed worldwide.

- This investment is protected with PROFINET for both manufacturers and end-users.

- PROFINET provides a transparent interface with PROFIBUS via a "Proxy".

- The Proxy is a PROFINET IO device on one side and a PROFIBUS master on the other.

- PROFIBUS Configuration is integrated into the PROFINET configurator and is downloaded via Ethernet.

Integration with Fieldbus

PROFINET

PROXY

PROFIBUS DP

PROXY

INTERBUS-S

PROFIBUS PA

Other fieldbusses?

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Component Based Automation

- Component Based Automation is a modular architecture for distributed control.

- Based upon an "object oriented approach" to distributed automation.

- Component Based Automation provides a scalable architecture for dealing with complex distributed control systems.
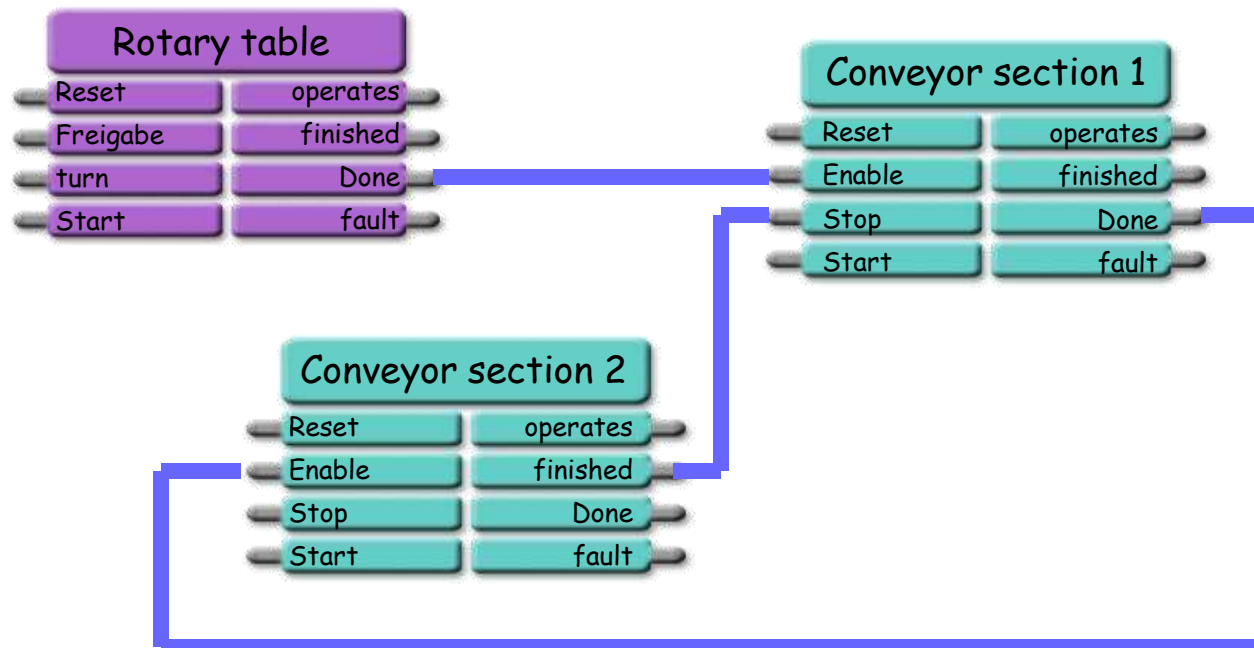
Component Based Automation

- Consider a manufacturing application consisting of a number of machines from different vendors.

- Each will incorporate a local control system to automate the machine.

- These intelligent machines must communicate in order schedule and control production.

