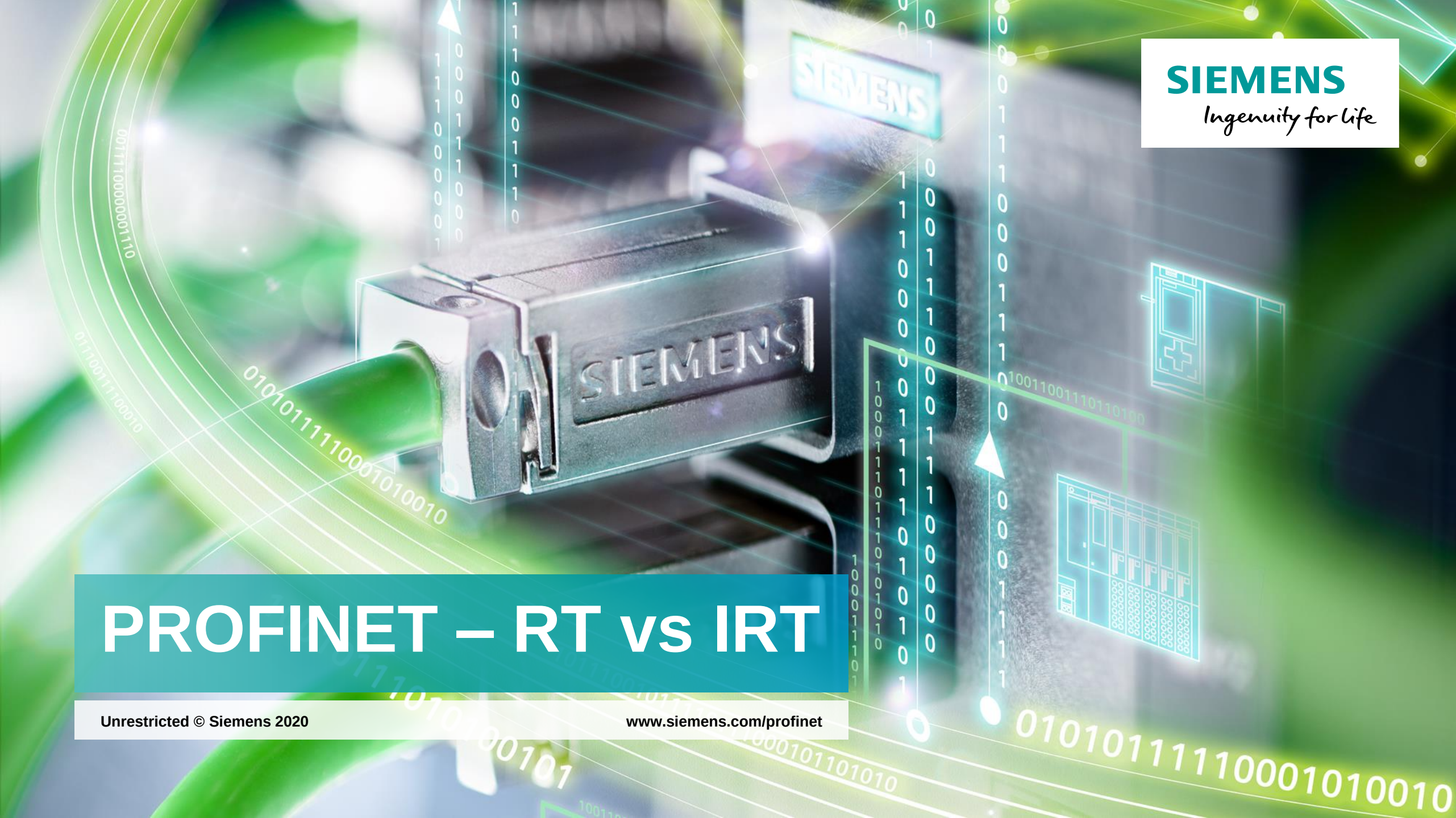


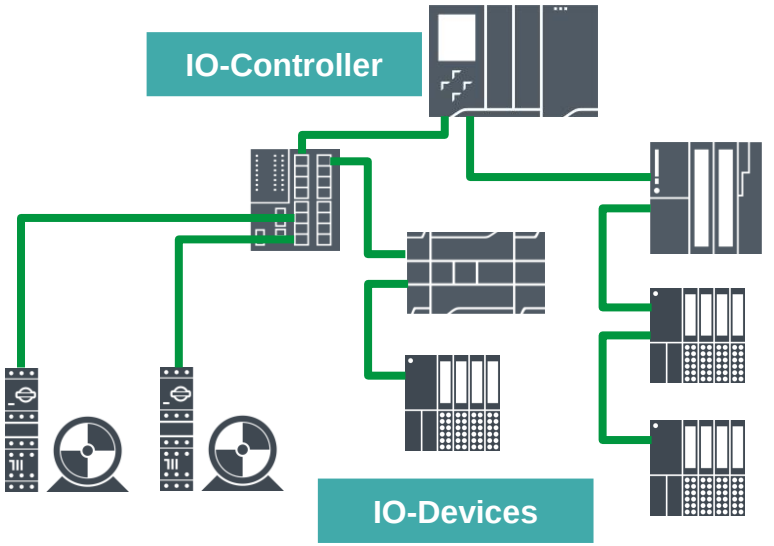
PROFINET – RT vs IRT

www.siemens.com/profinet

Communication Basics

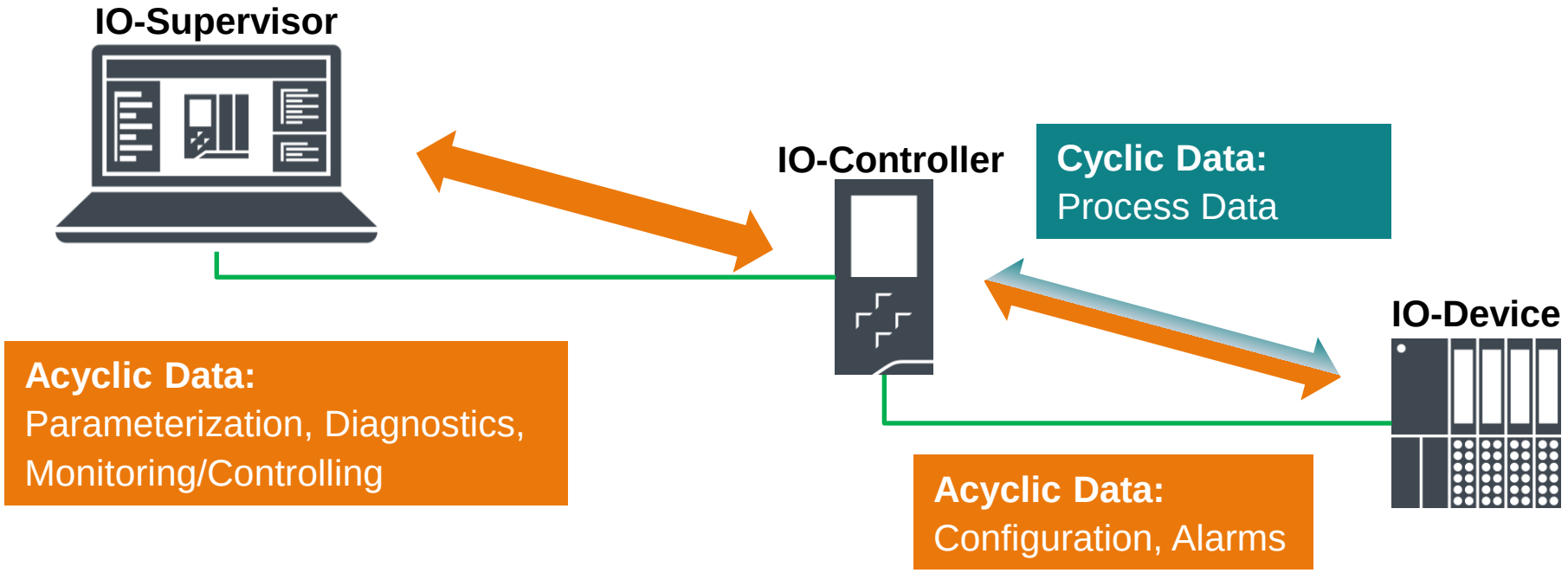
Ethernet + Profinet = Industrial Ethernet

- **Profinet is complimentary to Ethernet**
- **Profinet is “Industrial Ethernet”**
- **Profinet devices include IO-controllers and IO-Devices**
- **Profinet is “Fast Ethernet” ie 100Mbit/s Full Duplex**
- **Profinet devices, connectors and cable are suited to industrial applications**



Communication Basics
Transmission methods

- PROFINET follows a “Consumer-Provider” Model
- **Cyclic**, deterministic data transfer for time-critical applications
- Prioritization of time-critical data
- **Acyclic** data transmission for configuration, monitoring and diagnostics/alarming



