

# **SERCOS-III**

## **(Third Generation SERCOS interface)**

*Version 1.3.3*  
*November 2003*

*Interests Group SERCOS interface e.V.*

- ▶ **Chronology of SERCOS-III**
  - ▶ **Announcement of Third Generation SERCOS interface**
- ▶ **Basic ideas and properties of SERCOS-III**
  - ▶ **New features**
  - ▶ **Topology**
  - ▶ **Telegram structure**
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- ▶ **SERCOS-III hardware**
- ▶ **SERCOS-III in comparison to other Ethernet-based solutions**
  - ▶ **Comparison of data**
  - ▶ **Market positioning**
- ▶ **Summary**

# Chronology of SERCOS-III (1)



## ▶ November 2002

Foundation of a **Strategy Team** to define future strategy for SERCOS interface

*Team members: Andron, Automation Intelligence/Sanyo Denki, Bosch Rexroth, Elau, Rockwell Automation, University of Stuttgart, University of Akron*

## ▶ January 20-21, 2003

**1st Strategy Meeting** at Rockwell Automation in Milwaukee to make a SWOT analysis, discuss possible future scenarios & work out an action plan

## ▶ March 17, 2003

**Board Meeting** at Sheraton Frankfurt to release an action plan for Next Generation SERCOS

## ▶ April 8, 2003

Action plan is presented on **Members Meeting** in Hanover

## ▶ April 21, 2003

**Announcement** of Third Generation SERCOS interface (Press release)

# Chronology of SERCOS-III (2)



## ▶ April - July 2003

Several face-to-face **meetings and teleconferences** to discuss, rate and compare different technology options & their market impact

## ▶ July 22, 2003

**Final meeting** of Strategy Team to work out a common recommendation to the IGS Board

## ▶ July 24, 2003

**Board Meeting** at ISW in Stuttgart decides on SERCOS-III concept on the basis of the recommendation of the Strategy Team

## ▶ September 24-29, 2003

**Presentation of SERCOS-III concept to members of IGS, SERCOS NA & SERCOS Japan**

## ▶ October 22, 2003

**Kick-off Meeting SWG SERCOS-III (Stuttgart/Germany)**

## Third Generation of Standard is under development

- ▶ ... the initiative, Next Generation SERCOS" (NGS) has been launched in order to further develop the SERCOS interface standard **in the direction of using Industrial Ethernet**
- ▶ The **planned extensions** are:
  - ▶ Improving the ease of integration by supporting higher protocols from office and fieldbus communication (e.g., TCP/IP, Profibus and CIP).
  - ▶ Improving the performance by introducing higher transmission speeds.
  - ▶ Improving the interoperability of control and drive components by defining "motion control" profiles and developing the associated test suites to assure conformance.
  - ▶ Cost reduction by applying appropriate technology standards.

...

## Third Generation of Standard is under development

- ▶ It is planned to present the “Next Generation SERCOS” concept and to start the specification and development work at the **SPS/IPC/DRIVES trade show in November 2003**
- ▶ The described development is carried out under careful attention of the **best possible backward compatibility** in order to protect the investments of users and suppliers and to allow an uncomplicated migration to the new technology.

## **Basic ideas and properties of SERCOS-III**

# Basic ideas and properties of SERCOS-III



- ▶ **Well proven SERCOS Mechanisms** in combination with worldwide well known network physics (Ethernet)
  - ▶ Compatibility in data exchange mechanism with host
  - ▶ Reduction of costs for fiber optic cable
- ▶ Increase of transmission speed from 16 MBit/s to **100 MBit/s**
- ▶ Use of hardware-based **Synchronization** and **Ring Topology**
- ▶ Integration of an **IP-channel**
- ▶ Implementation of **Safety Functions**
- ▶ SERCOS-III controller with integrated **I/O-Functionality**
- ▶ **Reduction of Node Costs** to analog interface level – less than 12 €

# Features 1



- ▶ Cyclic and non cyclic communication maintained in SERCOS-III protocol
  - ▶ **Software compatibility** with existing software drivers
- ▶ Reduction of cycle time down to 31.25  $\mu$ s
  - ▶ Capability to support centralized control concepts
- ▶ Additional **IP-channel**
  - ▶ Integration of existing Ethernet units (via gateway)
  - ▶ Routing capability for proprietary protocols
- ▶ **Cross communication** of nodes
  - ▶ All telegrams are visible for each node
- ▶ **Synchronization & communication** between multiple motion controls

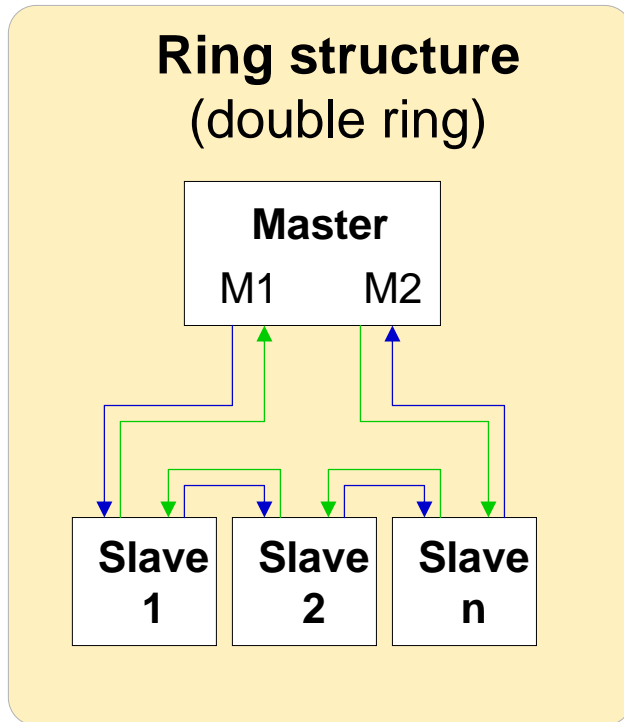
# Features 2



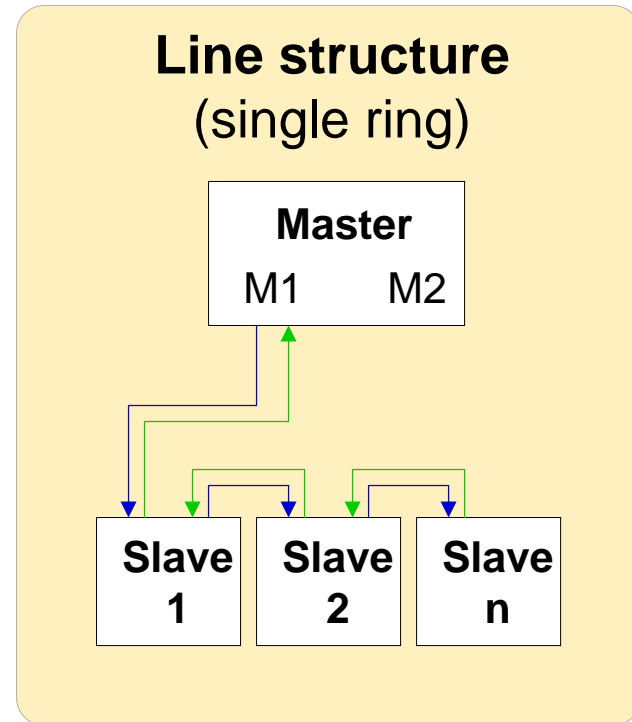
- ▶ Realization of **low cost devices**
  - ▶ Planned SERCOS-III GPC controller has enough CPU horsepower to realize smart I/O devices, gateways up to single chip drives
  