Data exchange between intelligent devices within the plant

Machine 1

Machine 2

Machine 3

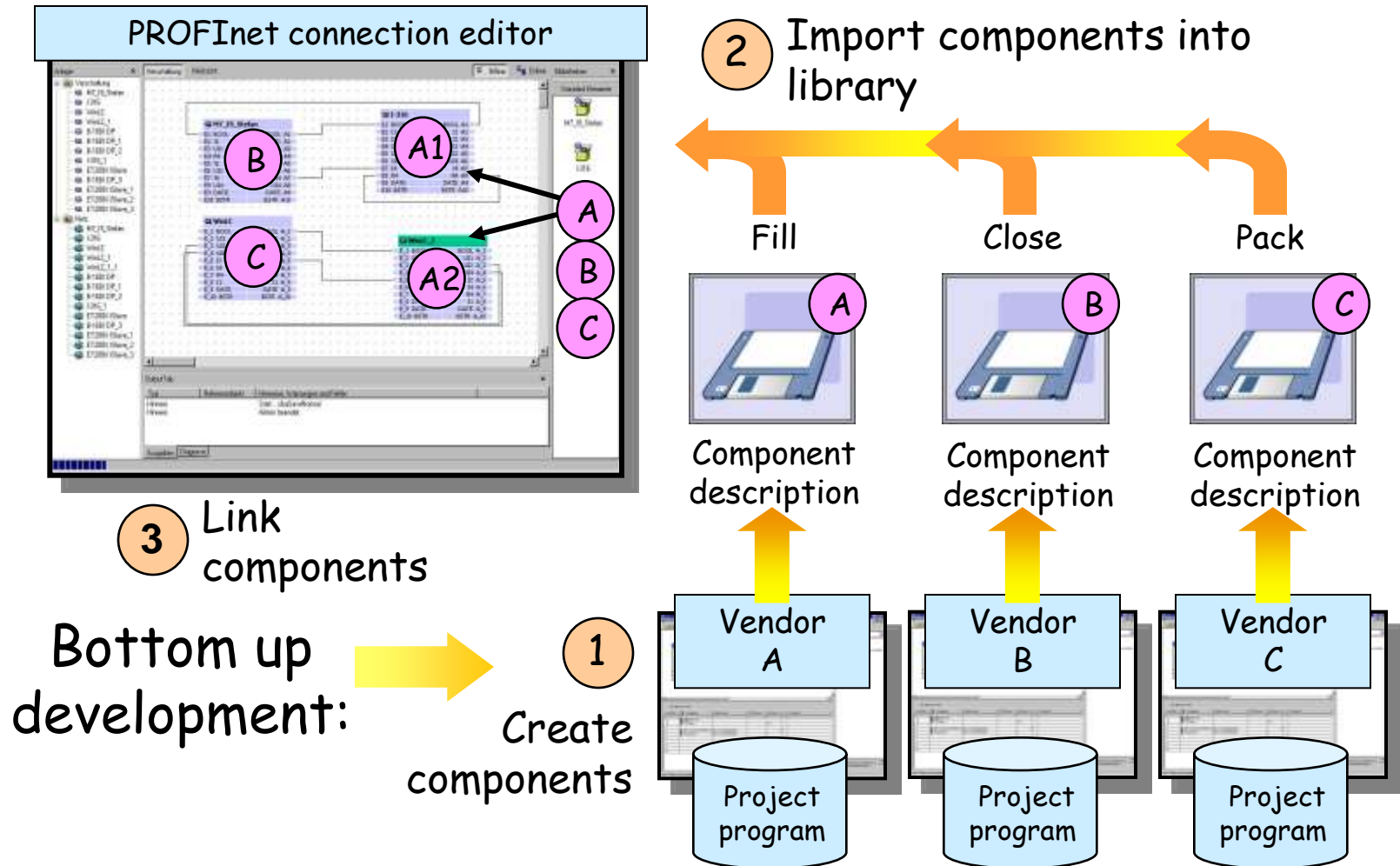Wash   Fill

Cap

Pack

Component Based Automation

- The OEM develops the application software for their device.

