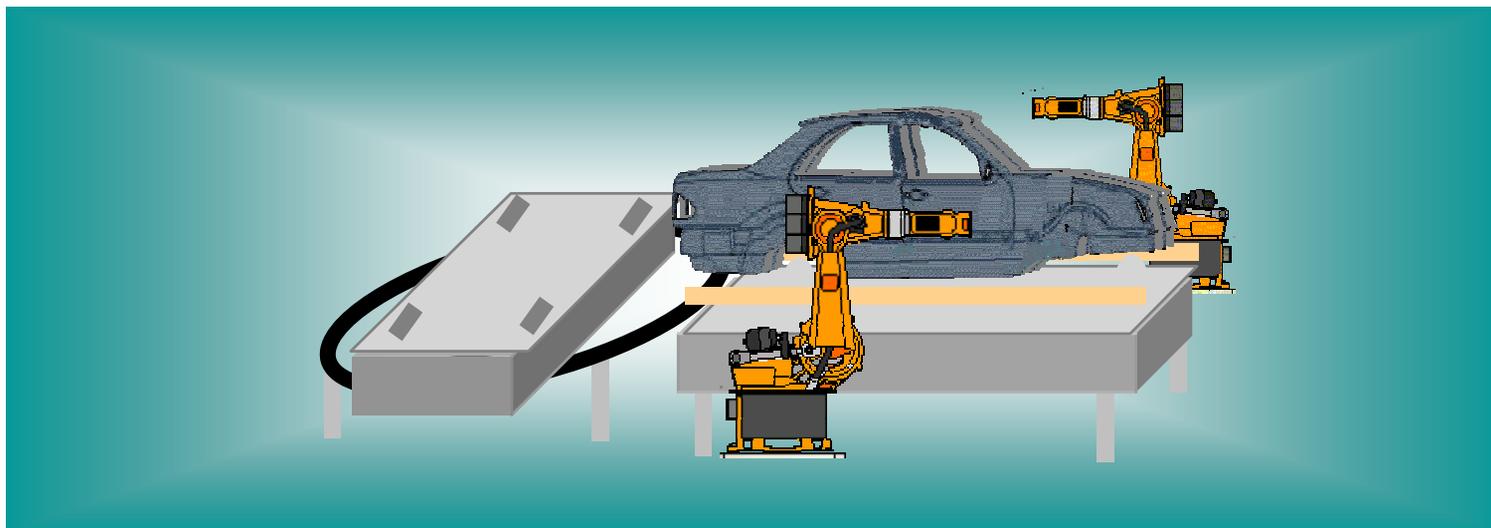


Functional Scope
Requirements
RT-Communication
IRT-Communication
Time-
Synchronisation
IRT-Schedule
Unsynch-Comm.
Synchr.-Comm.
Software-Stack
RT and CBA