- ▶ **Safe communication** for drive-integrated safety functions
  - ▶ Transmission of safe and unsafe data via the same mechanism
  - ▶ Examples: safe actual values, selection signals for drive integrated safety functions, safety I/Os
  
- ▶ **Redundancy** of the physical link against cable break
  
- ▶ **Hot plugging** of nodes during operation

## **SERCOS-III topology**

# Possible topologies for SERCOS-III

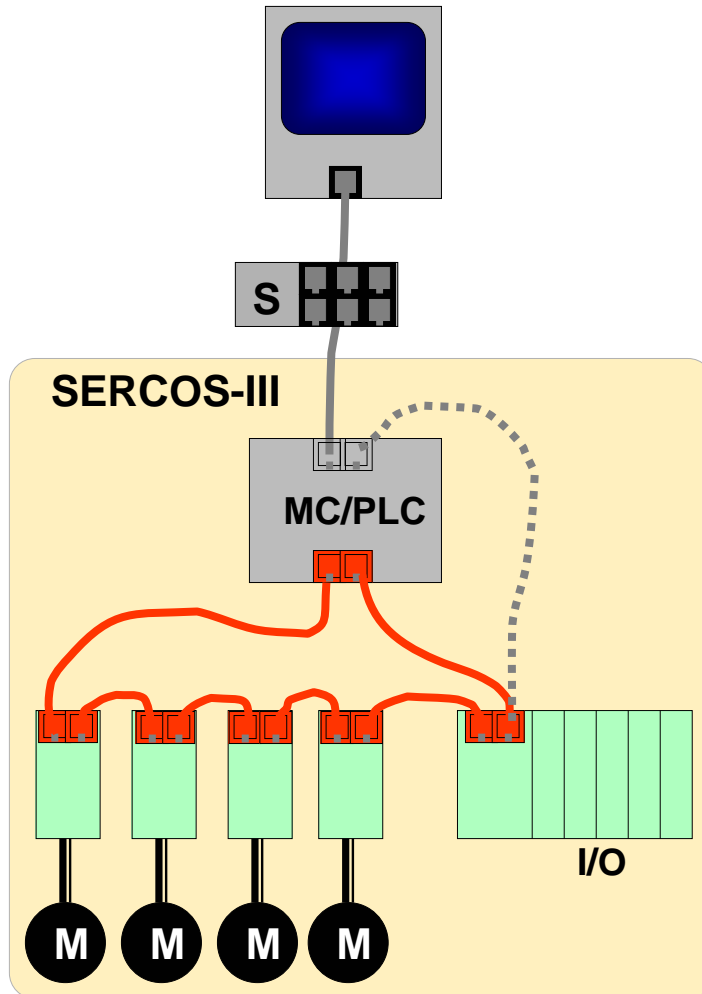


With hardware redundancy



Without hardware redundancy