- And creates an "application specific" component
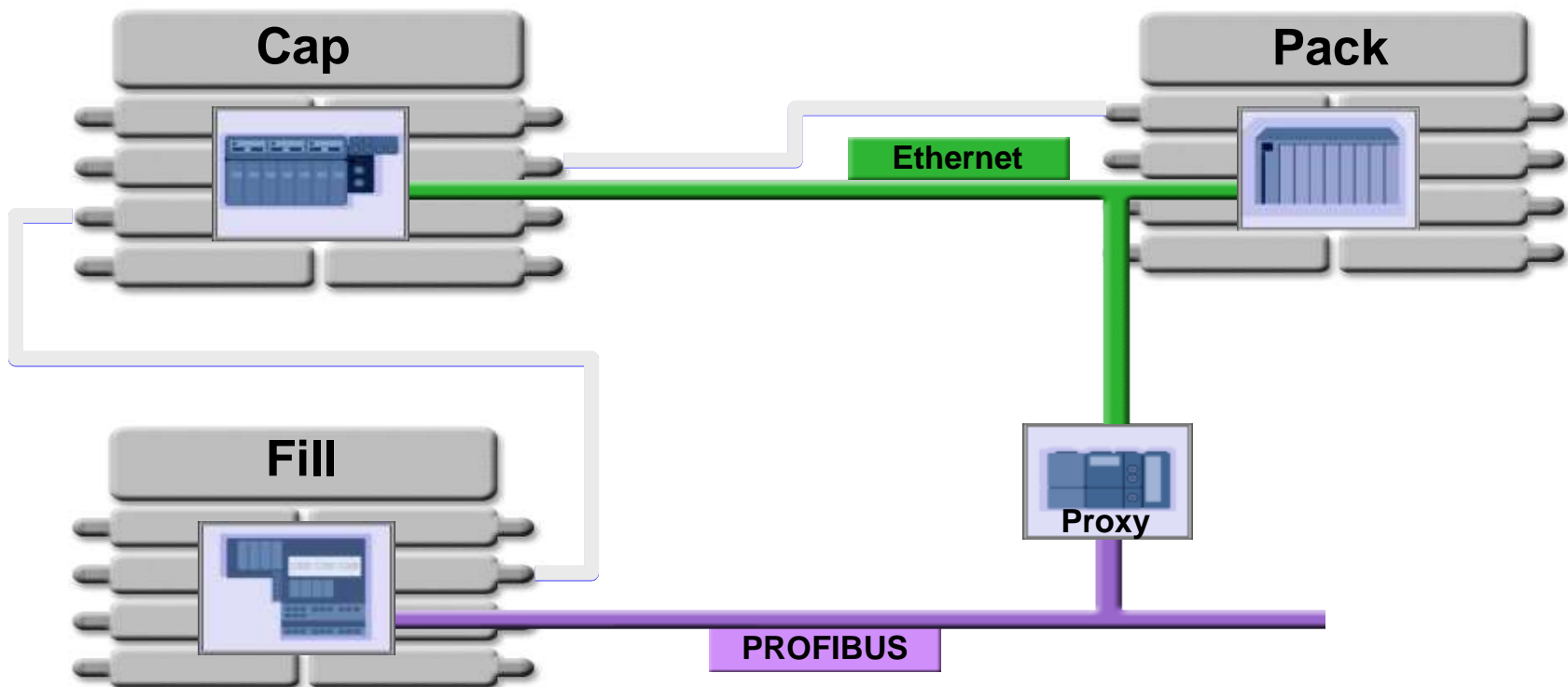
- With an agreed standardised interface.