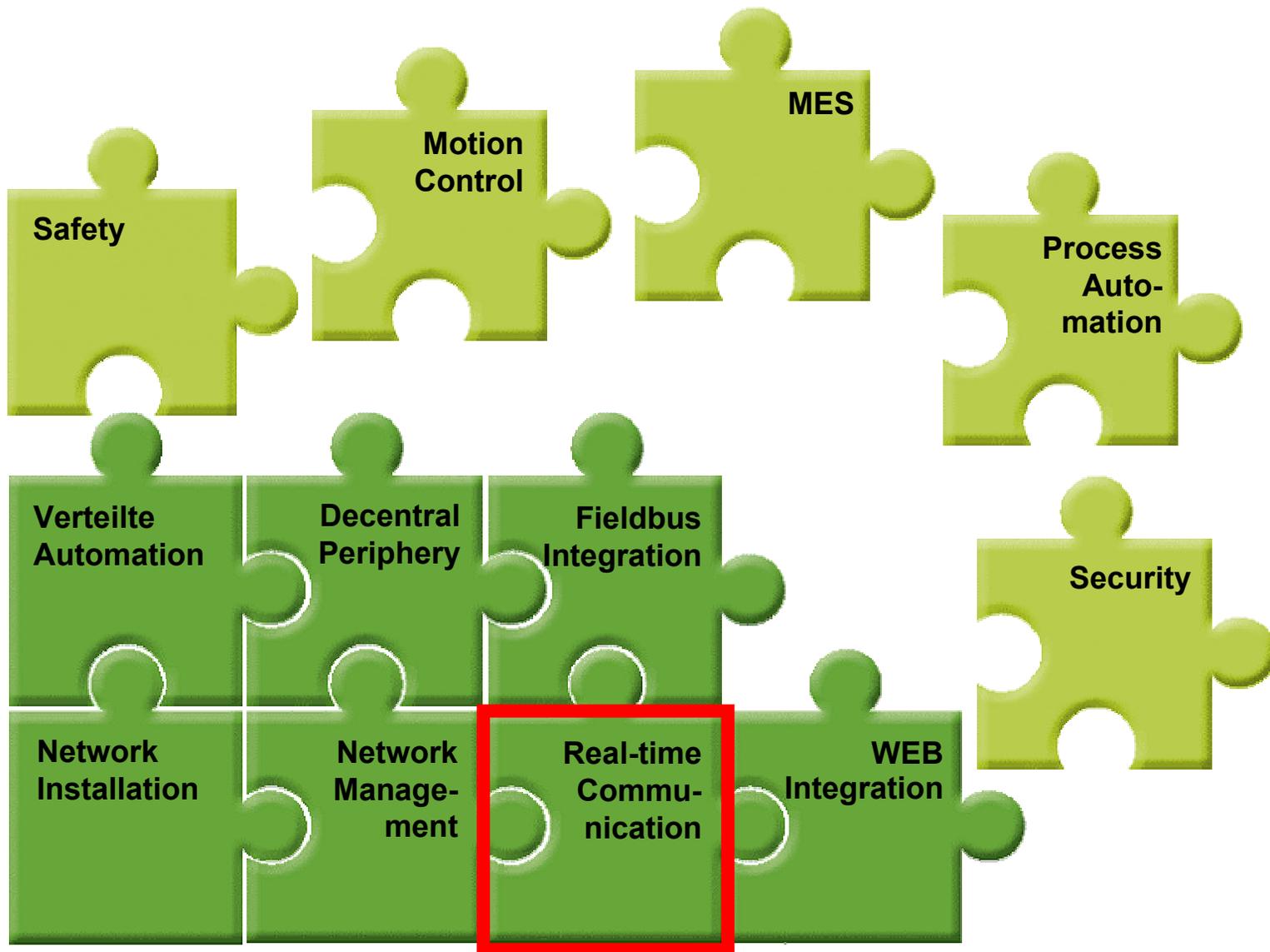
PROFINET



Real-Time Communication

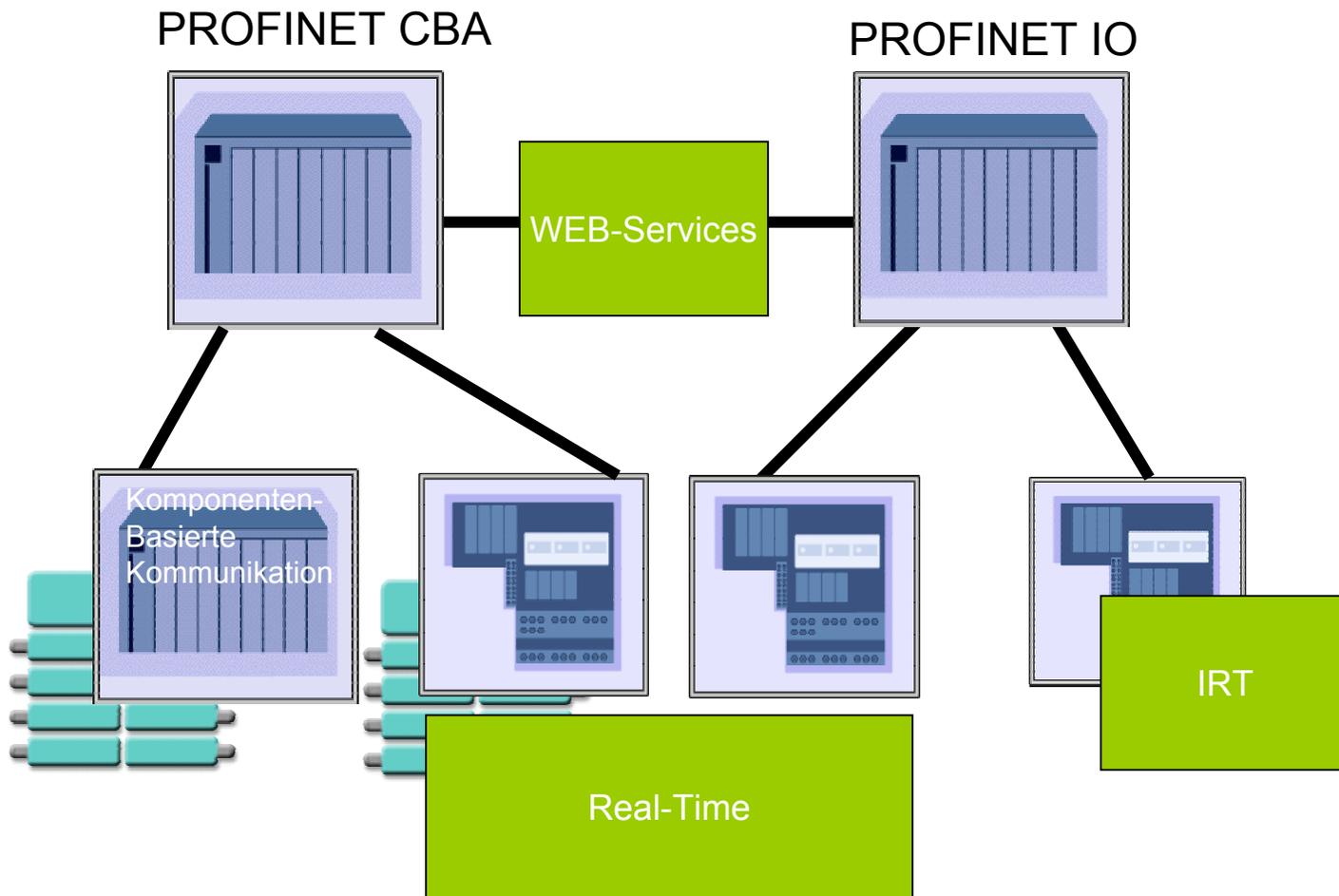
PROFINET Real-Time Communication

- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA



PROFINET Real-Time Communication

- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA



PROFINET Real-Time Communication

- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA

- **Refresh times**
 - Refresh time: time duration from the switch over of a input signal to the reaction on the correspondent output signal
 - **Factory Automation: 5-10 ms**
 - **Motion Control: cycle time 1 ms, Jitter <1 μ s**
- **The processor is responsible for the application and should not be burdened by the real-time communication excessively**
 - Main task is to handling the application program
- **The Real-Time communication must be able to be used in existing Ethernet infrastructures**
 - No influence of the existing communication
 - Use of standard network components (e.g. Switches)
 - Use of standard Ethernet controllers in devices

PROFINET Real-Time Communication

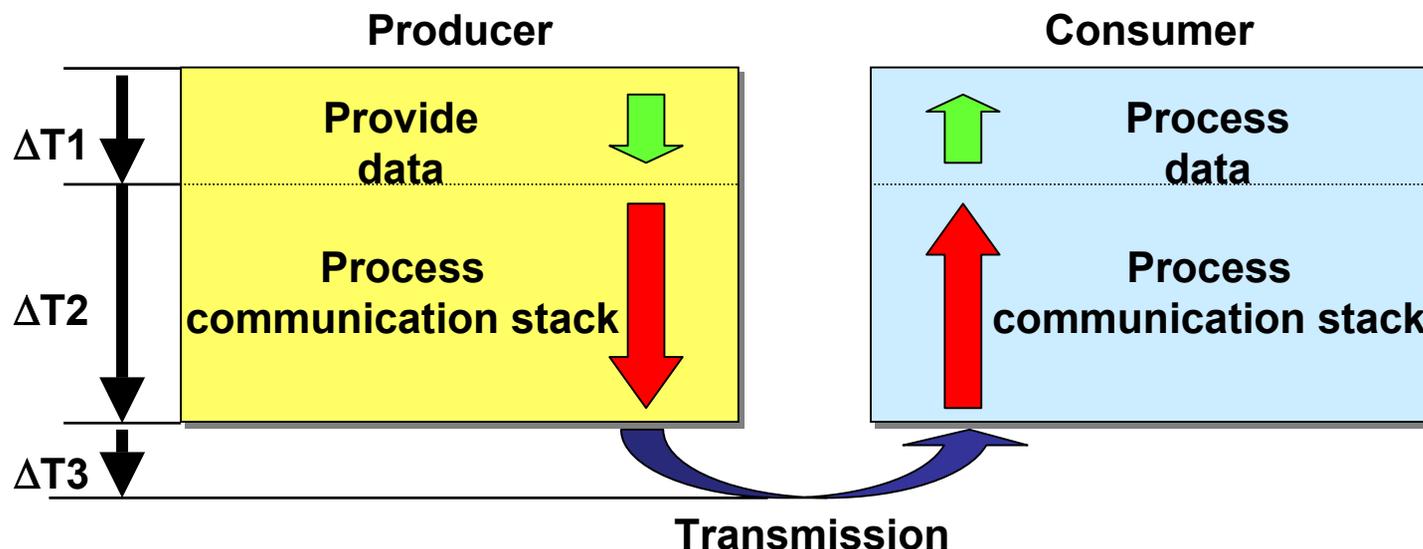
Functional Scope
Requirements
● RT-Communication
IRT-Communication
Time-Synchronisation
IRT-Schedule
Unsynch-Comm.
Synchr.-Comm.
Software-Stack
RT and CBA

- **PROFINET distinguishes between two real-time classes with differences regarding the performance:**
- **Real-Time:**
 - Using standard components
 - Performance characteristics like fieldbuses today (e.g. PROFIBUS)
 - Typical application area: Factory Automation
- **Isochronous Real-Time:**
 - Clock synchronized communication
 - Hardware support via Switch-ASIC
 - Typical application area: drive control in Motion Control applications

PROFINET Real-Time Communication

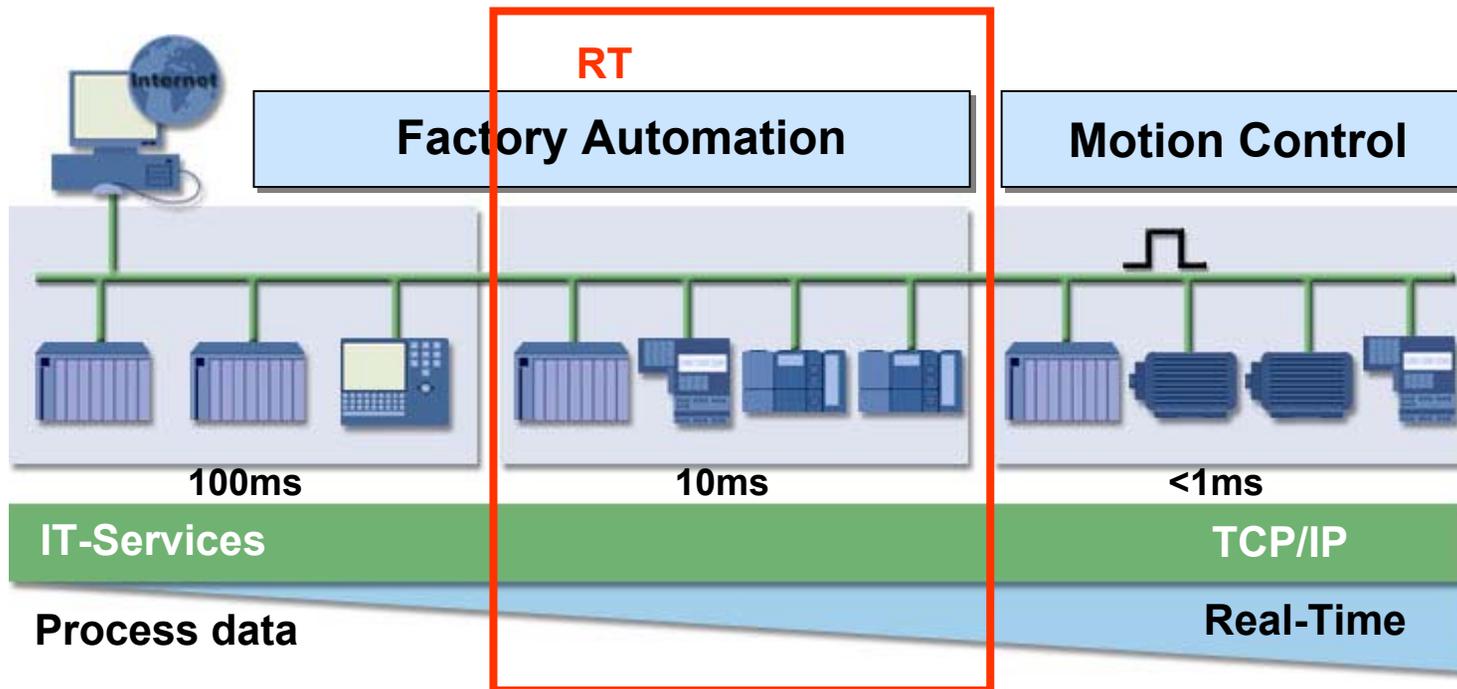
- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA

- The time needed for the provision and processing of the data is independent of communication
- Improved performance is possible only through optimization of the turnaround times in the stack
- The transmission speed on the line can be regarded as negligible (100 Mb/s)



PROFINET Real-Time Communication

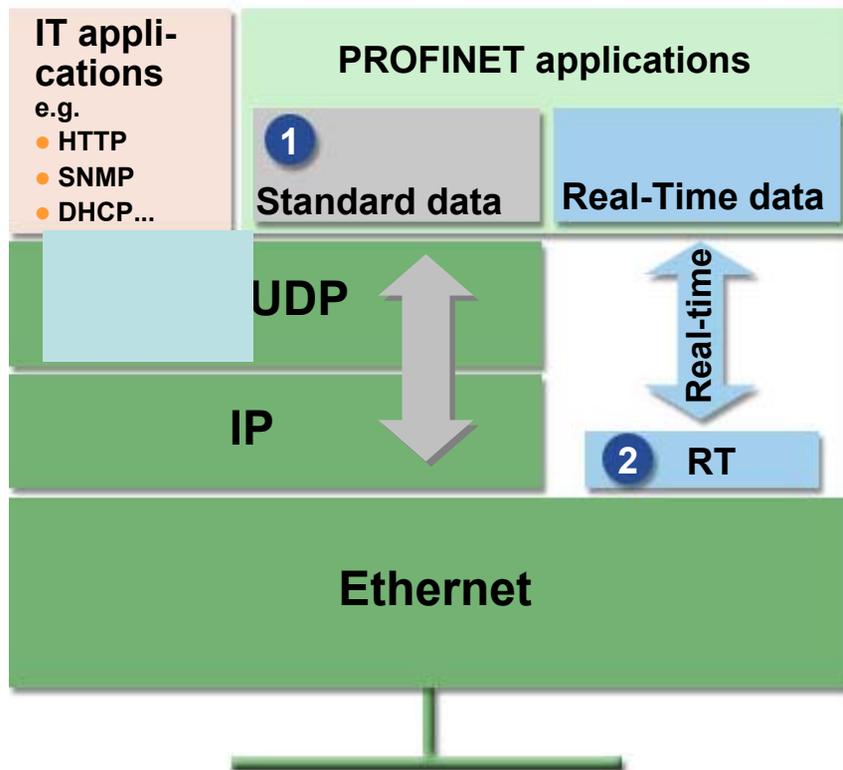
- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA



- **RT in PROFINET provides similar Real-Time properties like PROFIBUS**
- **Cycle times can be realized in the range of 5 to 10 ms**
- **PROFINET Real-Time is fully compatible to TCP/IP standard without any restriction**

PROFINET Real-Time Communication

- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA



- 1 Standard channel**
 - Device parameterization and configuration
 - Reading of diagnostics data
 - Negotiation of the communication channel for process data
- 2 Real-Time channel RT**
 - High-performance transmission of process data
 - Event-controlled signals

PROFINET Real-Time Communication

Functional Scope
Requirements
● RT-Communication
IRT-Communication
Time-Synchronisation
IRT-Schedule
Unsynch-Comm.
Synchr.-Comm.
Software-Stack
RT and CBA

- **Uniform Real-Time protocol for all applications**
 - Standardized frame format as defined in IEEE 802.3
 - Specific Ethertype for PROFINET Real-Time frames
 - 0x0800: IP frame
 - 0x8892: PROFINET Real-Time frame
 - Assignment of received data over frame-ID
 - cyclic transmission
 - a-cyclic transmission (Alarms and Events)
 - Status of device and data (e.g. run, stop, error)

PROFINET Real-Time Communication

- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA

56 Bits	8 Bits	6 Byte	6 Byte	2 byte	2 byte	2 byte	2 byte	40..1440 bytes	2 byte	1 byte	1 byte	4 byte
Preamble	SYNCH	Dest Addr	Src Addr	Tag	Tag Control	Type 8892H	Frame ID	User data	Cycle Counter	Data Status	Transfer Status	FCS
									APDU-Status			
				VLAN Tag								

VLAN Tag

see next page

Type
Frame-ID

the identification for RT-Frame is (0x8892)

see next page

Cycle Counter

will be incremented from the provider in 31,25µs-dteps.

Data Status

backup, primary, valid,invalid ...

Transfer Status

reserved

PROFINET Real-Time Communication

- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA

← Min. is 64 bytes →

			Frame			
Preamble mit SFD	Dest Addr	Src Addr	Type 8892	Frame ID	Application data	CRC
8 byte	6 byte	6 byte	2 byte	2 byte	<= 36*) ...1472	4 byte

	Tag (optional)		
Type 8100	Priority	0	VLAN-ID
2 byte	3-bit	1-bit	12-bit

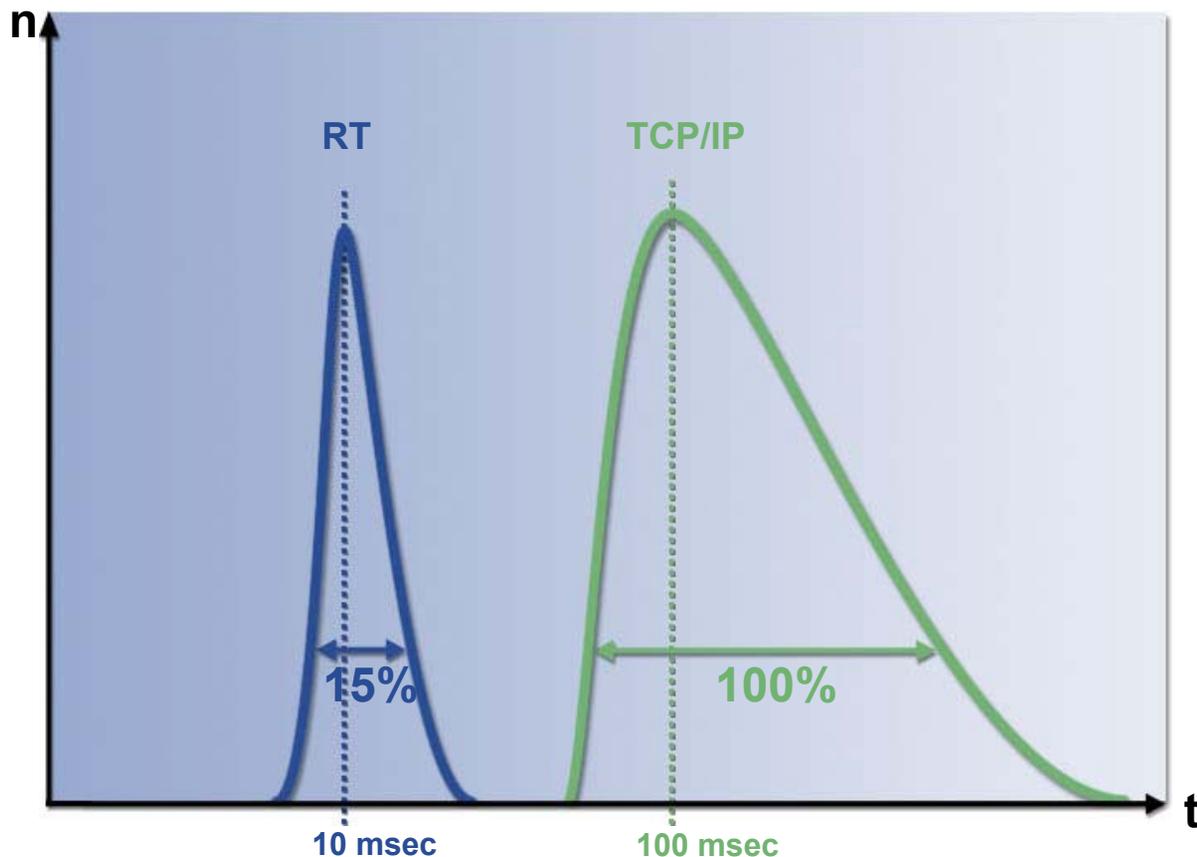
} VLAN-Tag
Acc. to 802.1 Q
(Usage is appl. specific)