# SERCOS-III in standalone machines



## Standalone Machines (e.g., machine tool)

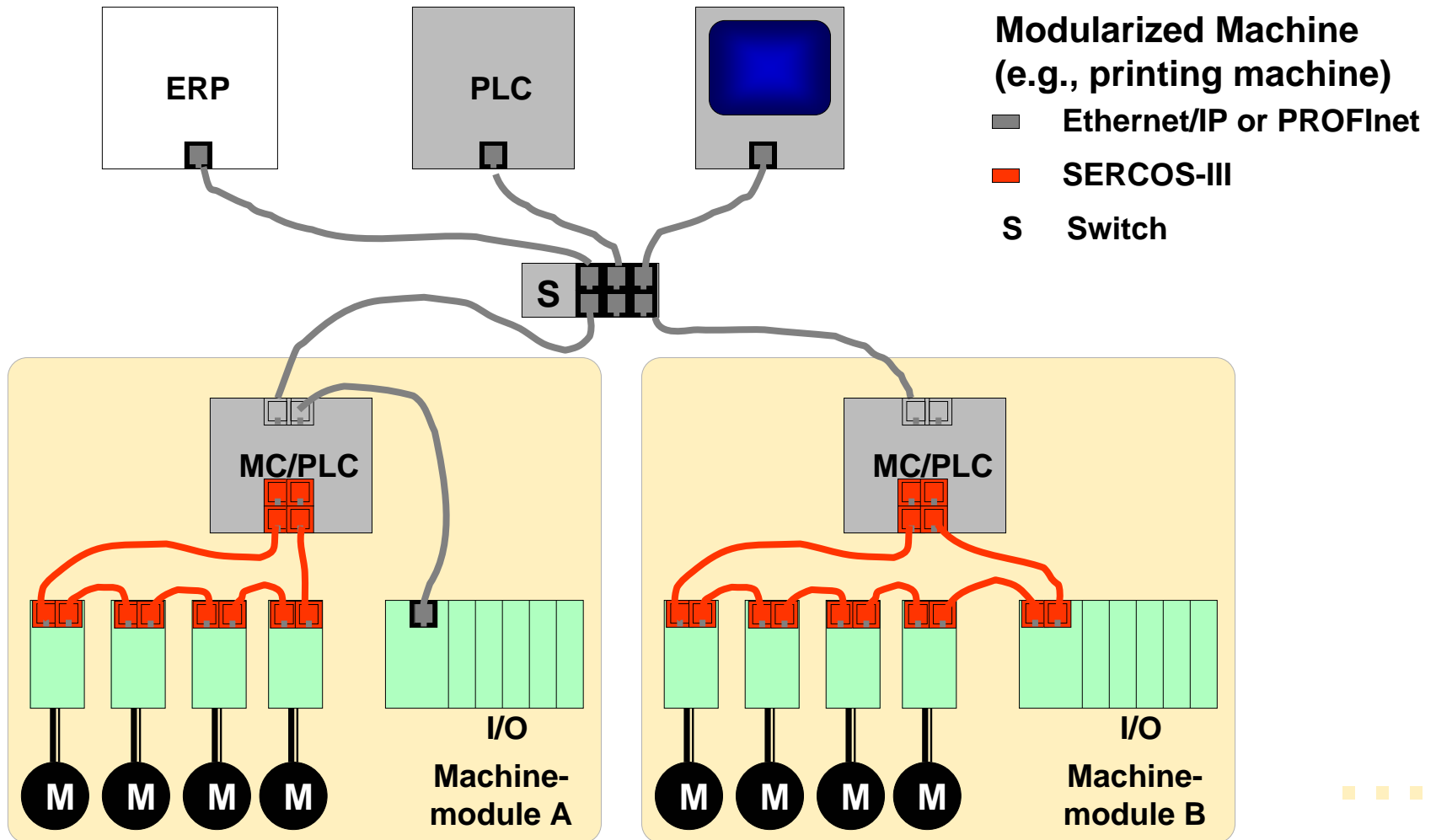
■ Ethernet/IP or PROFINET

■ SERCOS-III

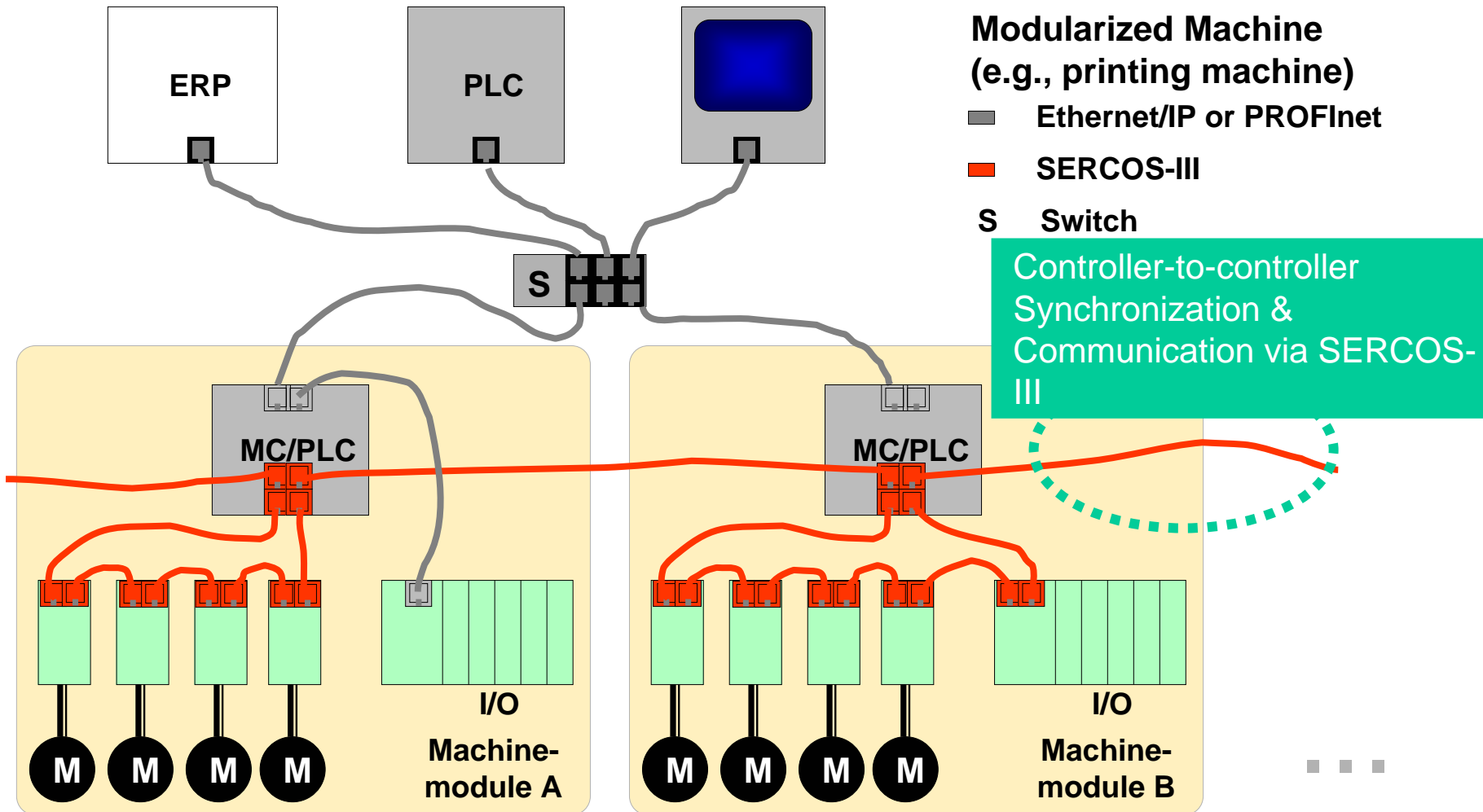
S Switch

I/O interfacing via SERCOS-III  
or by Using Ethernet/IP or ProfiNet

# Cross-communication and I/O-coupling

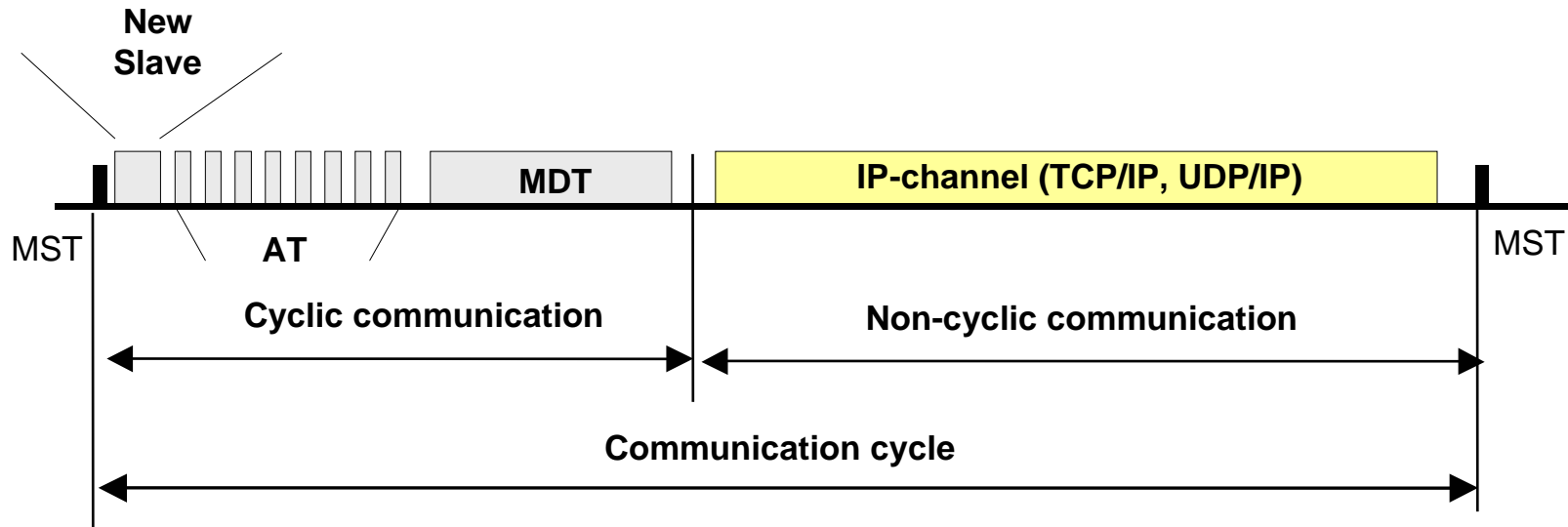


# Cross-communication and I/O-coupling

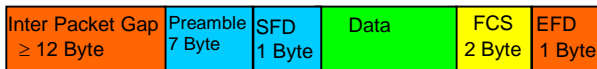