Communication Basics
Profinet communication channels

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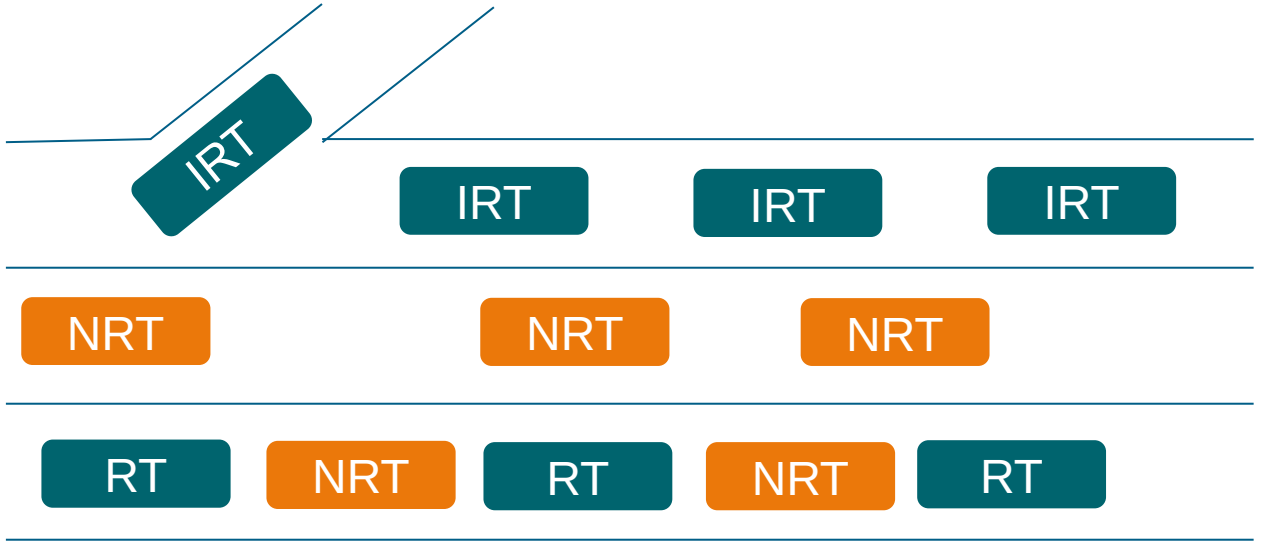
Ingenuity for life

None Real Time (NRT) <100ms cycle

- **Acyclic**
- **Uses TCP/IP**
- **Left lane**

Real Time (RT) <10ms cycle

- **Cyclic**
- **Skips the TCP/IP layers**
- **Over taking lane**



Isochronous Real Time (IRT) <1ms cycle

- **Cyclic**
- **Reserved Bus lane**

Communication Basics
Controller selection

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RT

- **~80% applications require RT only**
- **In this case any controller is suitable**

IRT

- **The remaining applications will require high speed capabilities**
  - **Synchronised Motion**
  - **Precision Measuring**
  - **Precision IO**

- **Ethernet switches can be used but selection guidelines must be followed**
  - **ie IRT = Conformance Class C**

Function		IO-Controller		
Controller		NRT	RT	IRT
	S7-1500	✓	✓	✓
	S7-1200	✓	✓	✗
	S7-300 / S7-400	✓	✓	✓
	Open Controller	✓	✓	✓

Communication Basics
OSI 7 layer model

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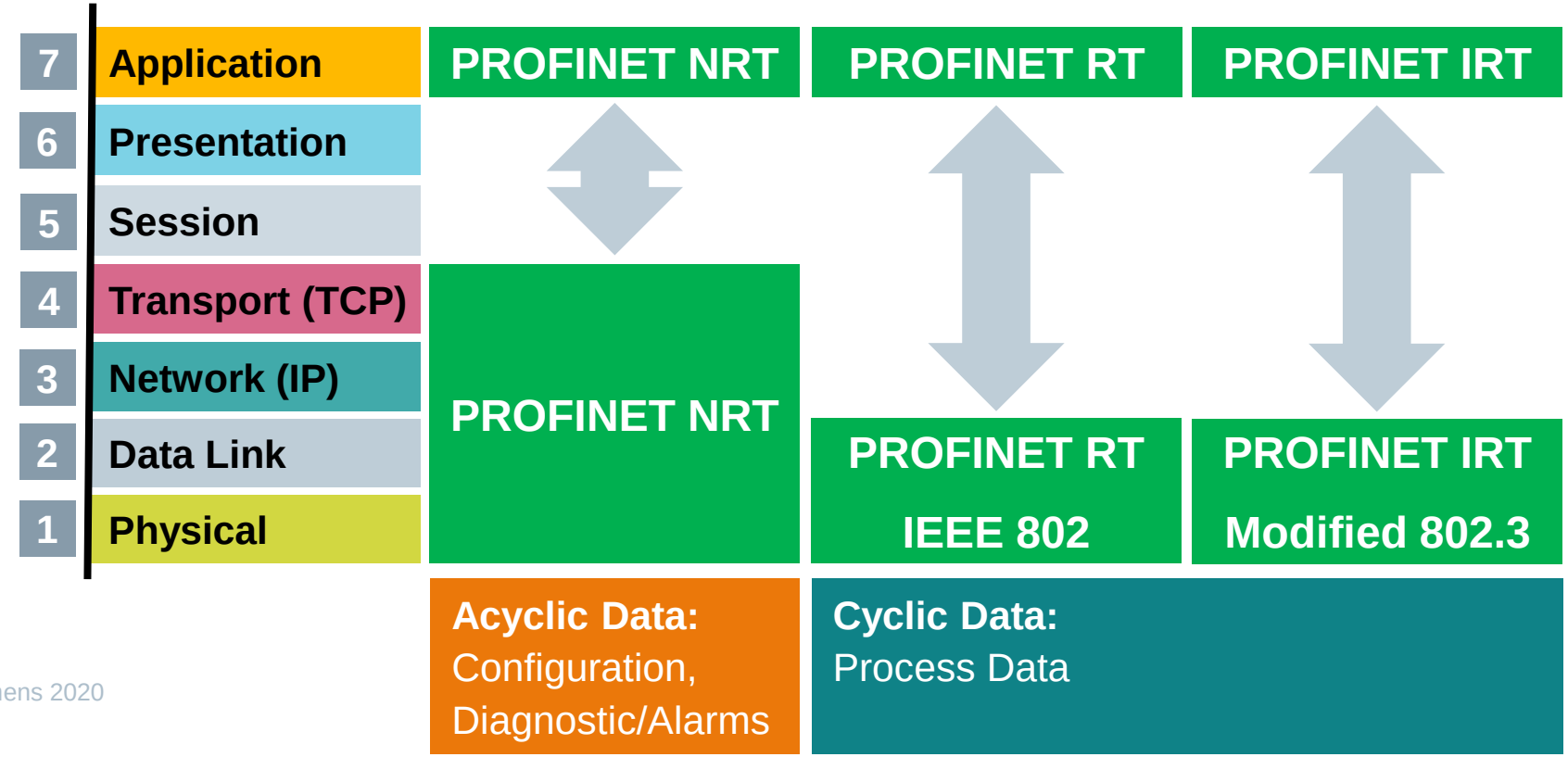
- **Each layer adds processing time**
- **NRT is used for configuration, web server, diagnostics and other none real time tasks**
- **RT is typically used for standard cyclic data acquisition**
- **IRT is used for high speed data transfer**