*) maybe 40 byte because some switches remove the VLAN Tag

RT-Frames are always marked with a VLAN-Tag

PROFINET Real-Time Communication

- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA



• RT improvements against standard TCP/IP

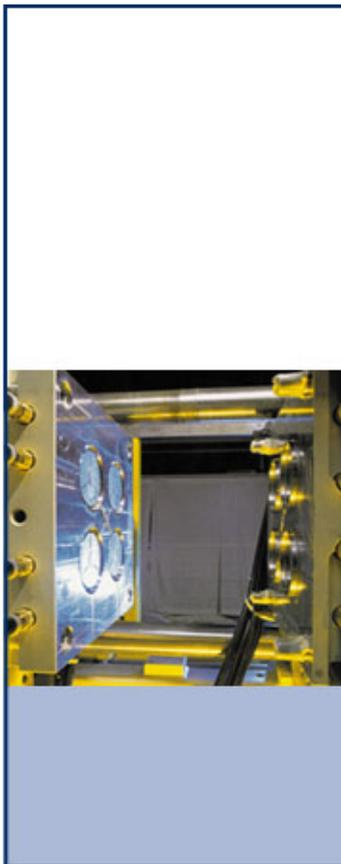
- Optimization of the absolute transmission time: factor 6-10
- Minimization of the variance of the transmission times: factor 5-8
- Improved behavior at replacement value: factor 7

PROFINET Real-Time Communication

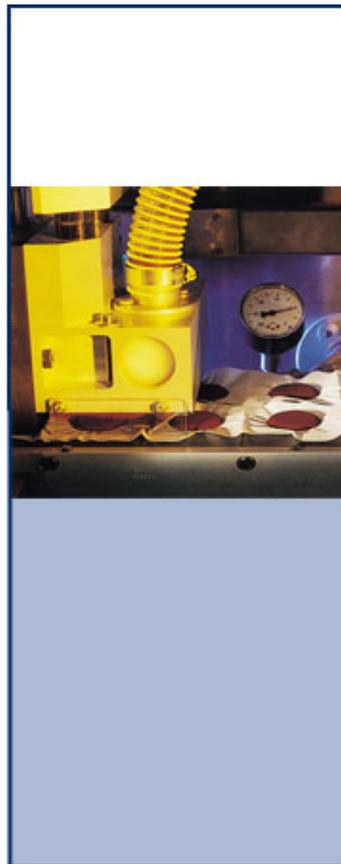
- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA



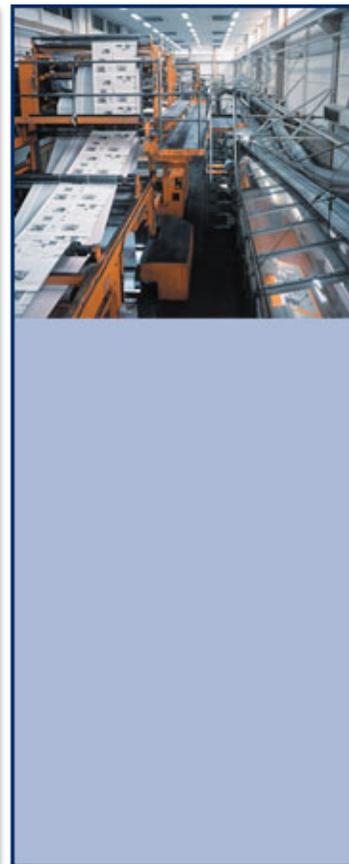
Wood-, glass- and ceramic-processing machines



Plastics injection molding machines



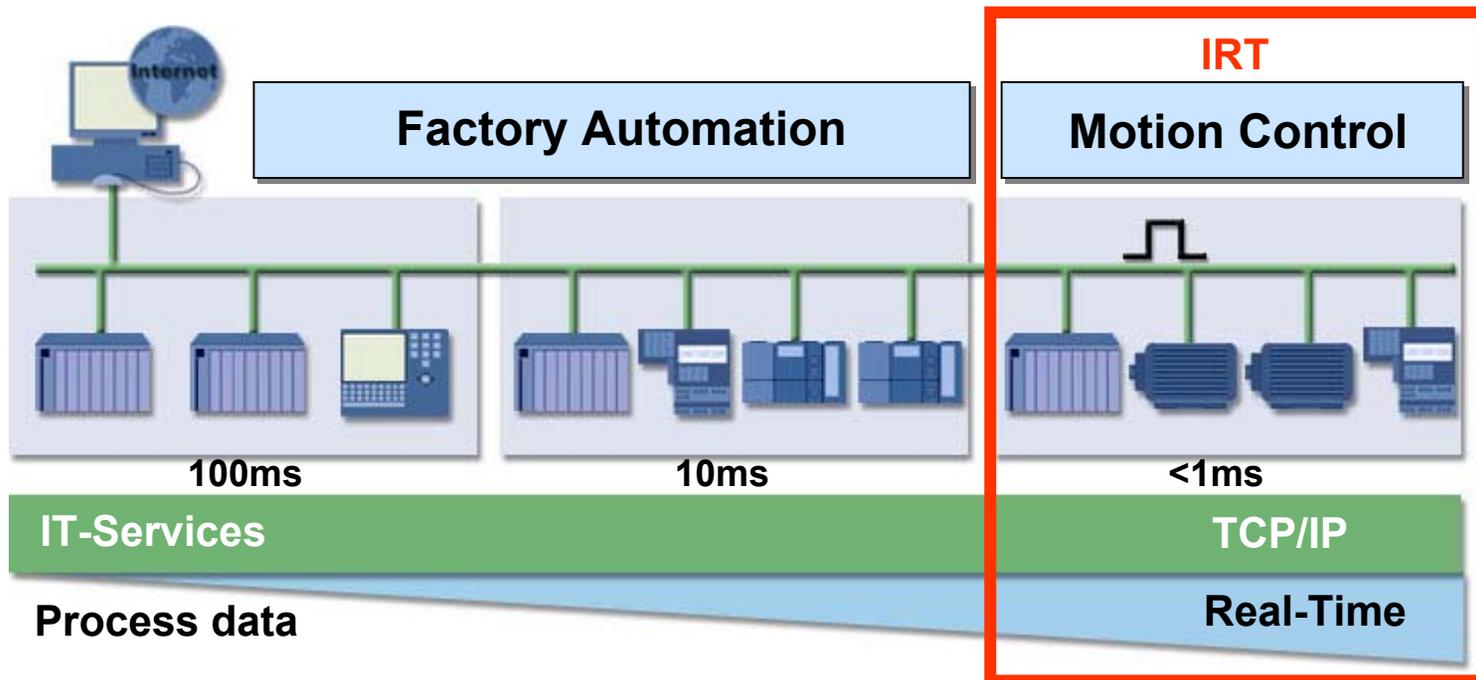
Packaging machines



Printing presses

PROFINET Real-Time Communication

- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA



• Requirements on Ethernet for Motion Control

- Highest performance
- Time synchronization inclusive determinism
- Openness for unrestricted access to the IT world, which means no restrictions for TCP/IP

PROFINET Real-Time Communication

Functional Scope
Requirements
RT-Communication
● IRT-Communication
Time-Synchronisation
IRT-Schedule
Unsynch-Comm.
Synchr.-Comm.
Software-Stack
RT and CBA

What are the pre-conditions ?

