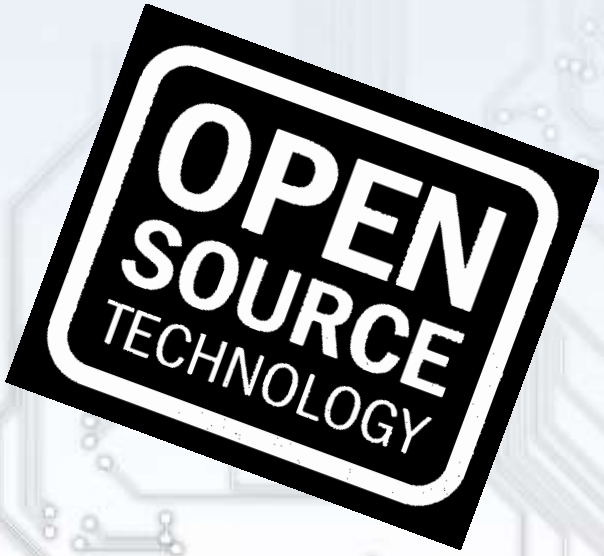
POWERLINK
+ Open Source IP-Core
=> FPGA



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Initial Questions

- POWERLINK:
  What is the working principle?
- Open Source IP-Core:
  What is provided?
- FPGA:
  What is an FPGA and why do we need one?

POWERLINK?

- Who?
  Sensors, control, actuators.
- What?
  Process data,
  like state of digital inputs and outputs, analog values, temperatures, speed, …
- How?
  Deterministic transmission of process data over Ethernet.

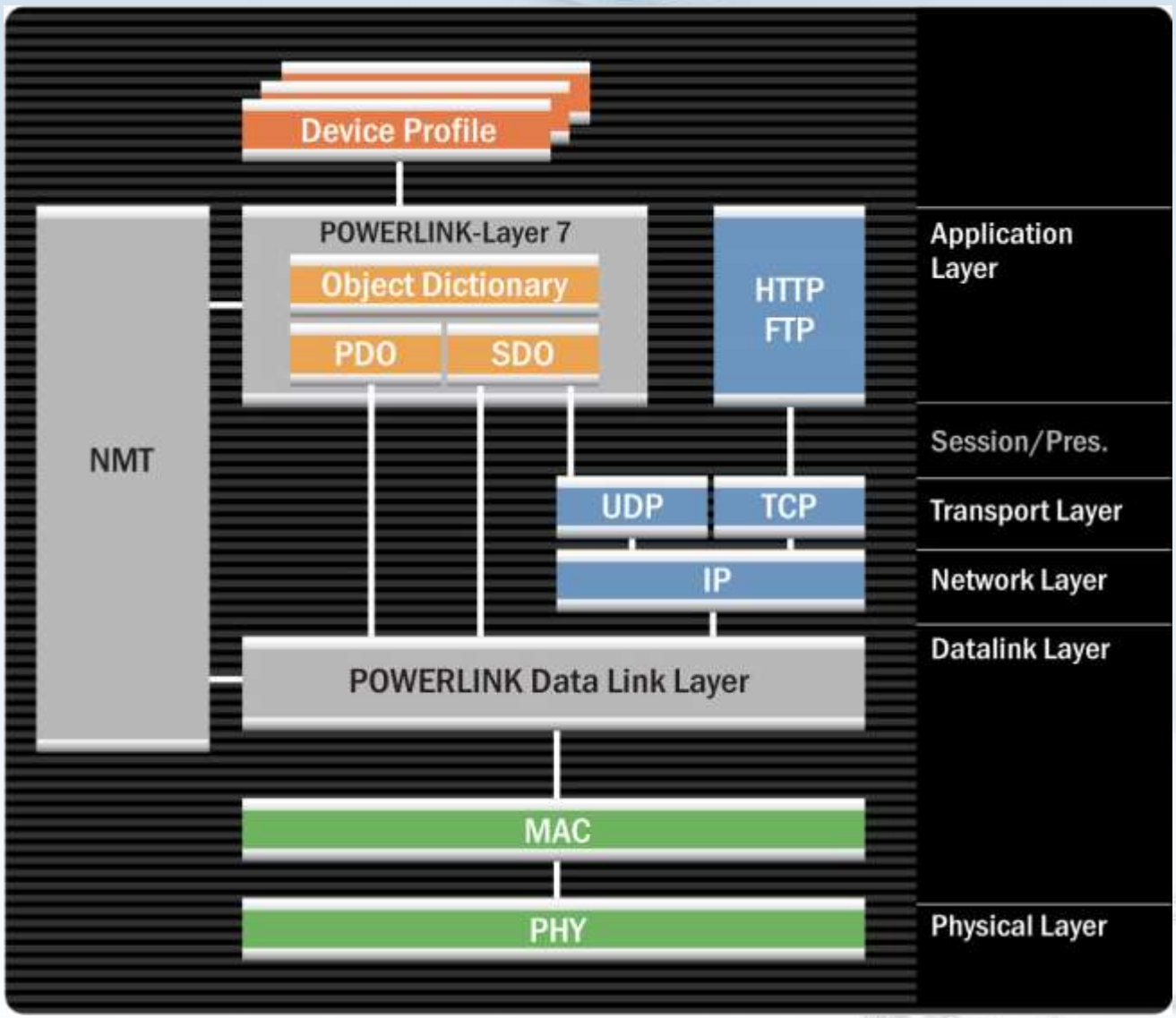
What is POWERLINK?