# **Telegram structure and treatment of cyclic and non-cyclic communication via IP-Protocol**

# Telegram structure

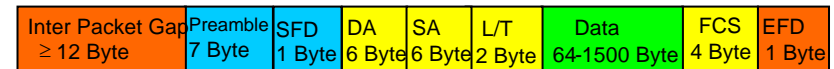


## Structure of cyclic data:



Optimized frame

## Structure of non-cyclic data:

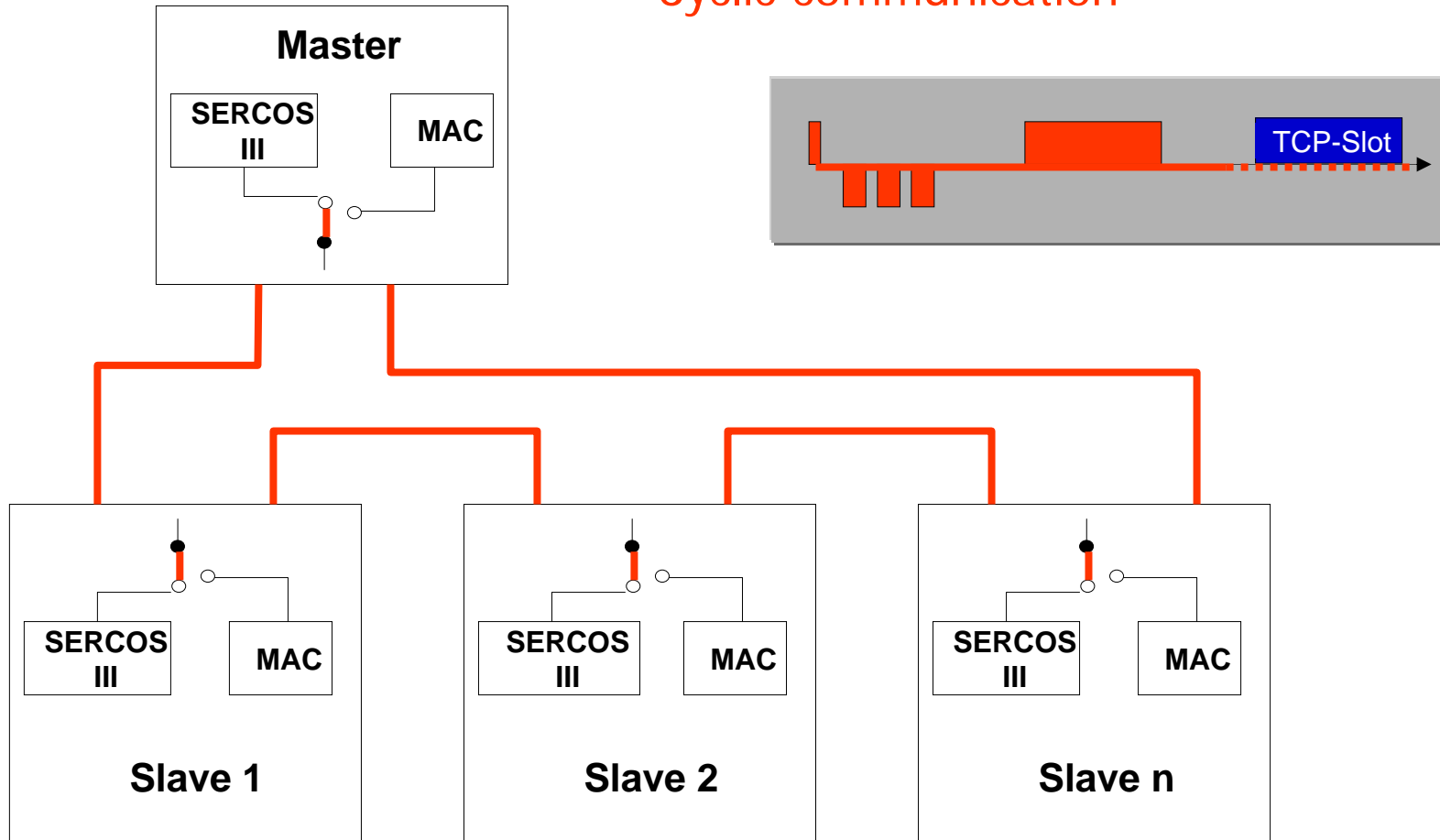


Standard Ethernet frame

# Switching between cyclic and non-cyclic communication (1)



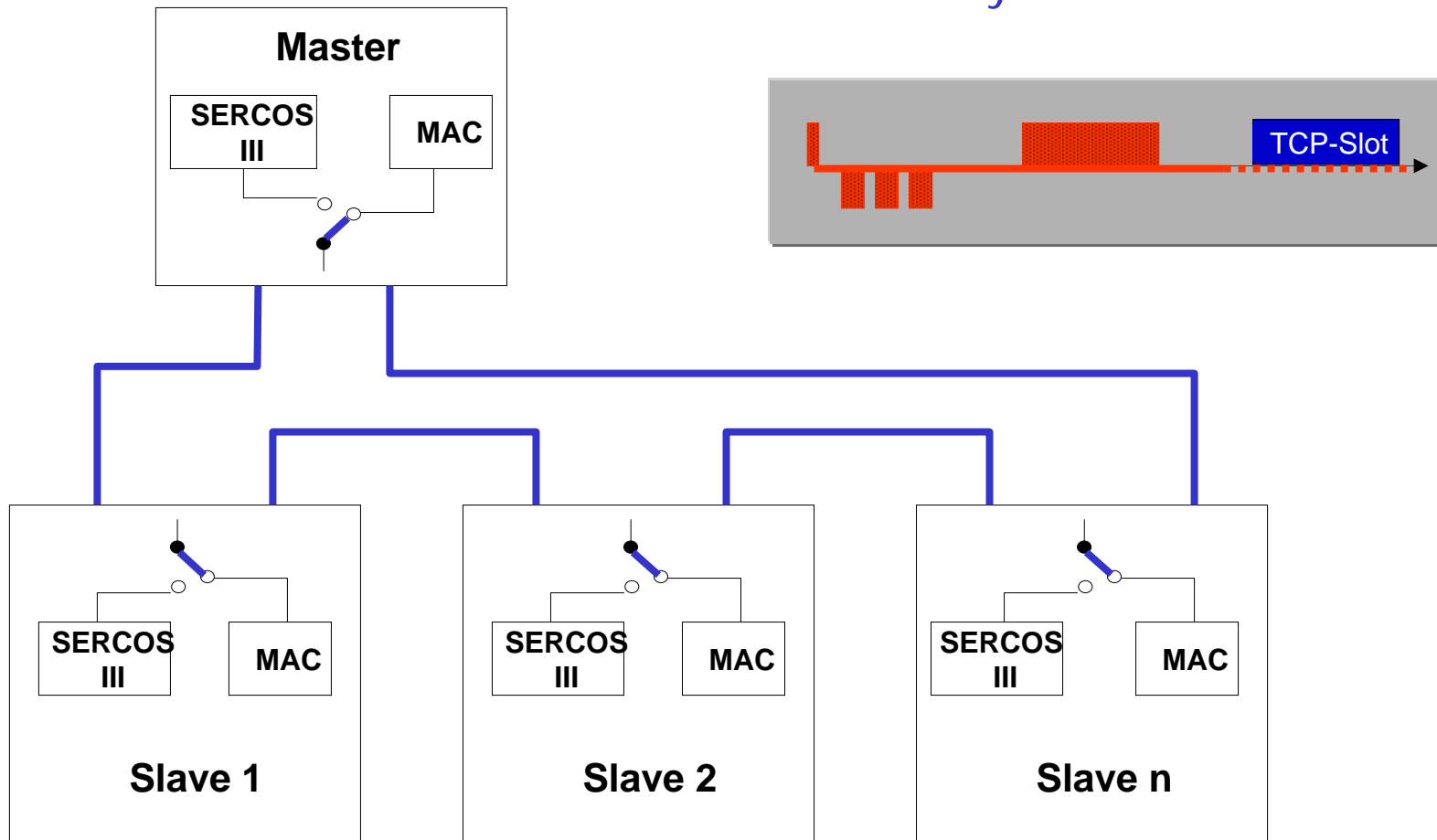
Cyclic communication



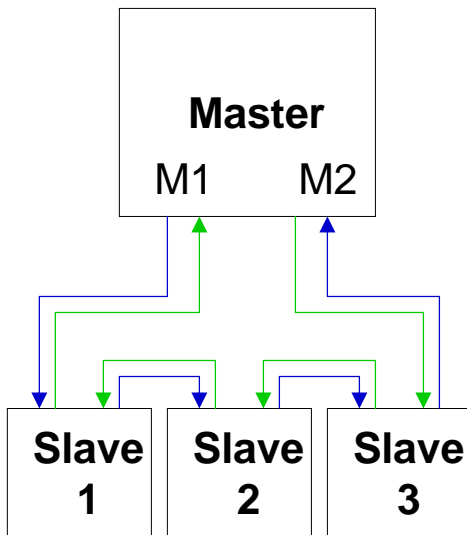
# Switching between cyclic and non-cyclic communication (2)