Communication Basics
OSI 7 layer model – closer look

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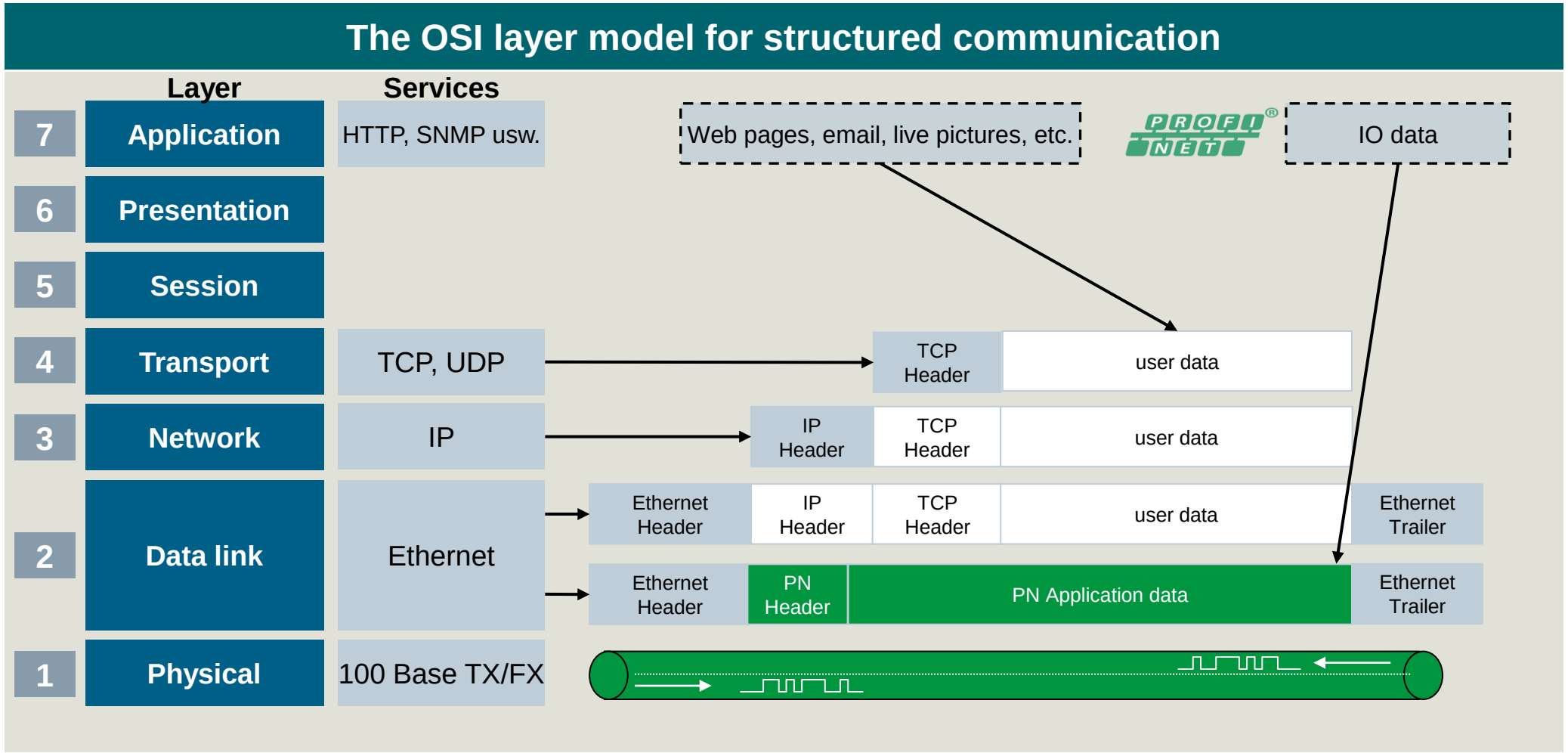
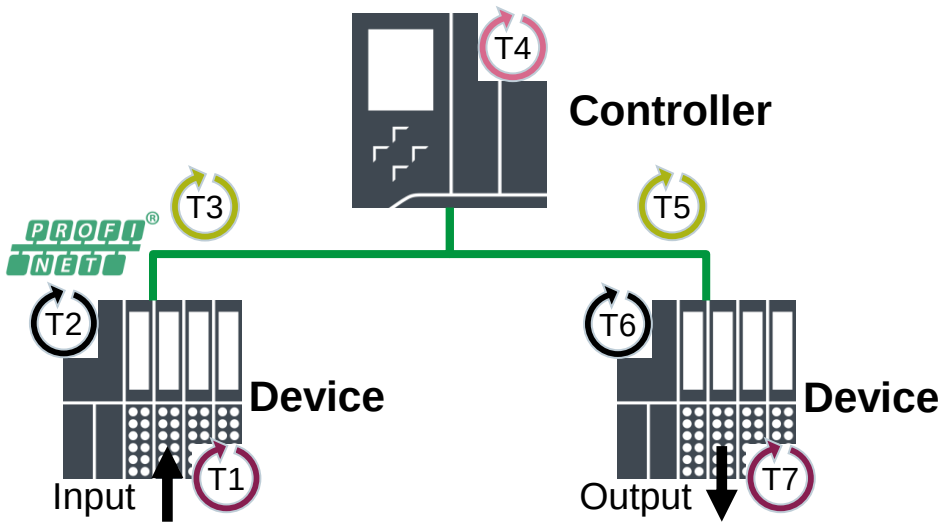
Ingenuity for life



Profinet RT
No synchronization of cycles



Various uncoordinated cycles

- T1: sampling of input
- T2: backplane bus ET 200
- T3: Profinet I/O
- T4: CPU cycle (OB1)
- T5: Profinet I/O
- T6: backplane bus ET 200
- T7: setting output

RT – Real Time:

- **Real-time communication** between controller and device
- Each device has its **own update time**
- Processing in the standard user program (e.g. **OB1**)

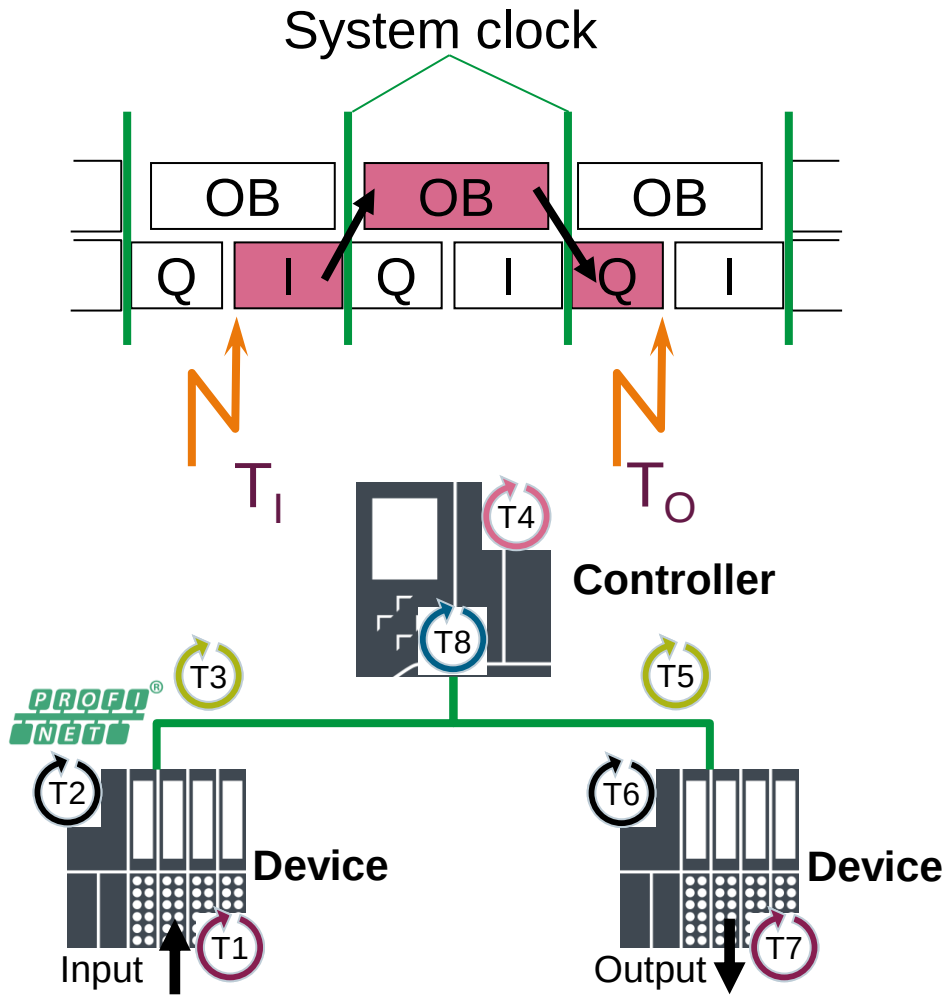
Reaction time (input-output)

- Best case: sum of all individual cycles
- Worst case: 2 x (sum of all individual cycles)

Time precision of output signal (OB1-output)

2 x sum of all cycles from CPU to output (T4 - T7)

Profinet IRT
Isochronous mode for fast reaction time



T_I: Read in ALL inputs of ALL devices at a fixed predefined time

OB: processing in the CPU

T_O: Writes ALL outputs of all devices at a fixed predefined time

IRT – Isochronous Real Time:

- All **cycles** are **synchronized** with each other
- **Special hardware** is needed ie HF modules
- IRT packets are transmitted in a **reserved bandwidth**
- **Isochronous mode: Synchronized processing** in the user program using "synchronous cycle" OB6x (T8)

Profinet IRT
Additional capabilities

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Cycle time

Typical 500 µs cycle

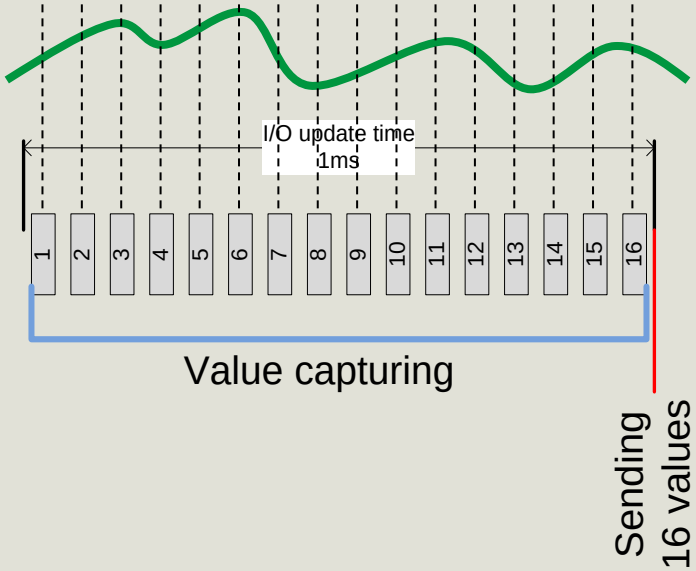
CPU1518 V2.0: **125 µs**

By optimized packing of data the transmission time gets reduced:

- Less time on LAN
- More time of the cycle for Sync-OB
- More time for Non-IRT on LAN

Oversampling

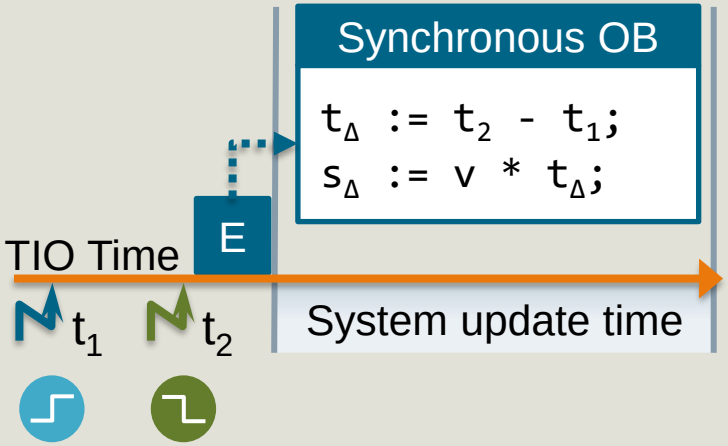
Peripheral module separates PN cycle into smaller sampling cycle. All samples are sent to the PLC.