- *Industrial Ethernet* Fieldbus Protocol (see [1])
- Based on IEEE 802.3u Fast Ethernet
- CANopen over Ethernet
- Real-time capable via slot communication
- Master-Slave Protocol
- Master = Managing Node (MN)
- Slave = Controlled Node (CN)
- Hot plugging
- Direct cross-traffic

What is openPOWERLINK?

- Open Source implementation of POWERLINK
- Development done by SYS TEC electronic GmbH
- Currently supported target platforms:
  - Linux
  - Windows
  - bare-metal (OS-less)
- License: BSD
- Pure software-based solution on standard Ethernet controllers, but hardware-acceleration possible

OSI Model


Device Profile
POWERLINK-Layer 7
Object Dictionary
PDO
SDO
NMT
HTTP
FTP
UDP
TCP
IP
POWERLINK Data Link Layer
MAC
PHY
Application Layer
Session/Pres.
Transport Layer
Network Layer
Datalink Layer
Physical Layer

How does POWERLINK work?

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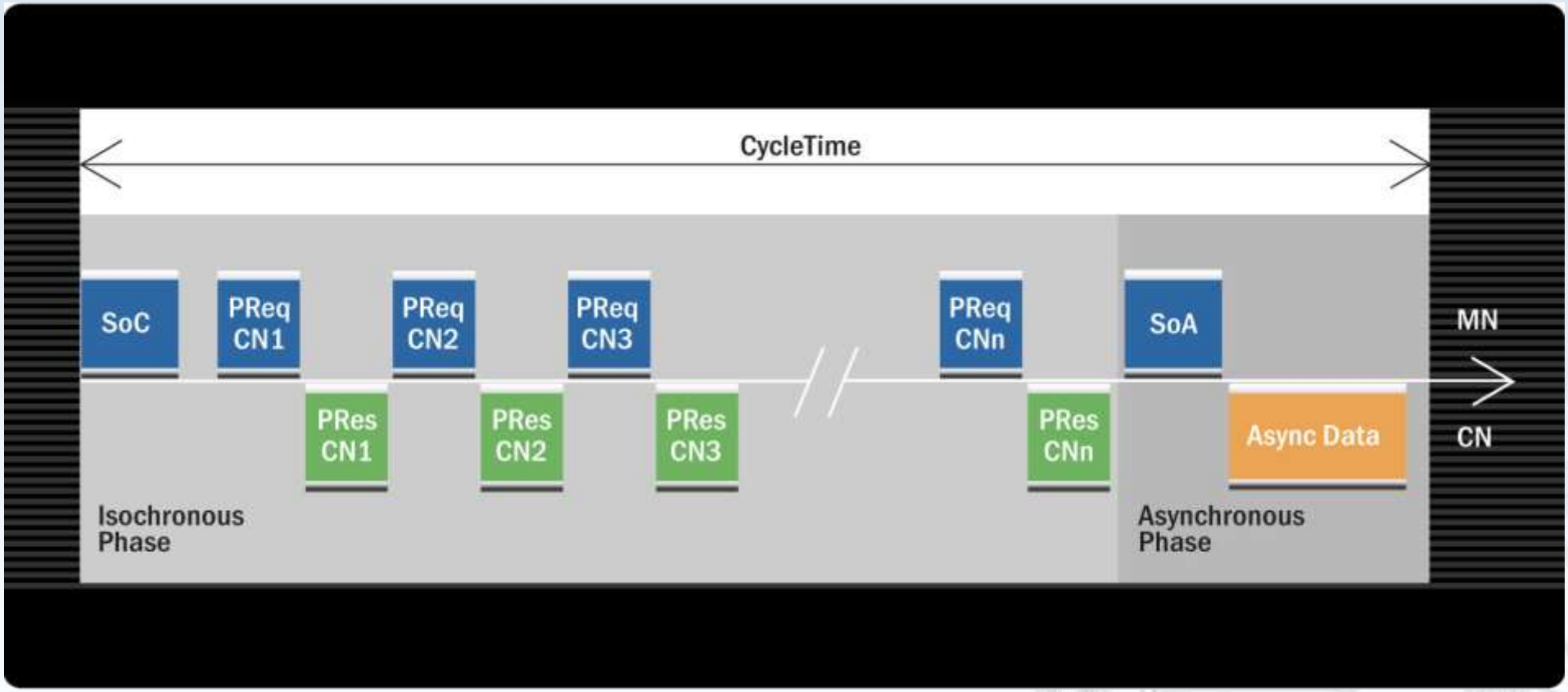
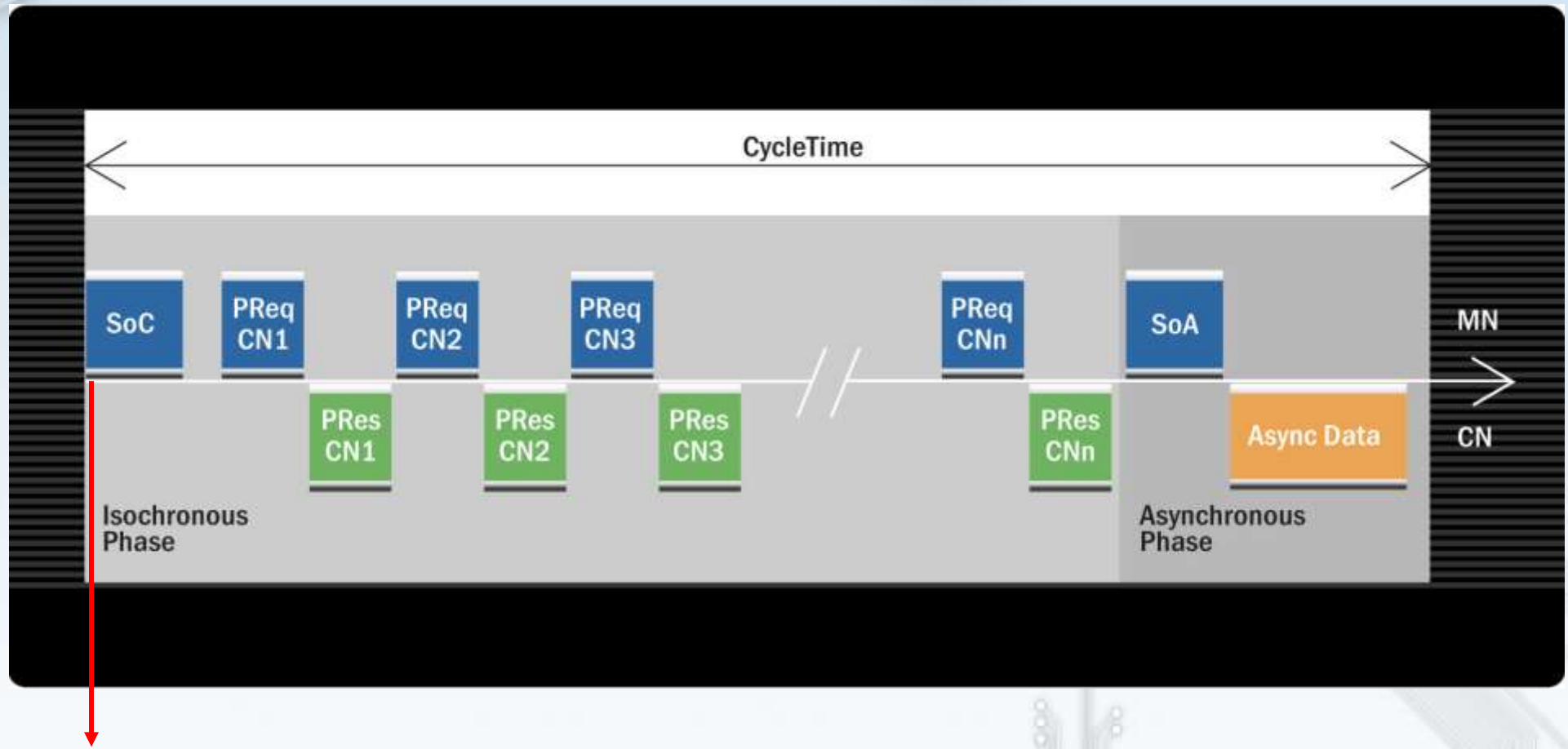
Slot Communication Network Management