## Non-cyclic communication

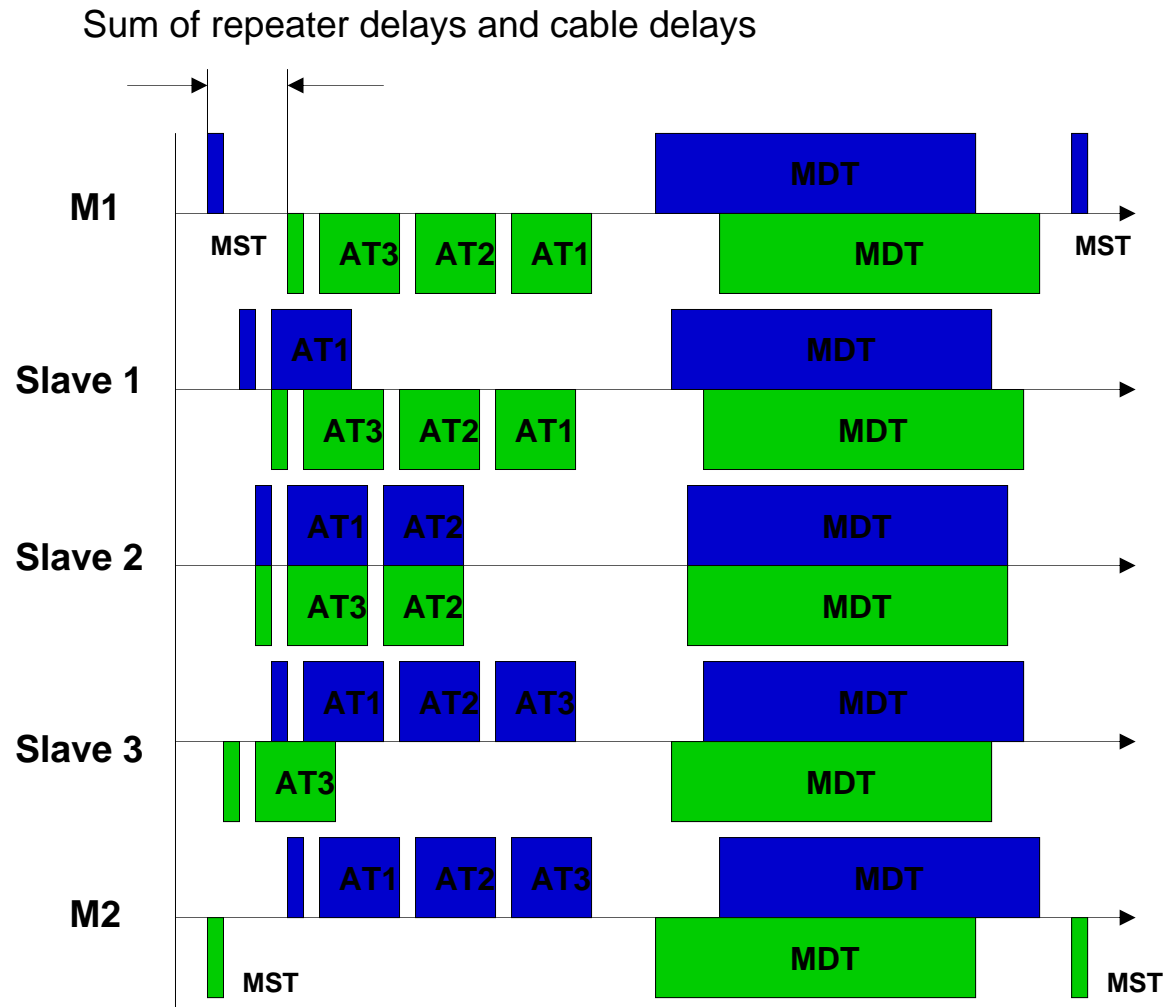


# Timing details during a com-cycle (example with 3 slaves)



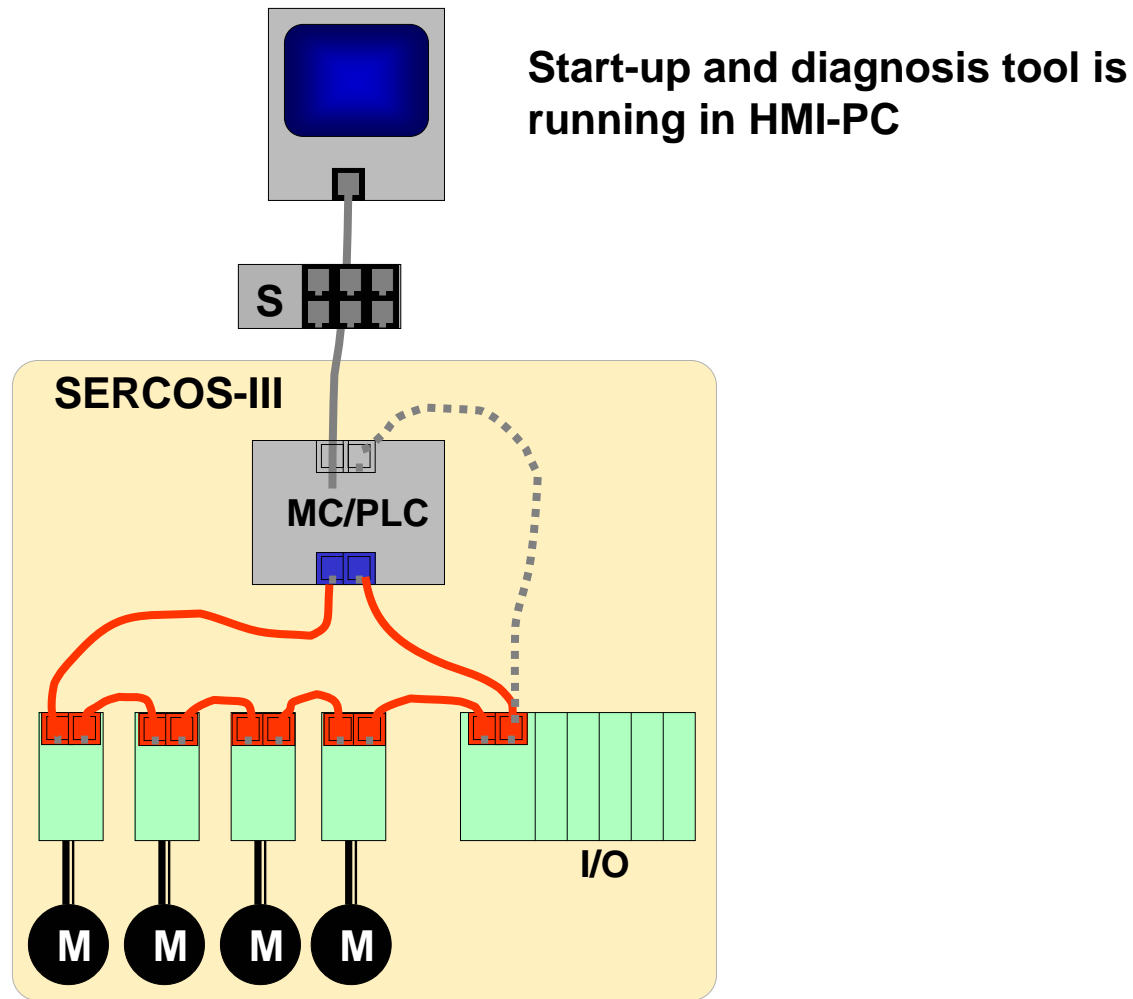
## Principle:

Every slave adds the AT to the „train“



## **Startup and diagnosis**

# Startup and diagnosis via HMI-PC

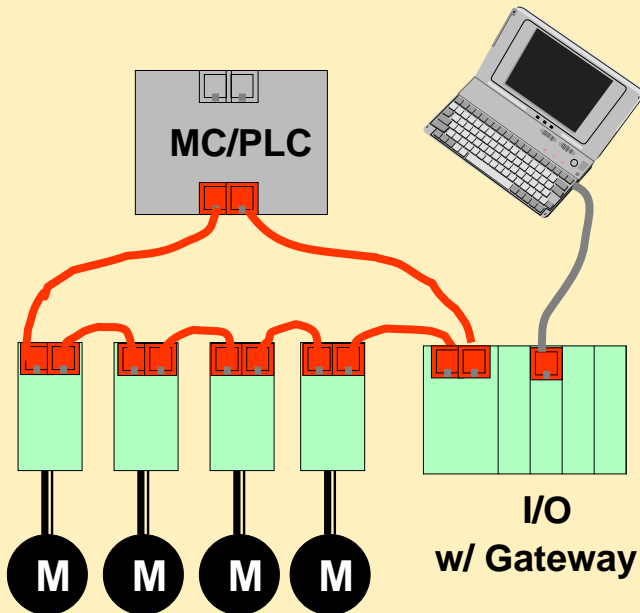