Time based IO

Rising and falling edge of signal are transmitted with timestamp
→ high precision signal capturing

Outputs triggered with timestamp
→ high precision reaction



Profinet RT/IRT
Functional Overview

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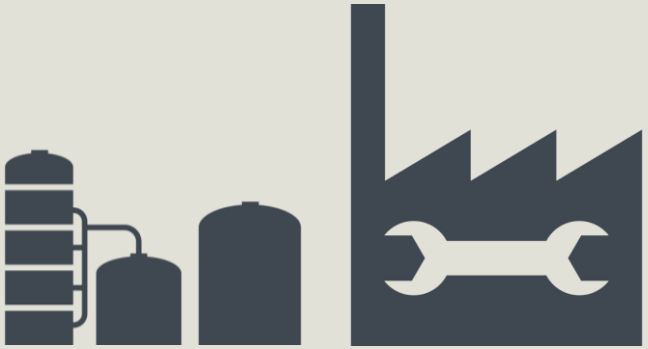
RT	IRT	Isochronous

• Real-time communication
• Update time >=250µs
• Applications:
  • manufacturing engineering
  • building automation
  • automation equipment
	• Real-time communication with reserved bandwidth and synchronized cycles
	• Update time >=125µs
	• Special hardware
	• Requirement for isochronous mode
	• Applications:
	  • Motion control
	  • Precise reactions
		• Real-time communication with synchronized OB61
		• Synchronization of the user program to all other synchronized cycles
		• Requirement for further functions
		e.g. Oversampling and time-based IO
		• Applications:
		  • Motion control
		  • Precise reactions
		  • measuring technology

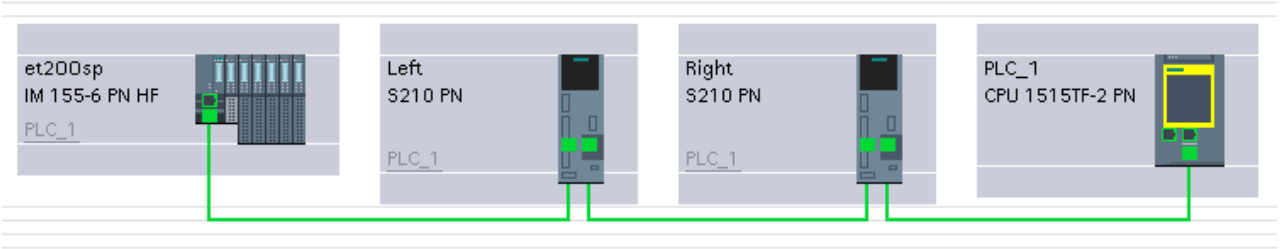


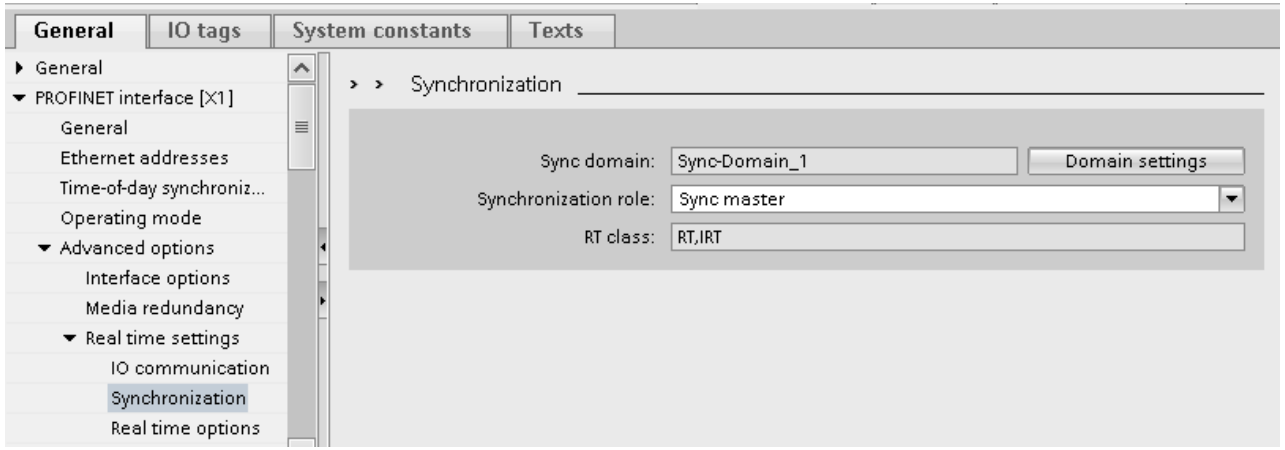
Profinet IRT
Key requirements

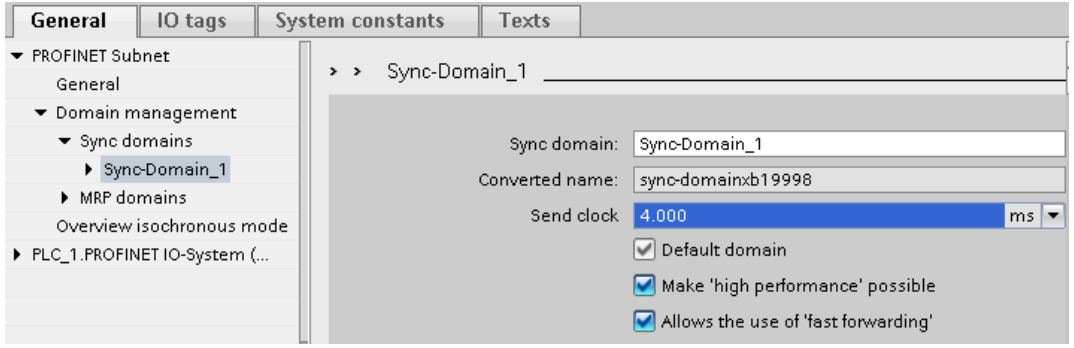
- **Define Topology in TIA ‘Topology view’**
  - **Ensures optimised data transfer**
  - **Allows scheduled transfers**

- **Configure interface real time settings and set synchronization role**

- **Ensure correct settings for the sync domain**
  - **Optional High performance**
  - **Optional Fast forwarding**







Profinet IRT
Key requirements

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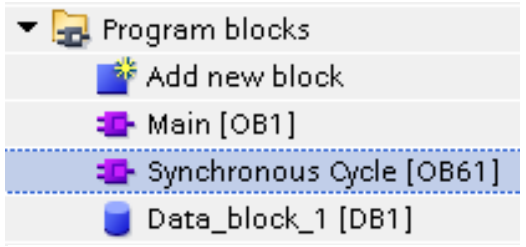
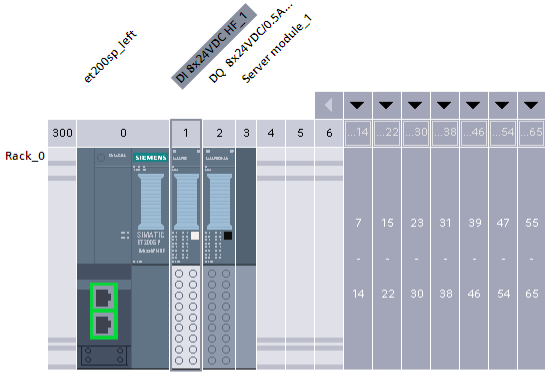
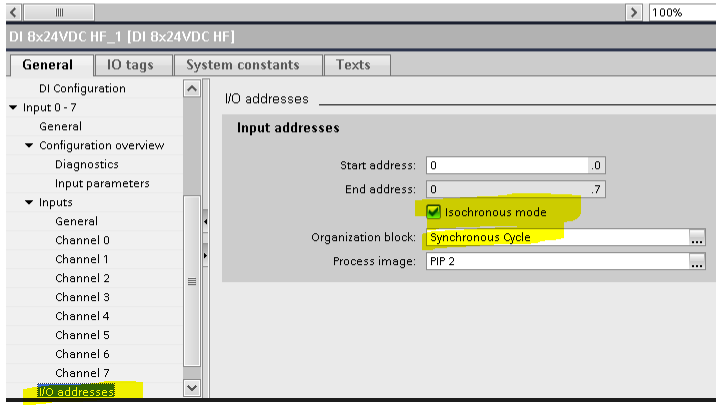
Insert Synchronous OB6x or Motion OB



Enable Isochronous mode on each IO Device

- **Will ensure IO is sync'd with Motion or OB6x**





Profinet IRT
IRT in reality (oscilloscope)