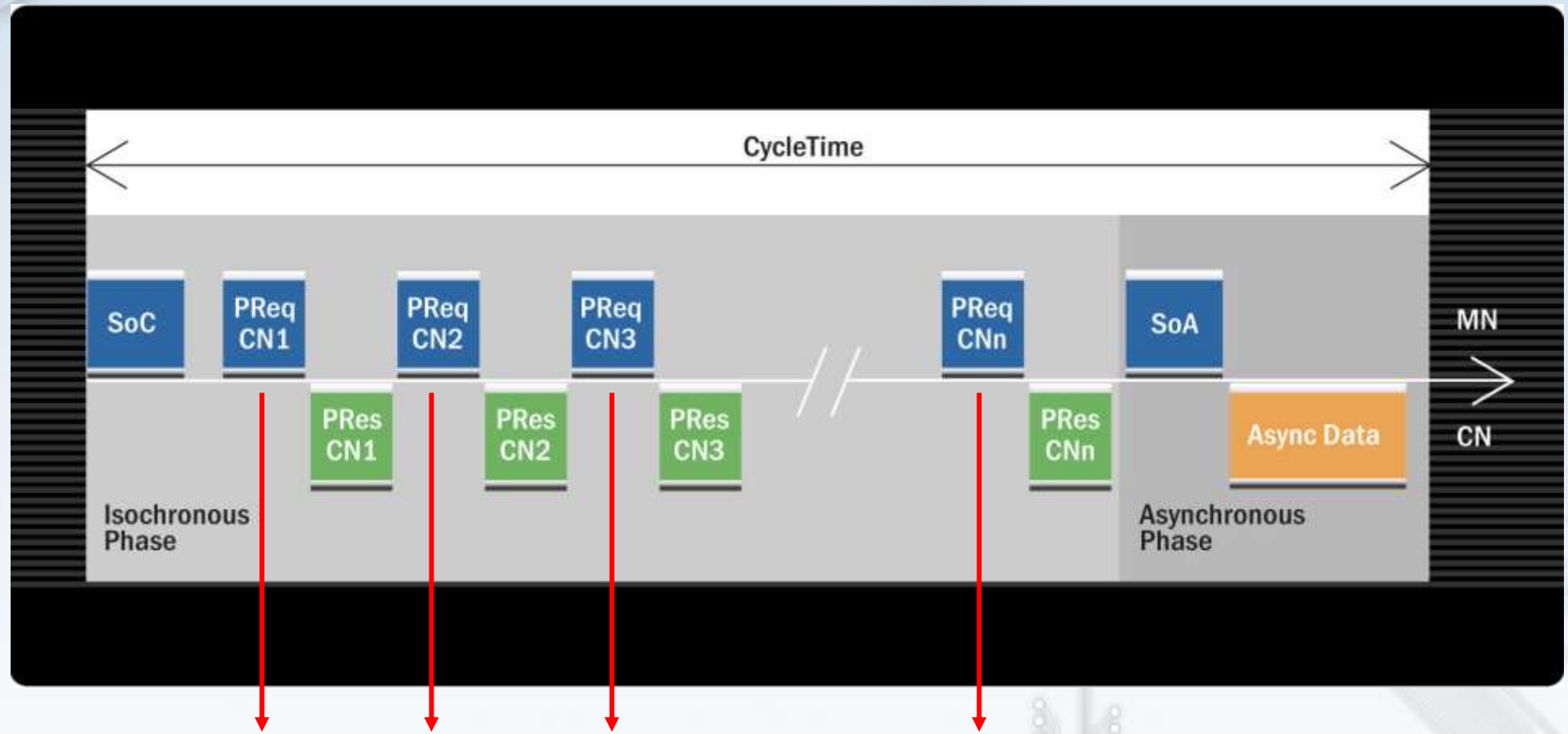
Demo (Wireshark)