# Startup and diagnosis via optional PC by TCP/IP

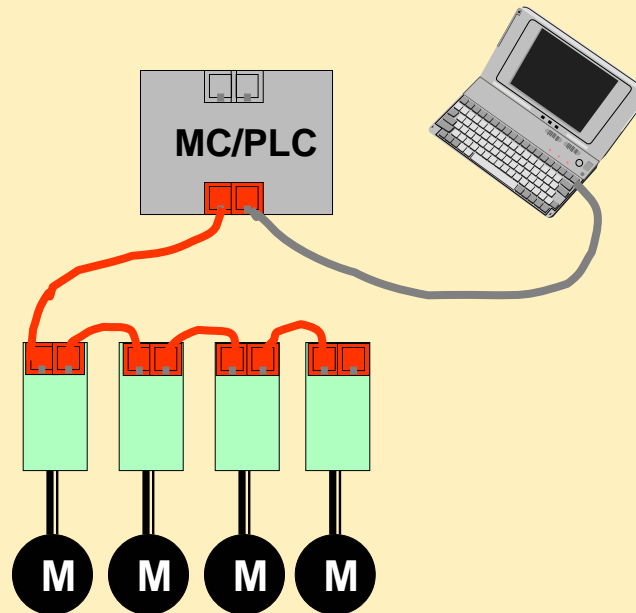


## Online

Double ring closed  
Coupling via gateway

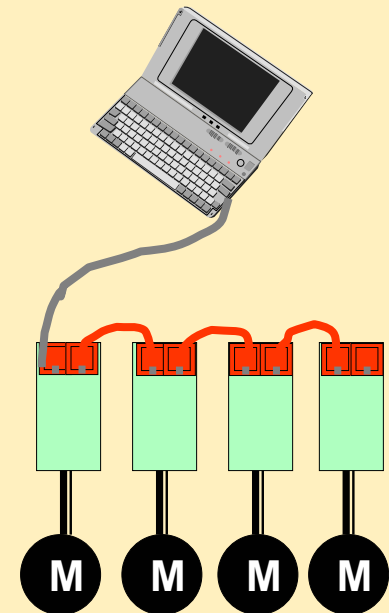


Line structure  
SERCOS-III Master with  
gateway function



## Offline

Direct coupling  
(w/o MC/PLC)