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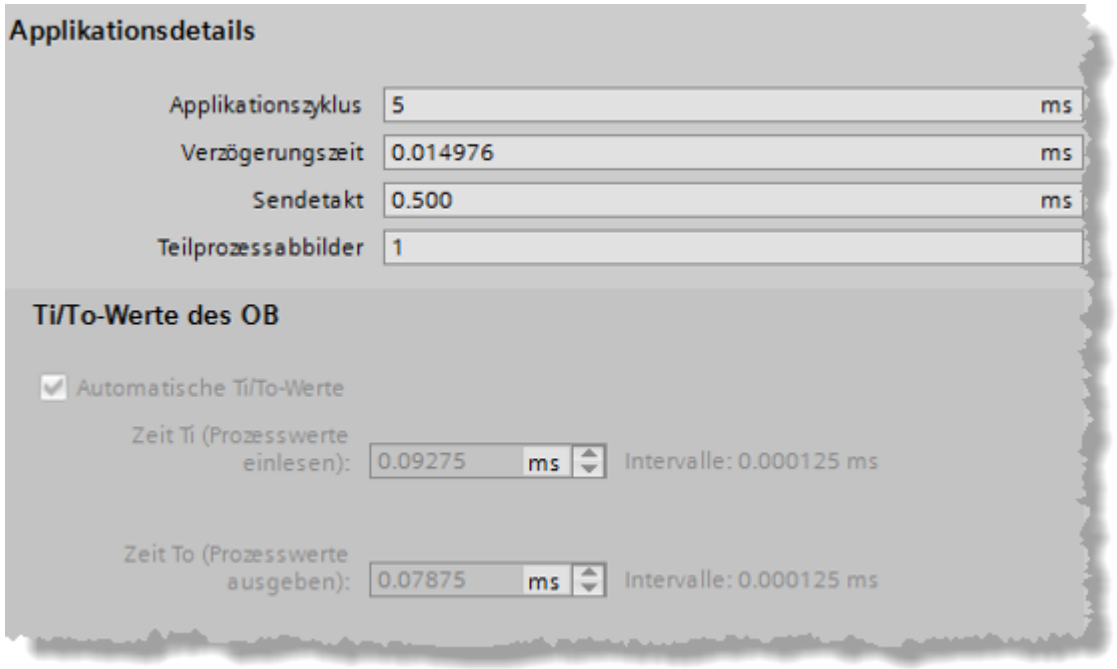

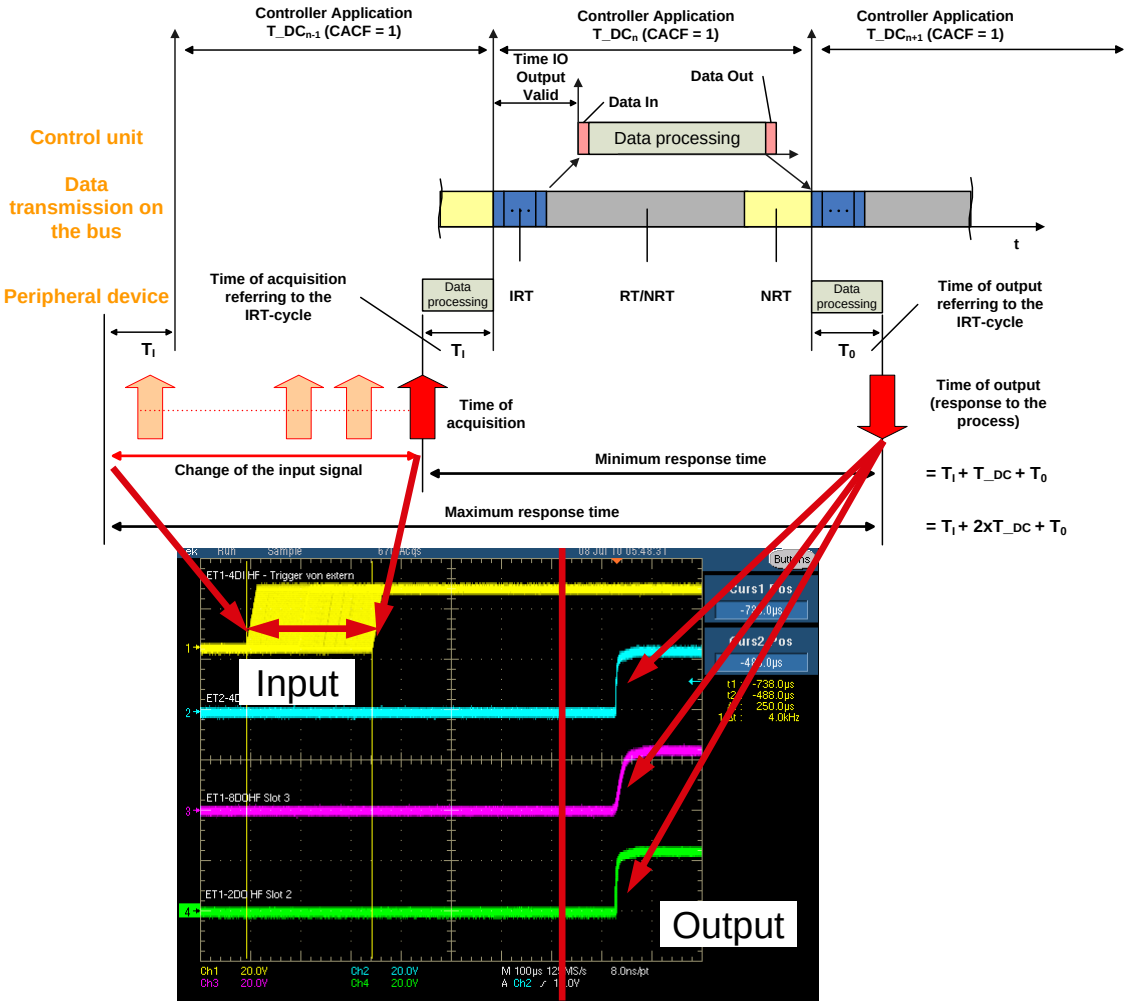

IRT on the oscilloscope vs. TIA Portal

- TIA / Step7 calculates timing beforehand
- Reaction time predefined
- Live result as expected

Profinet IRT
Time slice model

SIEMENS
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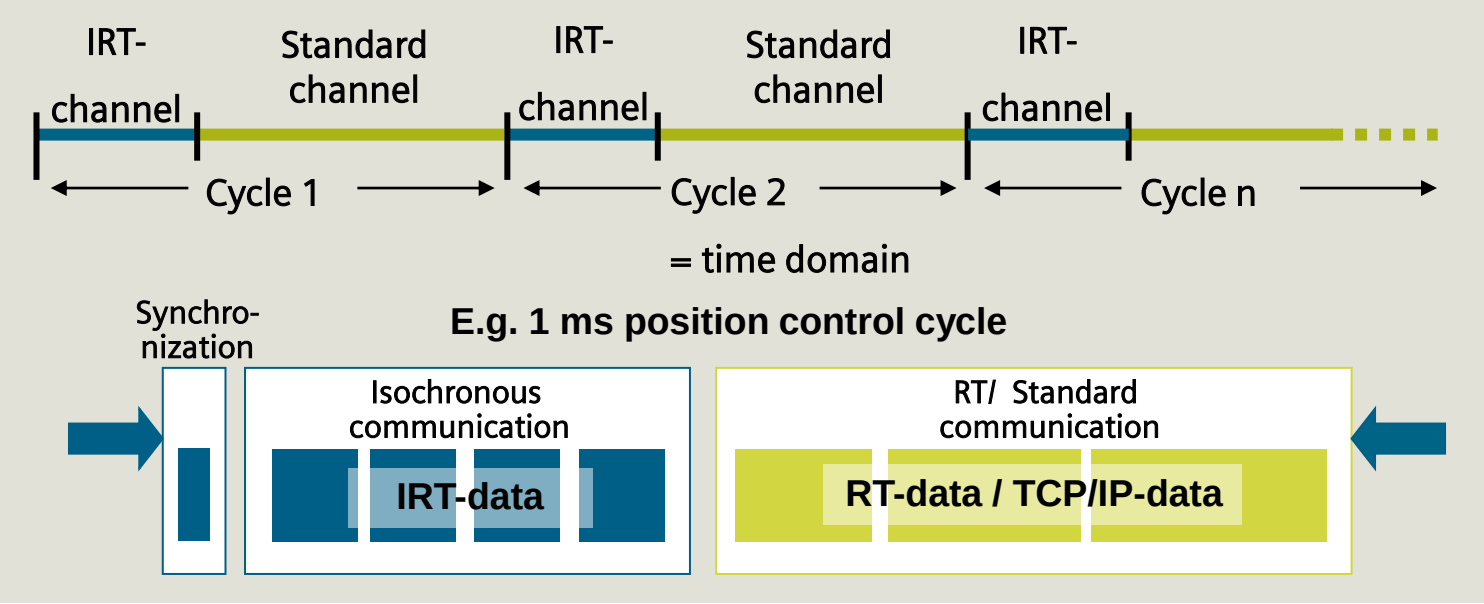
Partitioning of the bus cycle

- Separate time slices (time domains) for IRT and rest (RT, TCP/UDP,..)
- High precision cycle synchronization
- Based on optimized switch ASIC → special hardware needed