SoC Frame



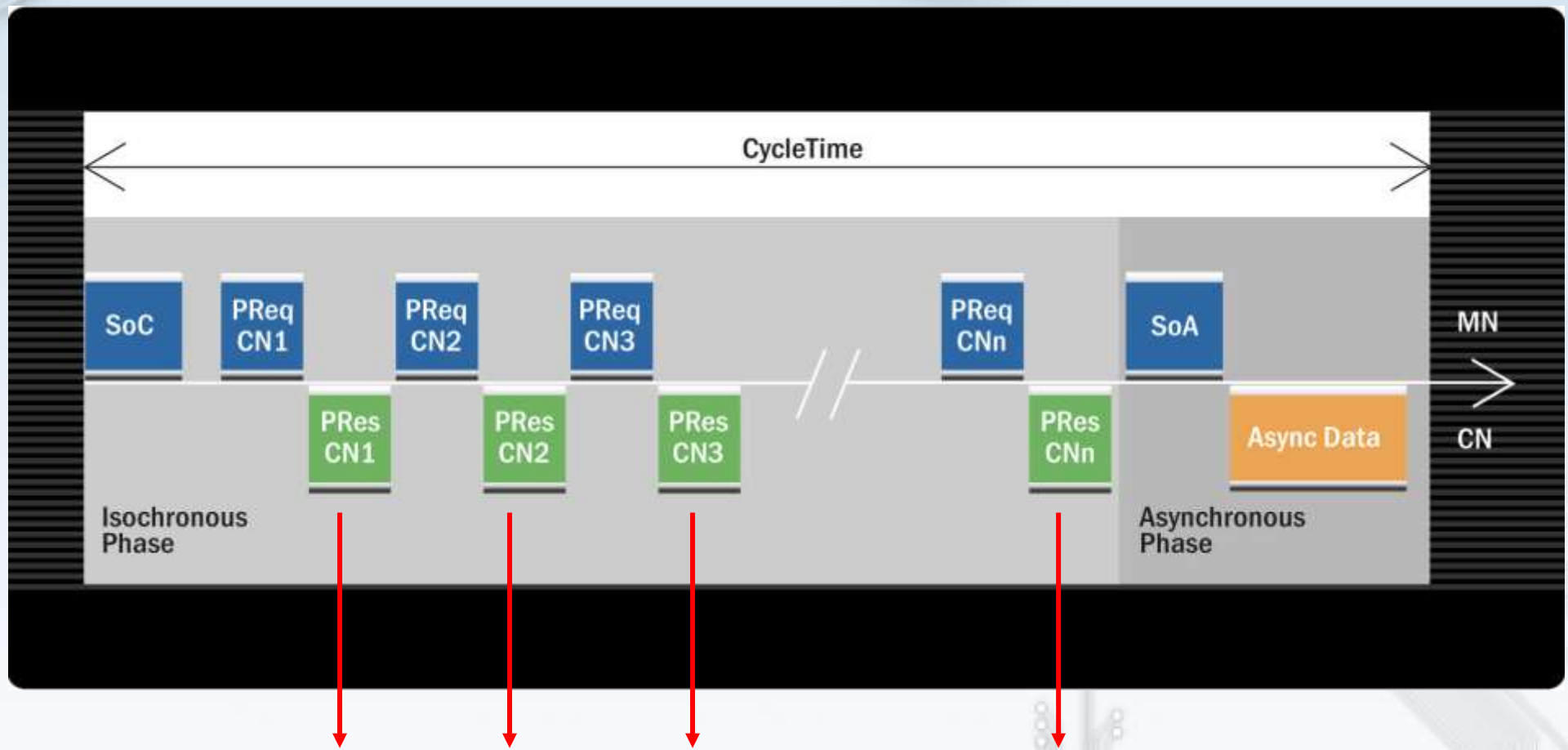
SoC: Start of Cycle synchronization event