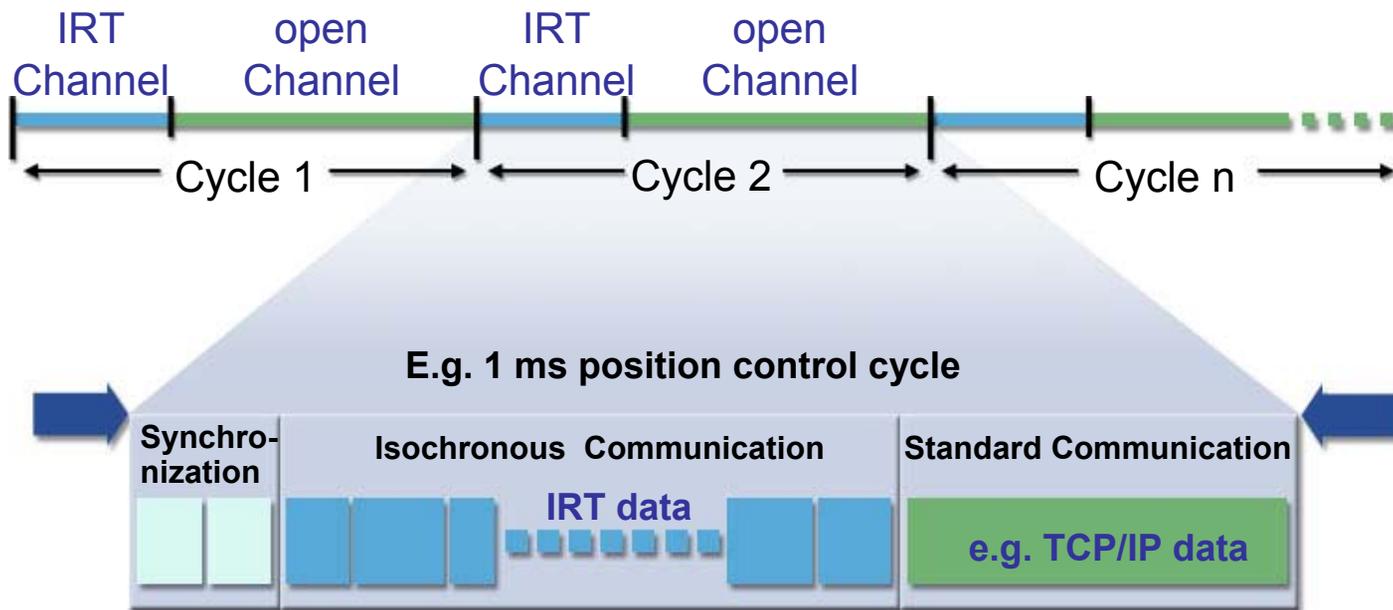
- **Segmentation of the communication**
- **Use of time based communication**
- **Clock-synchronization**

PROFINET Real-Time Communication

- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA

• Scheduling of communication systems

- High accurate cycle synchronization
- Separate time areas for real-time and TCP/UDP



PROFINET Real-Time Communication

- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA

- Synchronized communication
- Time based
- No VLAN-Tag necessary

56 Bits	8 Bits	6 Byte	6 Byte	2 byte	2 byte	36..1490 bytes	4 byte
Preamble	SYNCH	Dest Addr	Src Addr	Ether type	Frame ID	RT.-User data	FCS

Ethertype is 0x8892

PROFINET Real-Time Communication

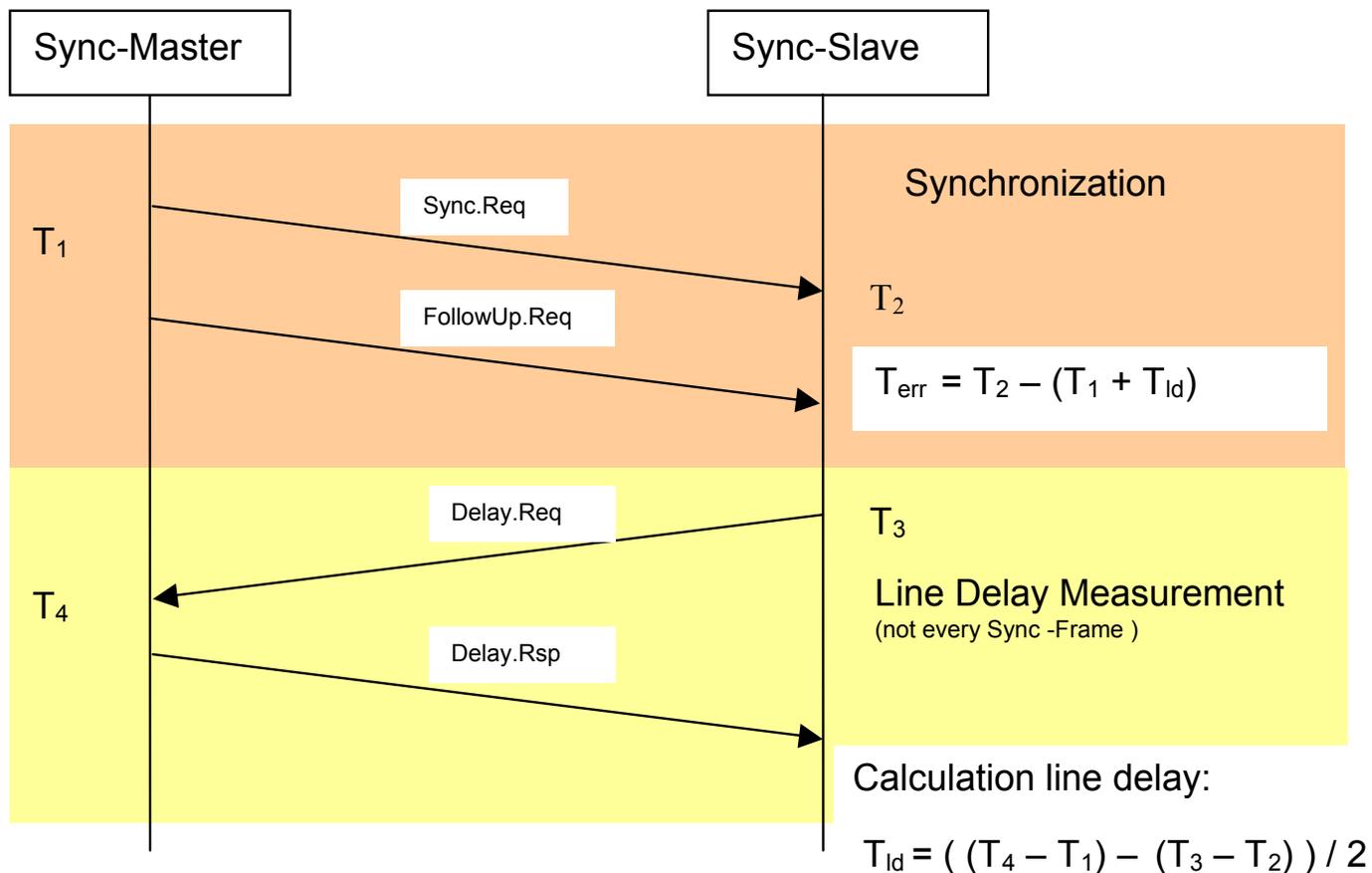
- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA

IEEE 1588 describes the clock synchronization

- PROFINET is compatible to IEEE 1588
- → but that's not always enough
- Extensions to IEEE 1588 → better accuracy
- The Precision Time Protocol has been implemented → $< 1\mu\text{s}$ Jitter
- Exact determination of the time during send and receive