## **SERCOS-III hardware**

# Realization possibilities for SERCOS-III Controllers

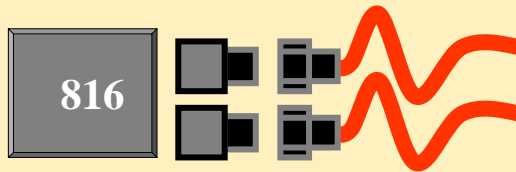


- ▶ Classical ASIC design
  - ▶ Only used for high volume consumer products
  
- ▶ FPGA solution with option of Gate-Array realization
  - ▶ Used in medium quantity applications. The realization of a fixed programmed gate array is very simple and cost effective.
  
- ▶ Integration of SERCOS-III controller in a standard communication controller
  - ▶ This option is very cost effective and allows the realization of „Single-chip Drives“

# Comparison of costs: SERCOS / SERCOS-III



## Current status:



### Interface-costs:

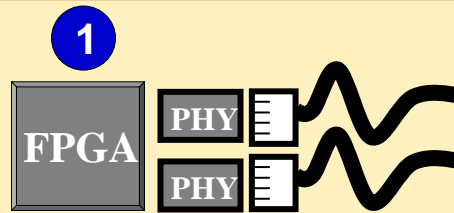
Material costs of  
main parts:

**24 €**

### Cable costs:

- Connectors: **7 €**
- Cable: **1 €/m**

## Planning for SERCOS-III:



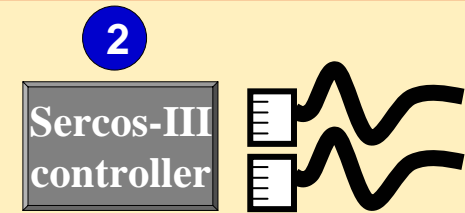
### Interface-costs :

Material costs of  
main parts:

**16 €**

### Cable costs :

- Connectors : **2 €**
- Cable : **1 €/m**



### Interface-costs :

Material costs of  
main parts:

**12 €**

### Cable costs :

- Connectors : **2 €**
- Cable : **1 €/m**

# **SERCOS-III**

## **in comparison to other Ethernet-based solutions**

# SERCOS-III data



- ▶ Transfer rate: 100 Mbit/s Ethernet
- ▶ Synchronization and time-slot mechanism as existing SERCOS interface
- ▶ Topology: Ring structure
- ▶ Hardware: FPGA or GPC Controller with integrated SERCOS-III mechanism
- ▶ Modes: SERCOS-mode, Standard-Ethernet-mode, mixed-mode
- ▶ Options:
  - ▶ I/O-Logic functionality

## Performance \*

	Telegram runtime	Electr. runtime	Total runtime
SERCOS-III	45 $\mu$ s	19,3 $\mu$ s	64 $\mu$ s
Profinet IRT	87 $\mu$ s	19,3 $\mu$ s	106 $\mu$ s
Powerlink	185 $\mu$ s	19,3 $\mu$ s	205 $\mu$ s
SERCOS 816	195 $\mu$ s	-	195 $\mu$ s
Profibus MC	1056 $\mu$ s	-	1056 $\mu$ s

Reference system: machine tool with 10 axes and 12 bytes of data per axis

\* Based on actual knowledge of the different solutions

# Cycle Times (without IP channel)



<b>Cyclic data</b>	<b>Cycle time</b>	<b>No. Axes</b>	<b>Comment</b>
8 Byte	31.25 us	8	Torque/position data
12 Byte	62.5 us	16	Velocity/position data
16 Byte	125 us	30	2 op.modes, add. Meas.data
12 Byte	250 us	72	Velocity/position data
32 Byte	250 us	36	„broad“ interface
12 Byte	500 us	150	Velocity/position data
53 Byte	1 ms	100	100 axes
32 Byte	1 ms	153	„broad“ interface
16 Byte	1 ms	254	max. number of drives
40 Byte	2 ms	254	max. number of drives
65 Byte	3 ms	254	max. number of drives