Profinet IRT
Time slice model in detail

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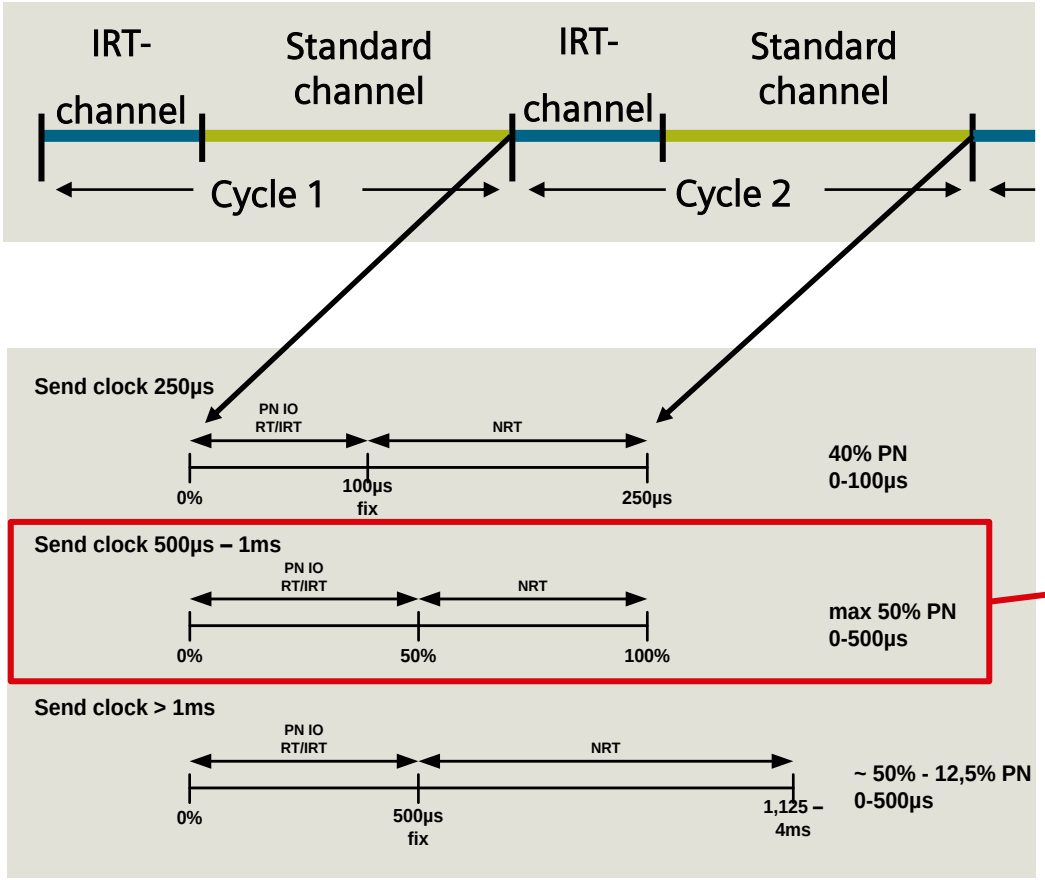
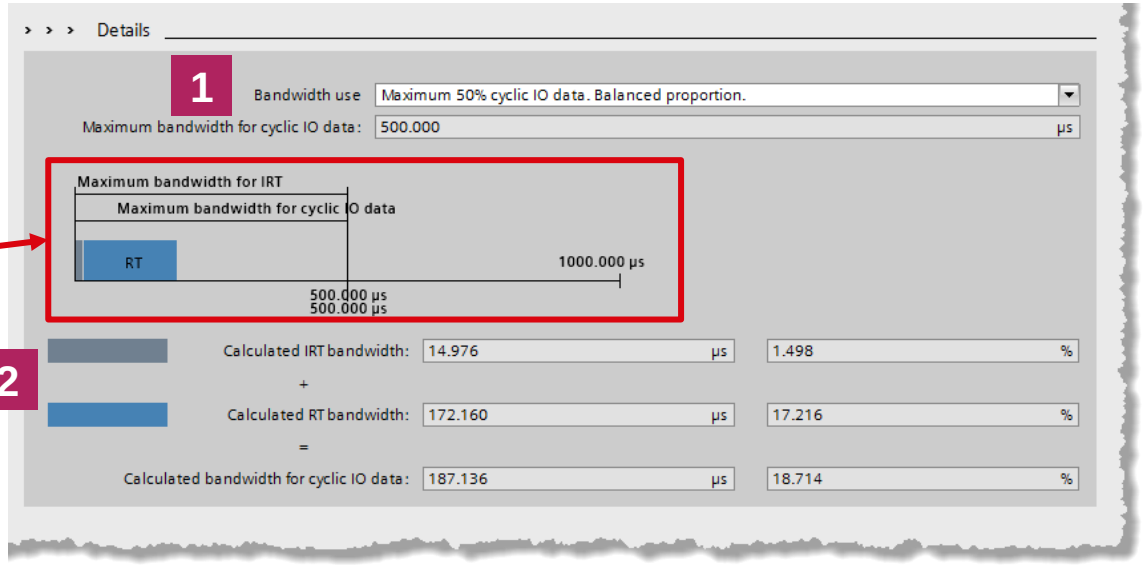
Fixed bandwidth for IRT in theory:



Overview in TIA Portal:

1 Reserved bandwidth can be set in TIA Portal

2 Used bandwidth is displayed separately for IRT and RT



Profinet IRT
Fast forwarding

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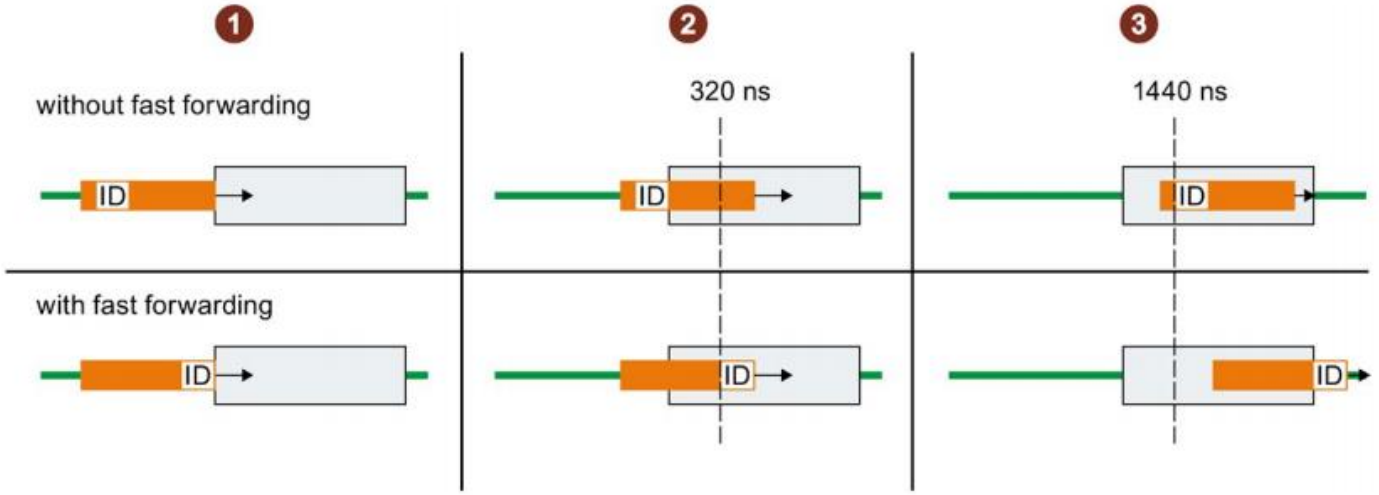
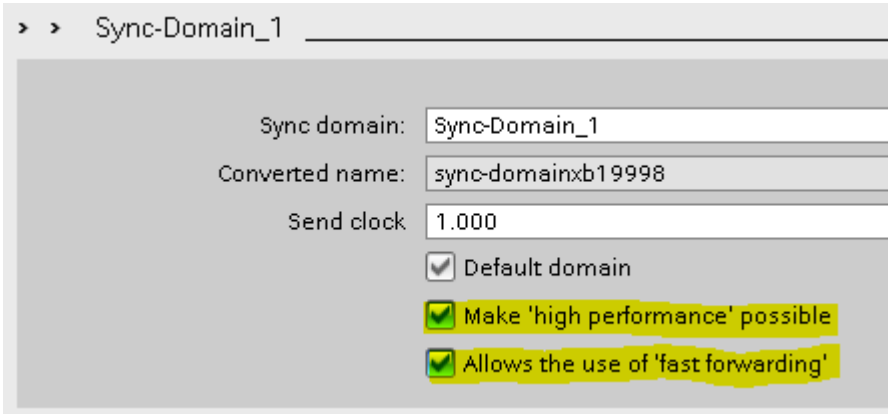
- **To forward frames, a device needs to see the frame ID**
- **This typically takes 1440ns**
- **Using performance mode, this is improved to 320ns**
- **Frame ID leads the Profinet frame**