Pack component

Access via standardised component interface

FB

Component Based Automation
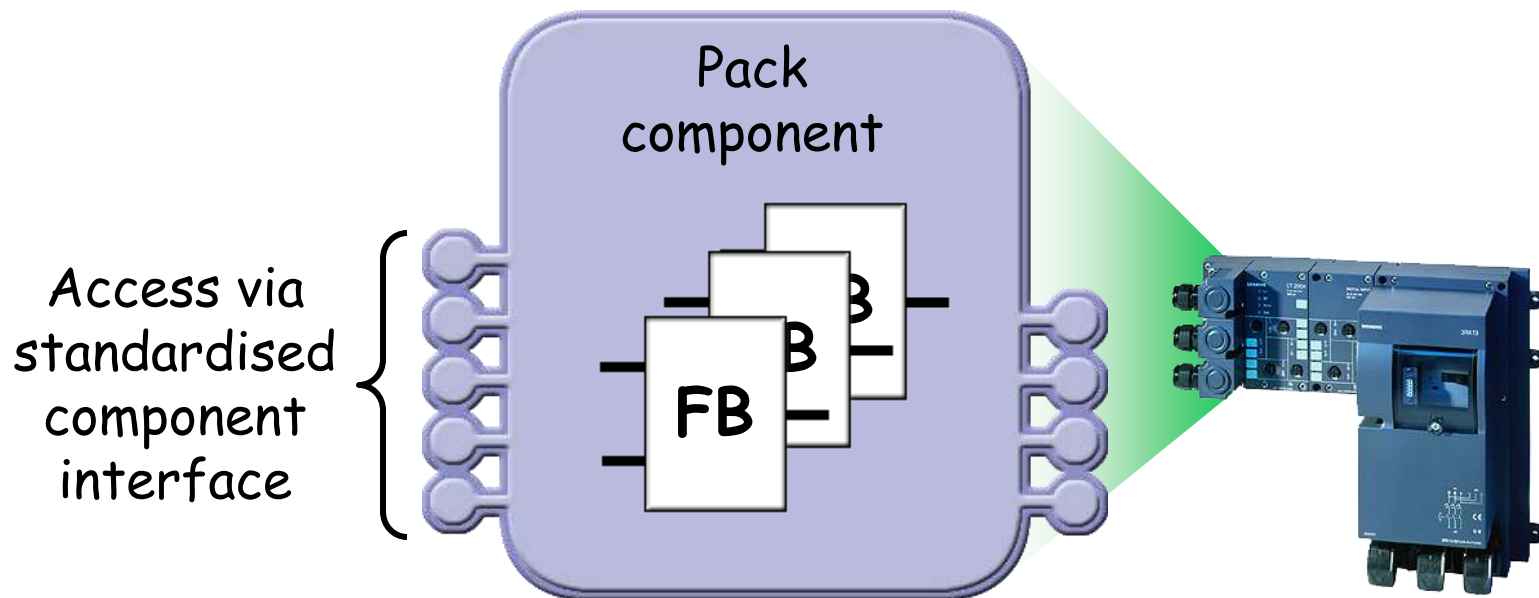
- Components can be exercised and tested by the machine vendor separately from the final application.

- Software components are then "wired" together to build the plant control system:

Rotary table	
Reset	operates
Freigabe	finished
turn	Done
Start	fault

Conveyor section 1	
Reset	operates
Enable	finished
Stop	Done
Start	fault

Conveyor section 2	
Reset	operates
Enable	finished
Stop	Done
Start	fault

Component Based Automation

PROFInet connection editor

2 Import components into library

Fill Close Pack

Component description Component description Component description

3 Link components

Bottom up development:

1 Create components

Vendor A Vendor B Vendor C

Project program Project program Project program

Component Based Automation

- The component software connection is independent of the communication connections:

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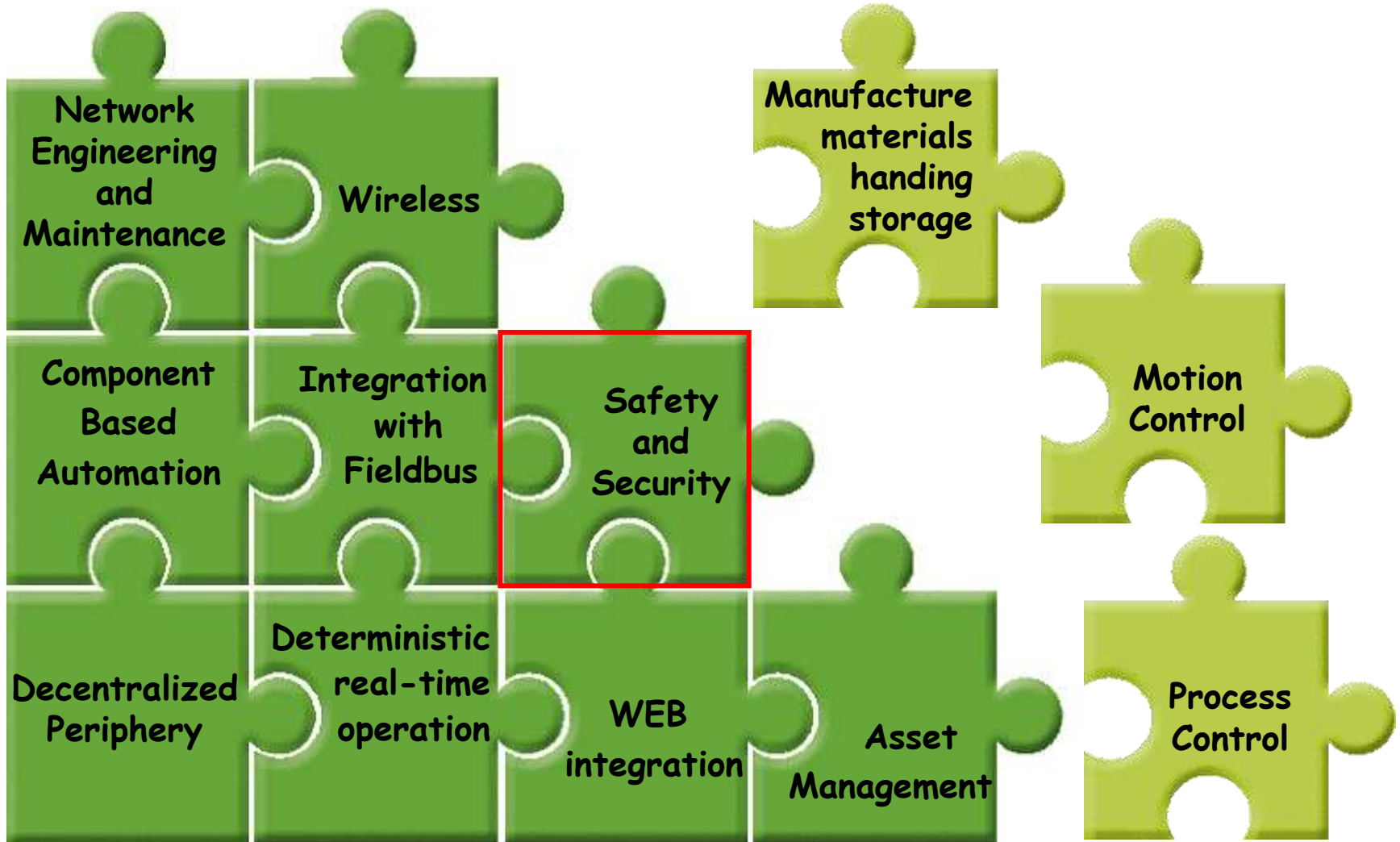
Functional Safety with PROFINET

- PROFINET also offers safety oriented communication that allows for integrating safety oriented components.

- A second 'safety fieldbus' is not necessary.

- ProfiSafe V2 is certified according to IEC61158 Safety Integrity Level 3 (SIL3).

- ProfiSafe is a profile that can run over PROFIBUS or PROFINET.