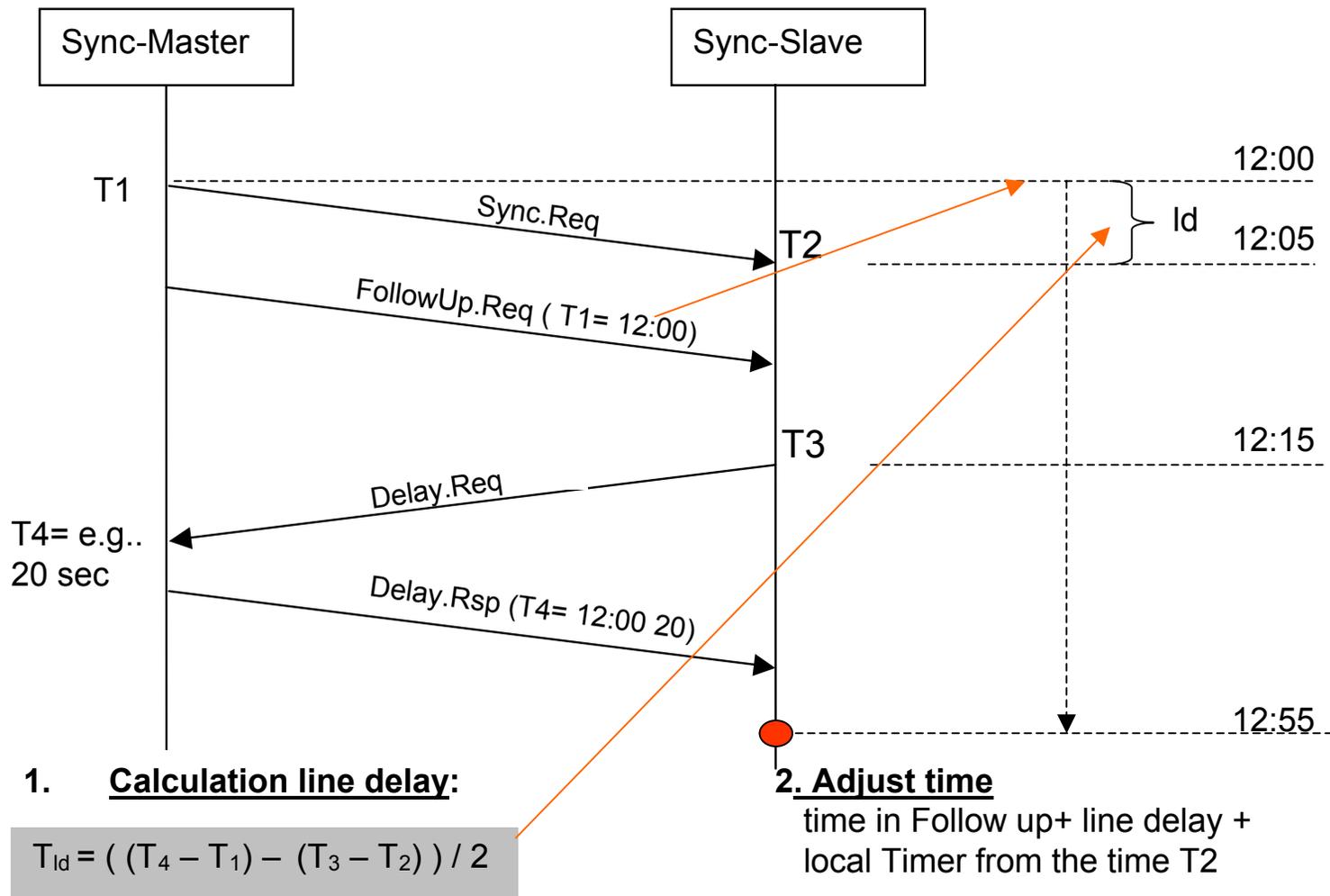
PROFINET Real-Time Communication

- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA



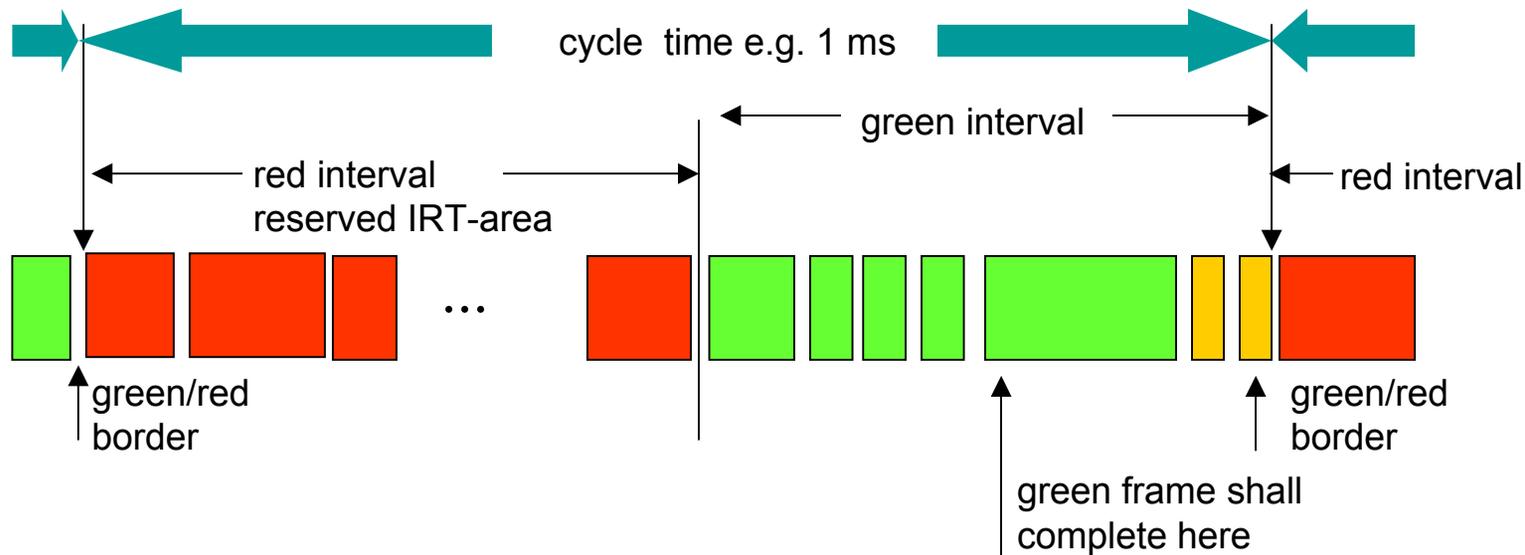
PROFINET Real-Time Communication

- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA



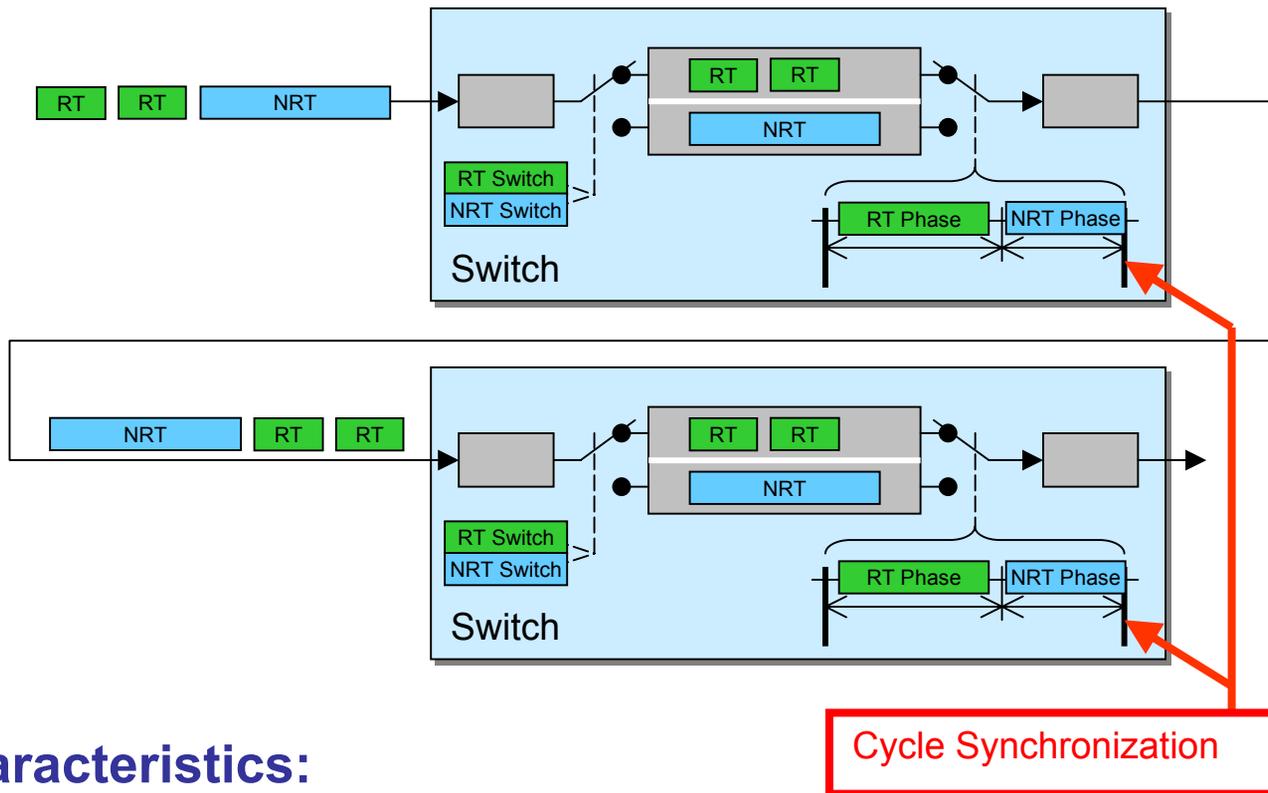
PROFINET Real-Time Communication

- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA



PROFINET Real-Time Communication

- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA

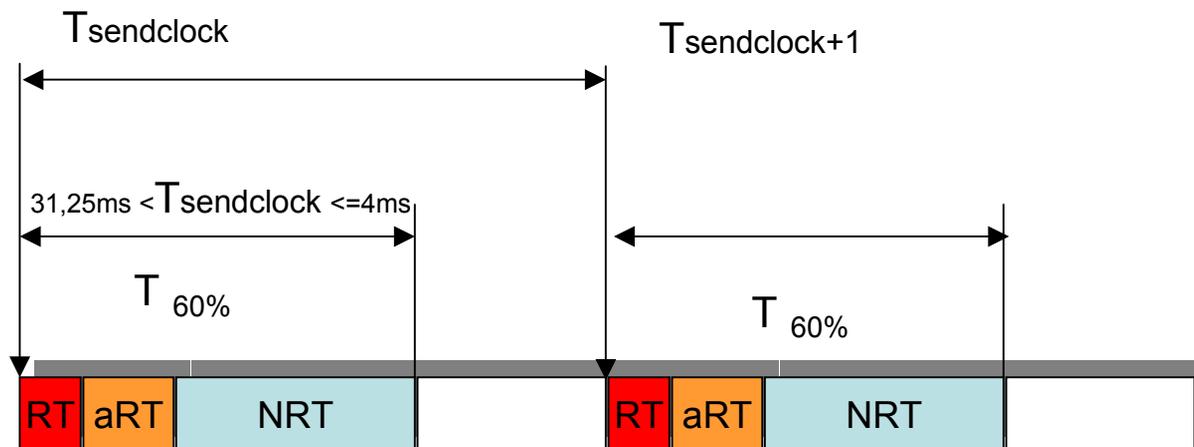


Characteristics:

- Real-Time networks can be compared with autobahns equipped with a passing lane, on which the NRT frames are passed by the RT frames.