Profinet IRT
Dynamic Frame Packing

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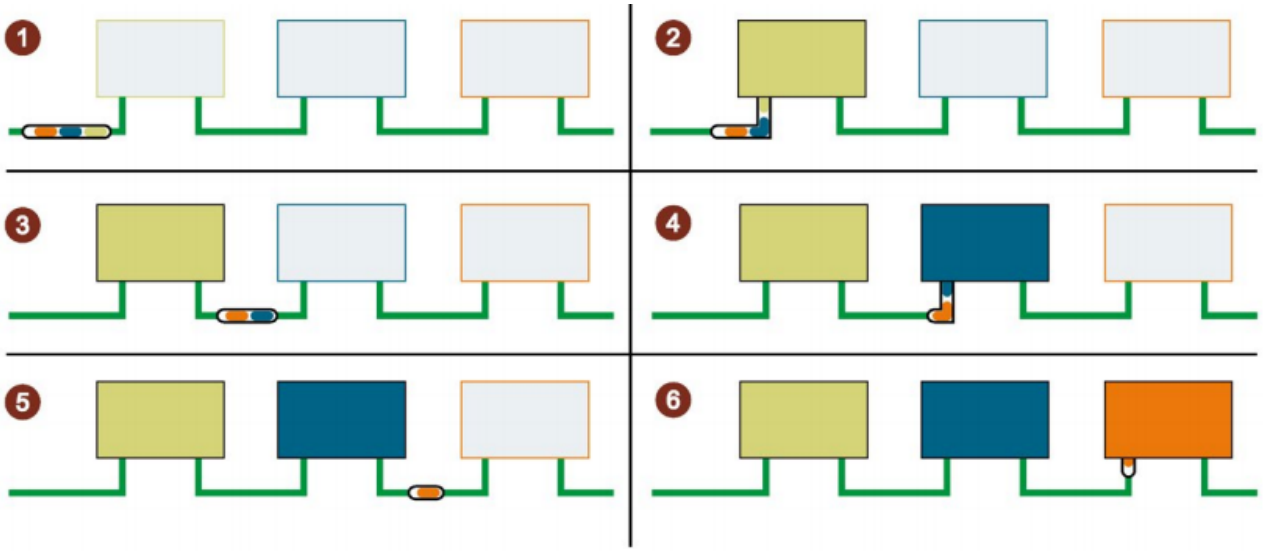
- **Each DFP frame includes a specific device data along with other devices on the line**
- **Each device takes its data and forwards on**
- **This leads to an overall improvement in network bandwidth**



① The PROFINET IO frame contains the user data for all 3 IO devices (green, blue and orange).
② The PROFINET IO frame reaches the first IO device. The IO device takes its user data (green) from the frame and forwards the remaining frame.
③ The PROFINET IO frame contains the user data for two IO devices (blue and orange).
④ The PROFINET IO frame reaches the second IO device. The IO device takes its user data (blue) from the frame and forwards the remaining frame.
⑤ The PROFINET IO frame contains the user data for one IO device (orange).
⑥ The PROFINET IO frame reaches the last IO device. The IO device saves the entire frame including user data (orange).

Profinet IRT
Fragmentation

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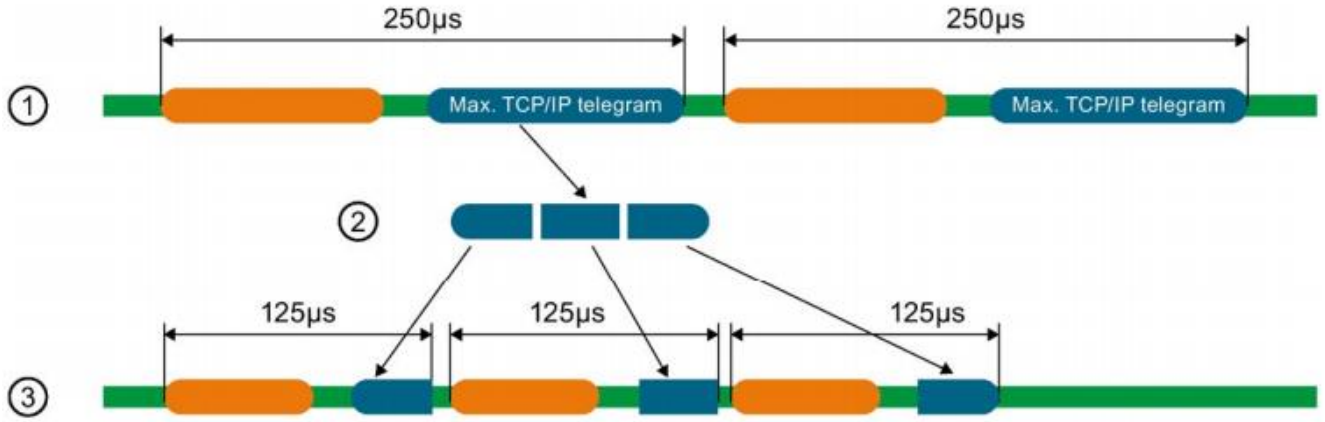
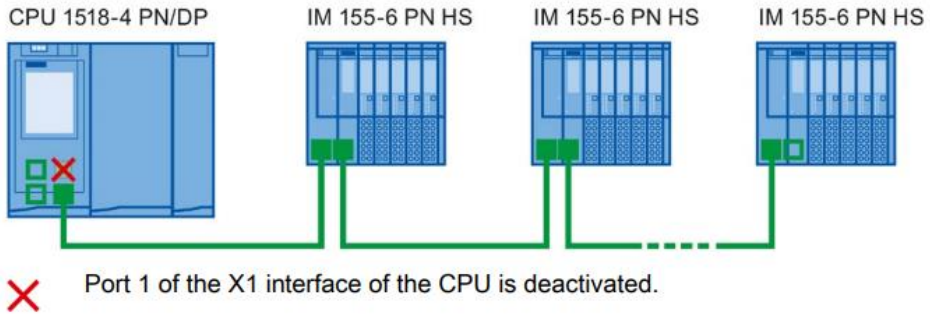
- **A complete standard Ethernet TCP/IP frame takes 125uS so cycle time cannot be reduced**
- **Performance mode allows fragmentation of these frames into sub frames**
- **Cycles times <250us are achievable**
- **Fragmented frames reassembled at the target device**
- **Fragmentation requires one port to be blocked on the IO controller**



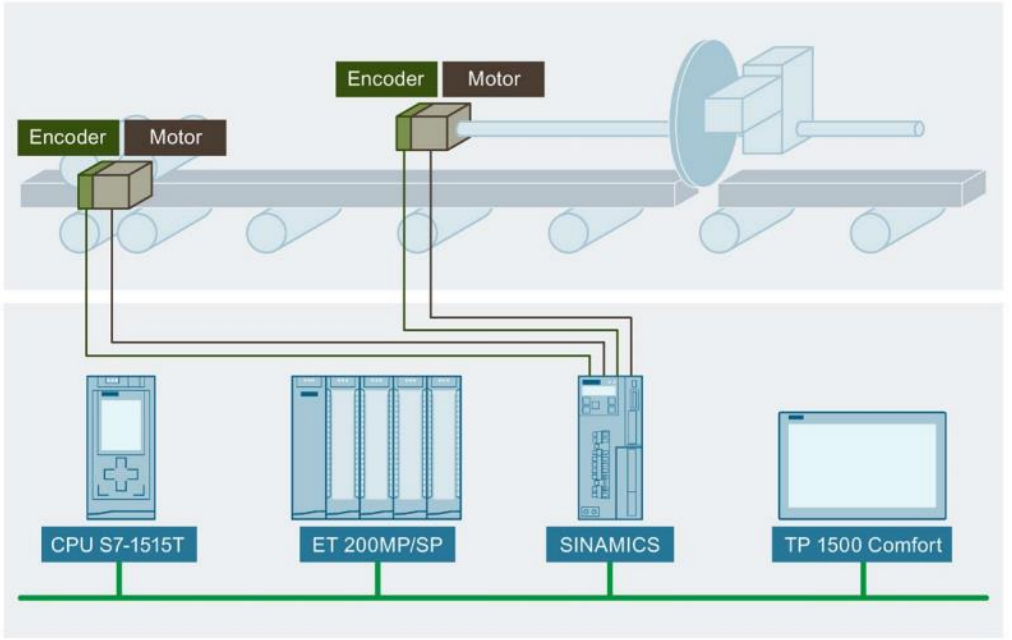
① A standard Ethernet frame with TCP/IP data is up to 125 µs.
② During fragmentation, the standard Ethernet frame is divided into frame segments.
③ The frame segments are divided into multiple short send clocks.



IRT Use Case 1: Motion Control

Flying Saw

- Saw axis is synchronised to the primary feed axis
- Configuration of Topology
- Each Servo drive is assigned to a Technology Object (TO)
  - Primary = Positioning axis
  - Saw = Synchronous axis
- Syncronisation done via OB91 MC-Servo



IRT Use Case 2: Time based IO

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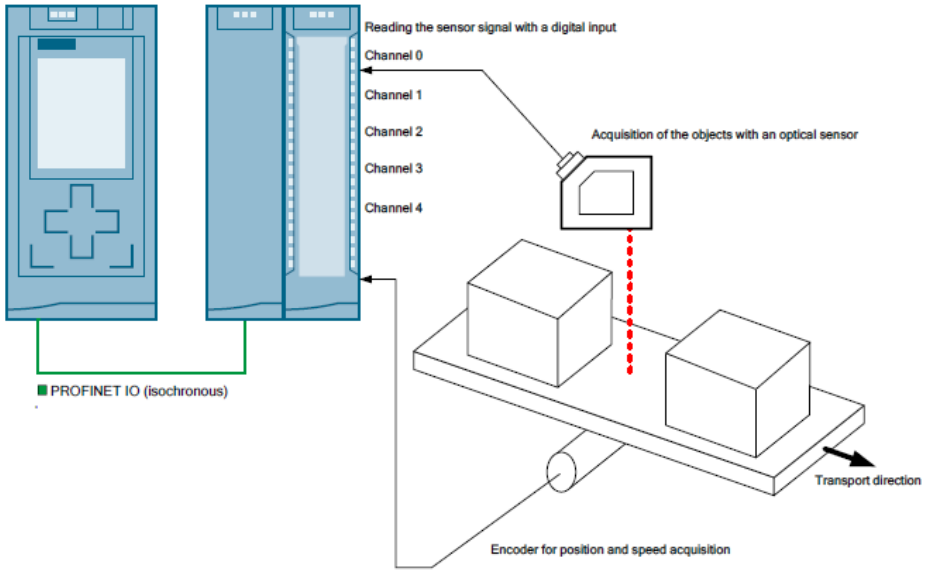
Ingenuity for life