# **SERCOS-III**

## **Positioning in the market**

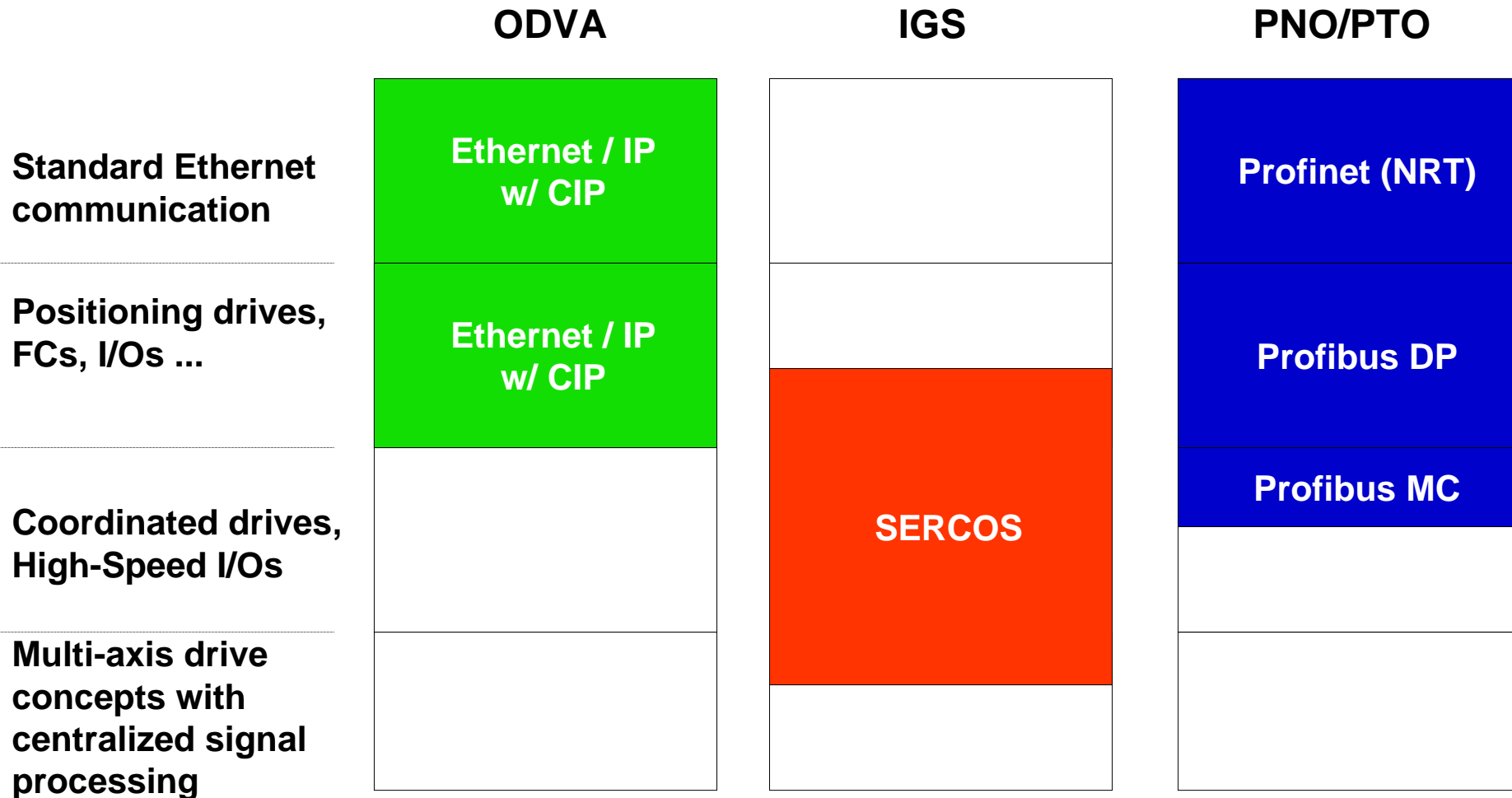
## ▶ **SERCOS-III**

- ▶ Hardware-Synchronization
- ▶ Communication with optimized Frames and SERCOS IDNs
- ▶ Collision- and delay-free communication

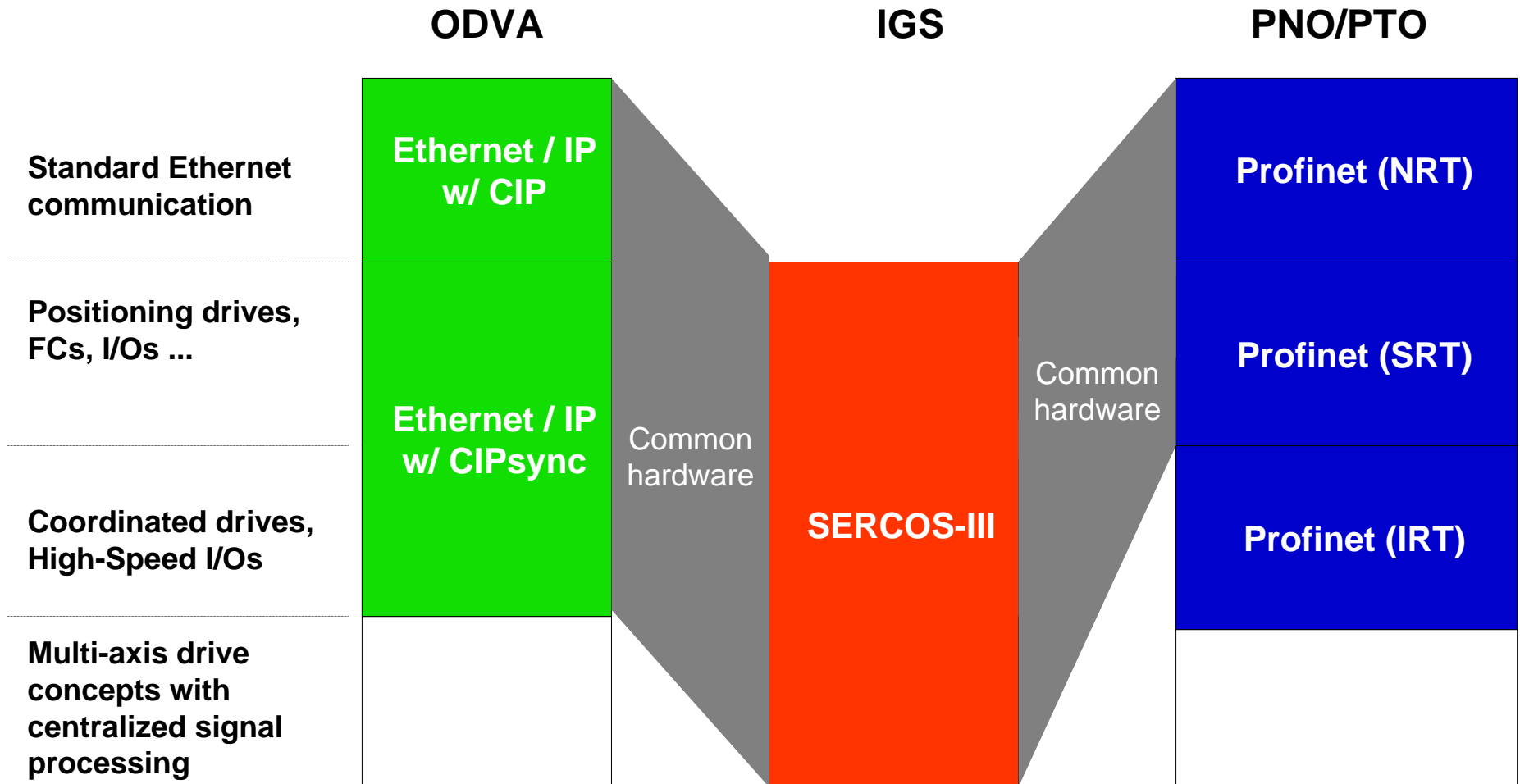
## ▶ **Application areas**

- ▶ Standard and high-performance interpolating drives
- ▶ Control-to-control synchronization
- ▶ I/O interfacing
- ▶ Drive concepts with centralized signal processing (min. cycle time 31.25 $\mu$ s)

# Communication worlds: PNO, ODVA and IGS (Current situation)



# Communication worlds: PNO, ODVA and IGS (Future Situation)



# Conclusion

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- ▶ SERCOS-III proposal combines advantages of existing SERCOS interface with advantages of Ethernet
- ▶ SERCOS-III uses the simple and well proven synchronization mechanism and profiles of SERCOS interface
- ▶ SERCOS-III keeps the effort of migration from existing SERCOS low
- ▶ SERCOS-III covers the actual and future needs for a drive and I/O communication system
- ▶ SERCOS-III is based on a standard hardware
  - ▶ High volume, reasonable price, high availability