- The cycle synchronization communicates the point of time to the switches to pass through the RT frames.
- In the Real-Time phase the RT frames have "green light".

PROFINET Real-Time Communication

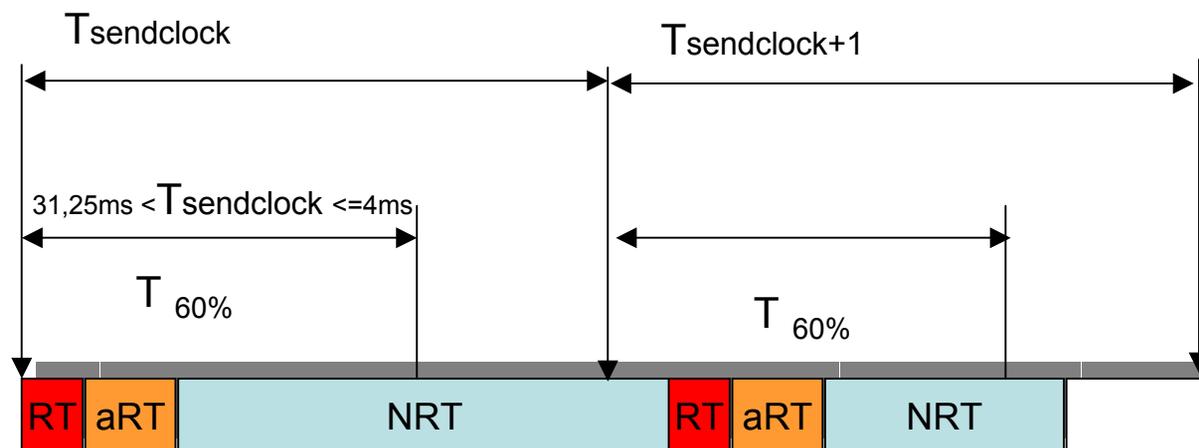
- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynchron-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA



RT = Real-Time-Communication
aRT = acyclic Real-Time-Communication (e.g. Alarms)
NRT = Non-Real-Time-Communication

PROFINET Real-Time Communication

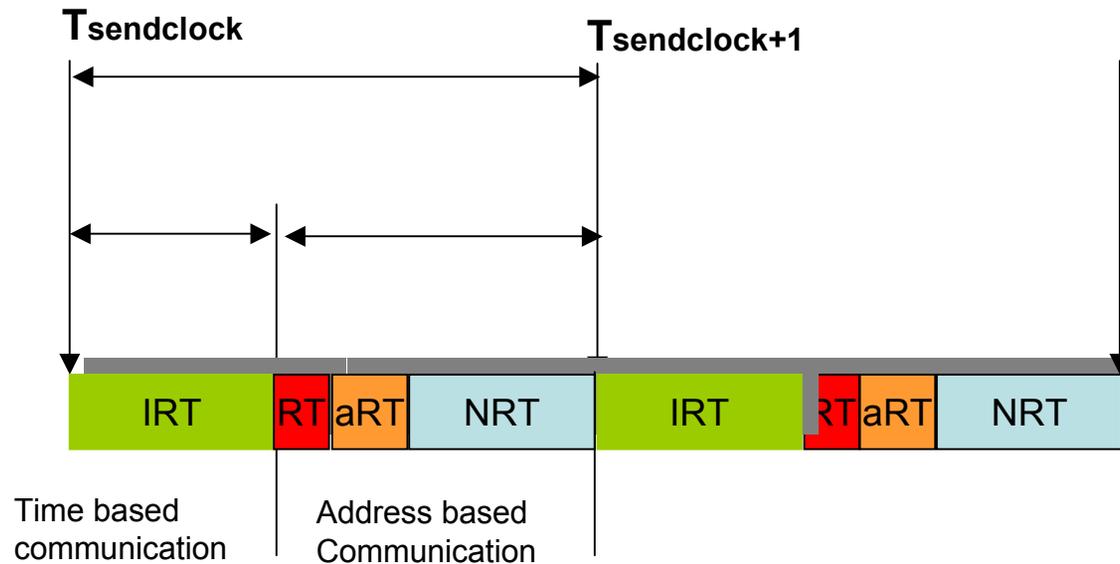
- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynchron-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA



RT = Real-Time-Communication
aRT = acyclic Real-Time-Communication (e.g. Alarms)
NRT = Non-Real-Time-Communication