Measure box length on conveyor

- Speed detection can be from various sources
  - Sinamic Drive/Servo
  - Profinet encoder
  - TM Timer DIDQ and a suitable encoder
- Sensor input via TM Timer DIDQ 16x24V or TM Timer DIDQ 10x24V
- Sensor input rising and failing edges are time stamped
- Measuring function block is called within Synchronous OB6x
- Independant of varying cyclic variations of standad OBs



IRT Use Case 3: Precise Control

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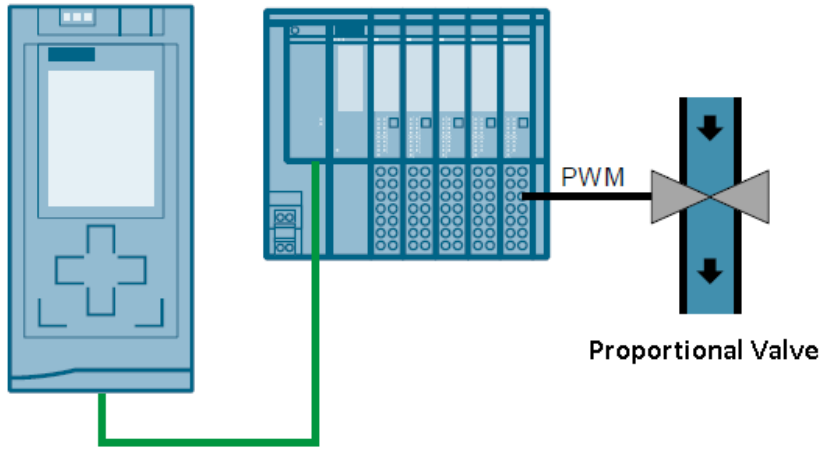
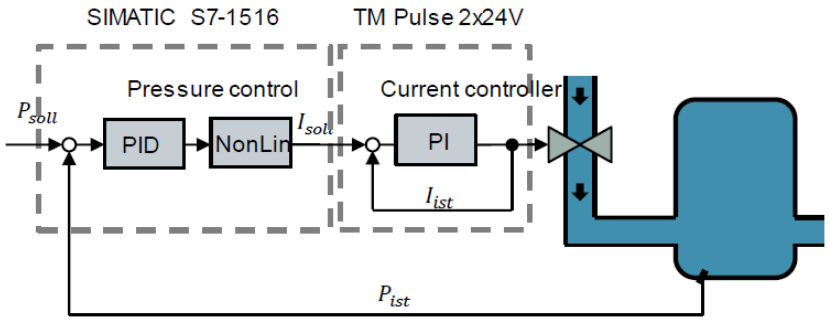
Precise hydraulic pressure control

- Utilises ET200SP TM Pulse 2x24V
- Various output modes to suit proportional valve
  - PWM
  - Pulse train
  - On/Off delay
  - Freq output
  - PWM with DC motor
- Dithering can be superimposed on the PWM output to ensure easy movement even with sticky valves
- Isochronous mode improves control properties but not essential





IRT Use Case 4: Precise measurements

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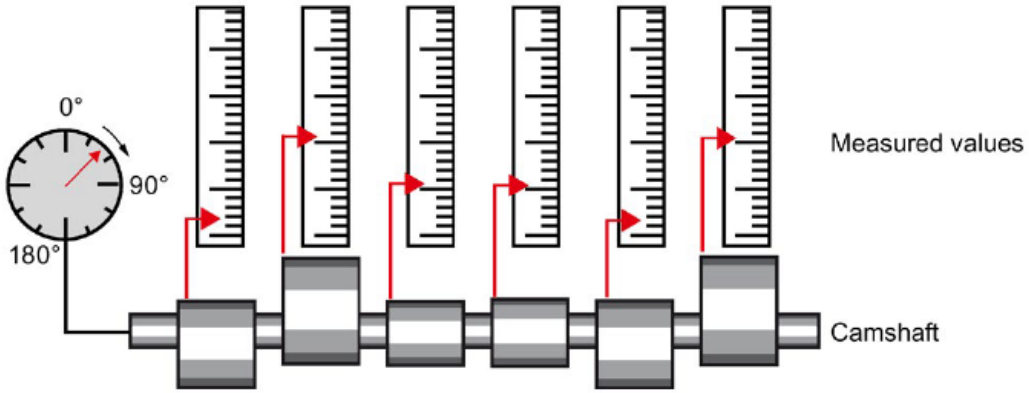
CAM shaft measurement

- Measure each cam during rotation with high accuracy
- Measurements are syncronously caputured while in motion
- Program code is managed within Synchronous OB6x
- Due to high speed measurements, machine cycle is reduced



IRT Use Case 5: Measured values

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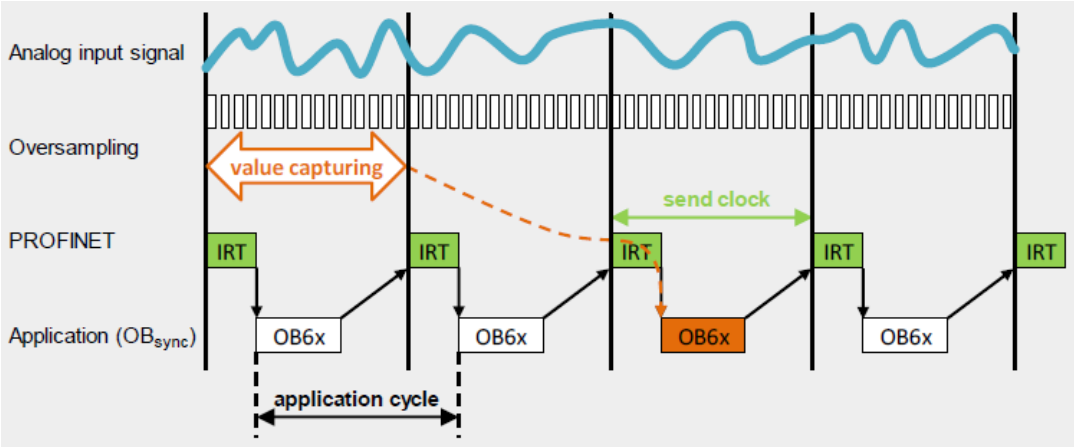
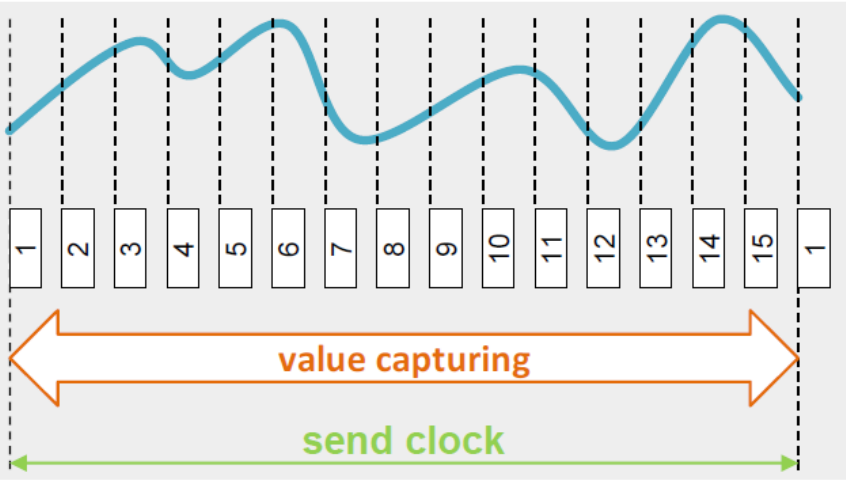
Ingenuity for life

Signal Oversampling

- Allows high speed inline testing of product
- Can be activated in ET200SP High Speed (HS) modules
- Requires distributed IO
- Oversample range 2 -16 sub cycles/cycle
- Requires Isocronous mode via OB6x





Profinet RT vs IRT

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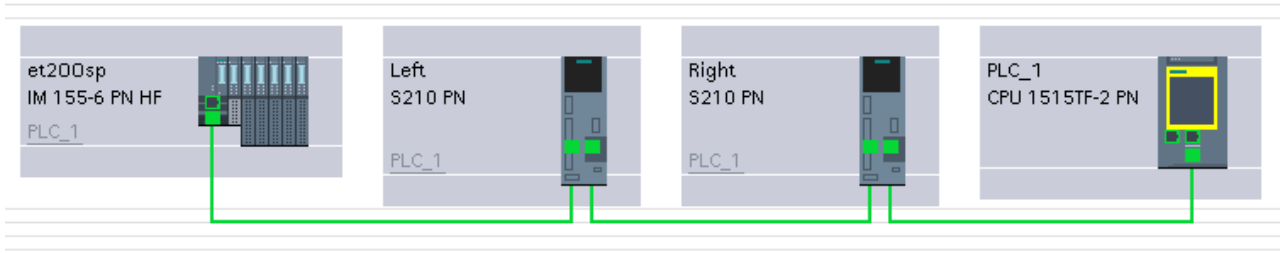
L I V E D E M O



1. RT monitoring via Oscilloscope
2. TIA Portal Settings
3. Isochronous OB + Settings
4. IRT monitoring via Oscilloscope

Q&A

SIEMENS
Ingenuity for life

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