Functional Safety with PROFINET
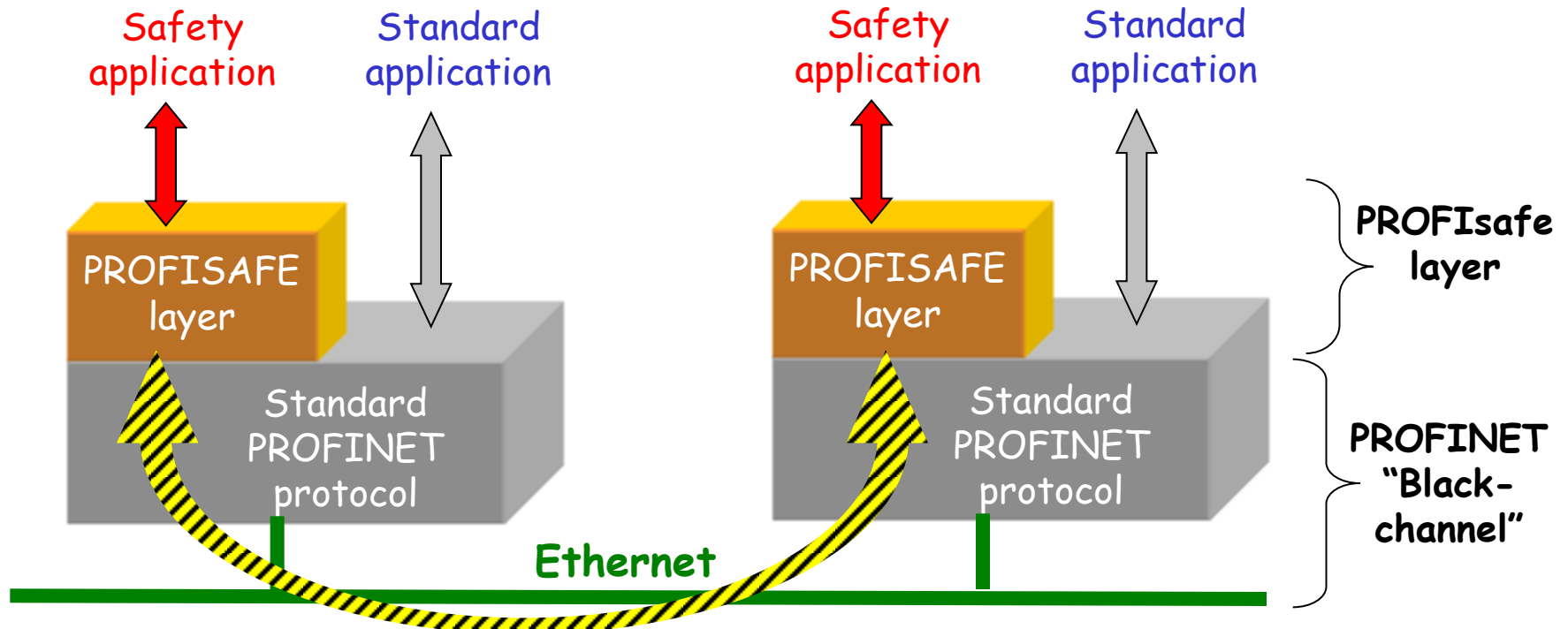
- PROFIsafe V2 provides functional safety for both PROFIBUS and PROFINET systems.

- Suitable for use in SIL3 applications.

Industrial Acceptance and Applications

- PROFINET builds on the success of PROFIBUS and ensures a future for both.

- PROFINET has been in development for about 10 years.

- Take up of Industrial Ethernet has been slower than initially predicted.

- PROFIBUS is still growing exponentially – currently over 30 million devices installed.

- Over 2 million PROFINET devices are currently installed – currently growing at about 40% per year!

Industrial Acceptance and Applications

- In 2004, AIDA, a consortium of the big four European automotive manufactures announced adoption of PROFINET as the industry standard.

- The main reasons for this decision were reported to be:
  - The integration of safety-related information,
  - The simple integration of existing PROFIBUS and Interbus systems.

Some Myths about PROFINET

- PROFIBUS runs at up to 12Mbit/s, whereas PROFINET runs at 100Mbit/s. Therefore PROFINET is about 8 times faster than PROFIBUS.

<p style="text-align:center; color:red">NOT TRUE!</p>

  – PROFINET gives very similar performance to PROFIBUS.

- PROFINET will replace PROFIBUS in the next five years.

<p style="text-align:center; color:red">NOT TRUE!</p>

  – PROFINET will replace some PROFIBUS DP devices, but PROFIBUS PA will continue.
  – Both DP and PA will be supported for many years to come.

Some Myths about PROFINET

- PROFINET is not standard Ethernet

<p align="center" style="color:red">NOT TRUE!</p>

  - PROFINET always uses completely standard Ethernet. It just doesn't always use TCP/IP protocols – only for not time critical communications.

- PROFINET systems can be maintained by out IT people.

<p align="center" style="color:red">TRUE, BUT NOT A GOOD IDEA!</p>

  - PROFINET is much more than just an IT network. Real time determinism, reliability, device diagnostics and security are all much more important than on IT systems

PROFINET problems

- It is widely accepted that 90% of all PROFIBUS problems are caused by poor layout and installation.

- PROFINET will generally reduce these physical-layer problems because all Ethernet wiring is point-to-point (only two devices on a cable).

- However, it will not eliminate wiring problems.

  - We will still see problems with routing, interference pickup, grounding etc. etc.

- Software problems may be more common since the range of protocols used is very extensive.

- The problems associated with Industrial Ethernet systems are quite different to those in IT.

  - people with IT experience need additional training.