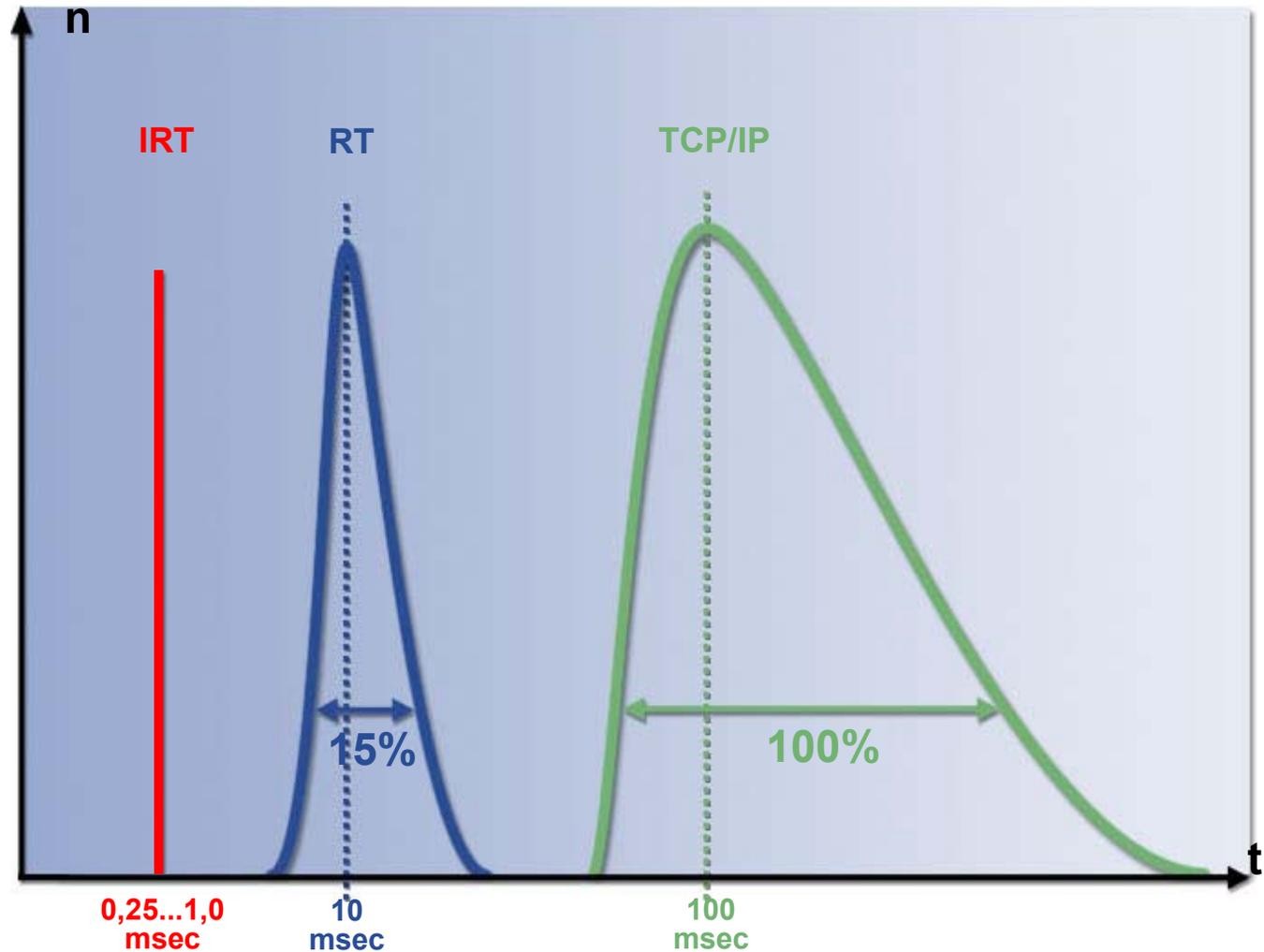
PROFINET Real-Time Communication

- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.**
- Software-Stack
- RT and CBA



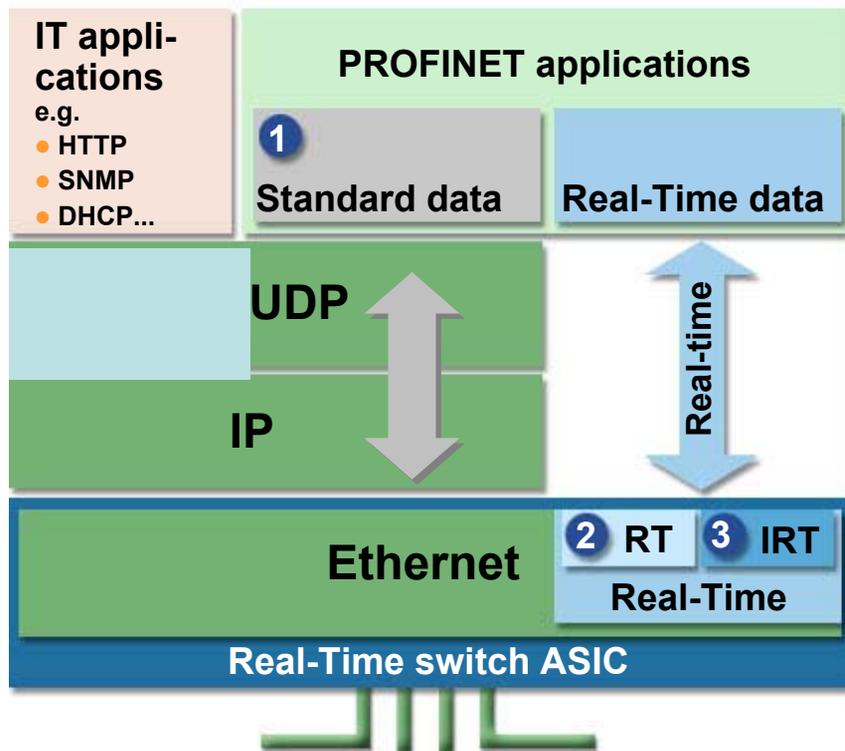
PROFINET Real-Time Communication

- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA



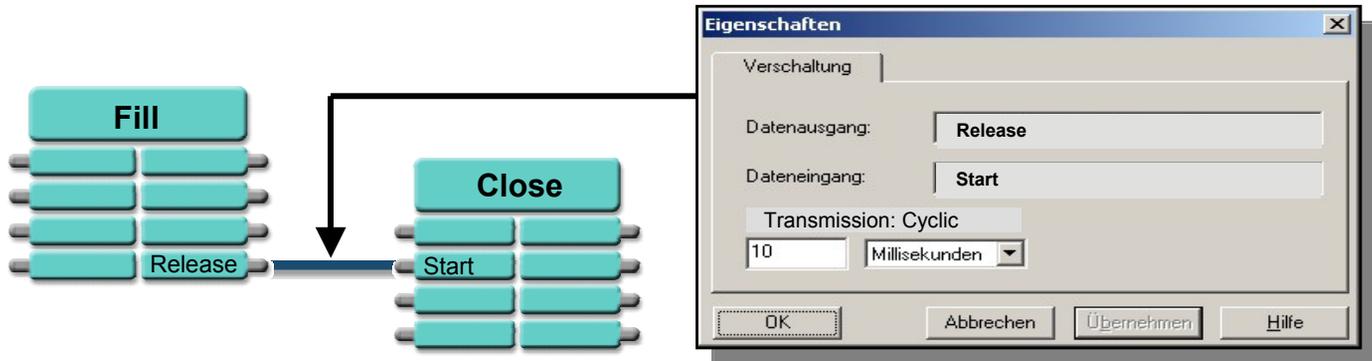
PROFINET Real-Time Communication

- Functional Scope
- Requirements
- RT-Communication
- IRT-Communication
- Time-Synchronisation
- IRT-Schedule
- Unsynch-Comm.
- Synchr.-Comm.
- Software-Stack
- RT and CBA



- 1 Standard channel**
 - Device parameterization and configuration
 - Reading of diagnostics data
 - Negotiation of the communication channel for user data
- 2 Real-Time channel RT**
 - Performant cyclic transfer of process data
 - Event-controlled signals/alarms
- 3 Real-Time channel IRT**
 - Isochronous transmission of process data
 - Jitter <math>< 1\mu\text{sec}</math>

- The user chooses the QoS „Real-Time Data Transmission“ in the configuration tool



- The Communication relationships between the devices is established over TCP/IP
- Subsequently, process data are transmitted cyclically between devices via the Real-Time channel