PReq Frame



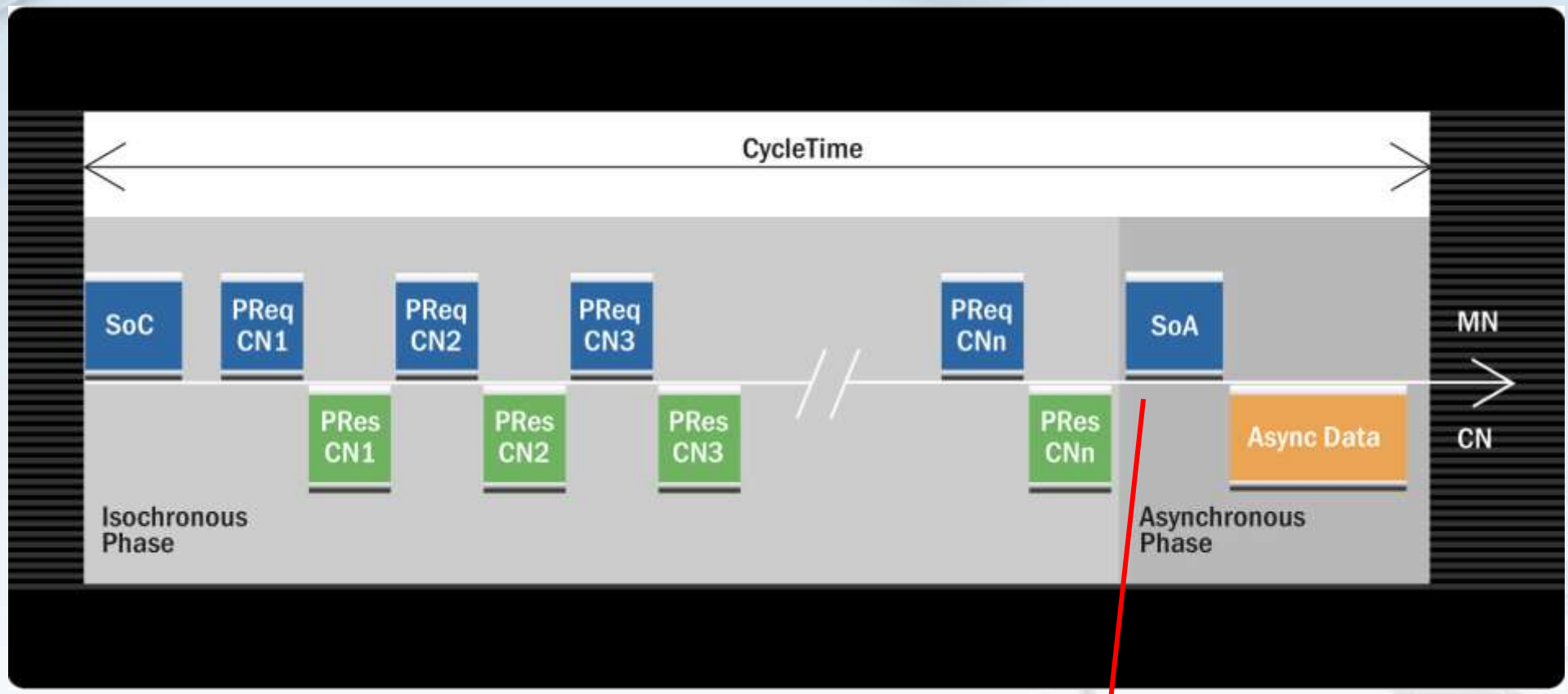
PReq: Poll Request from MN for specific CN contains PDO payload

PRes Frame



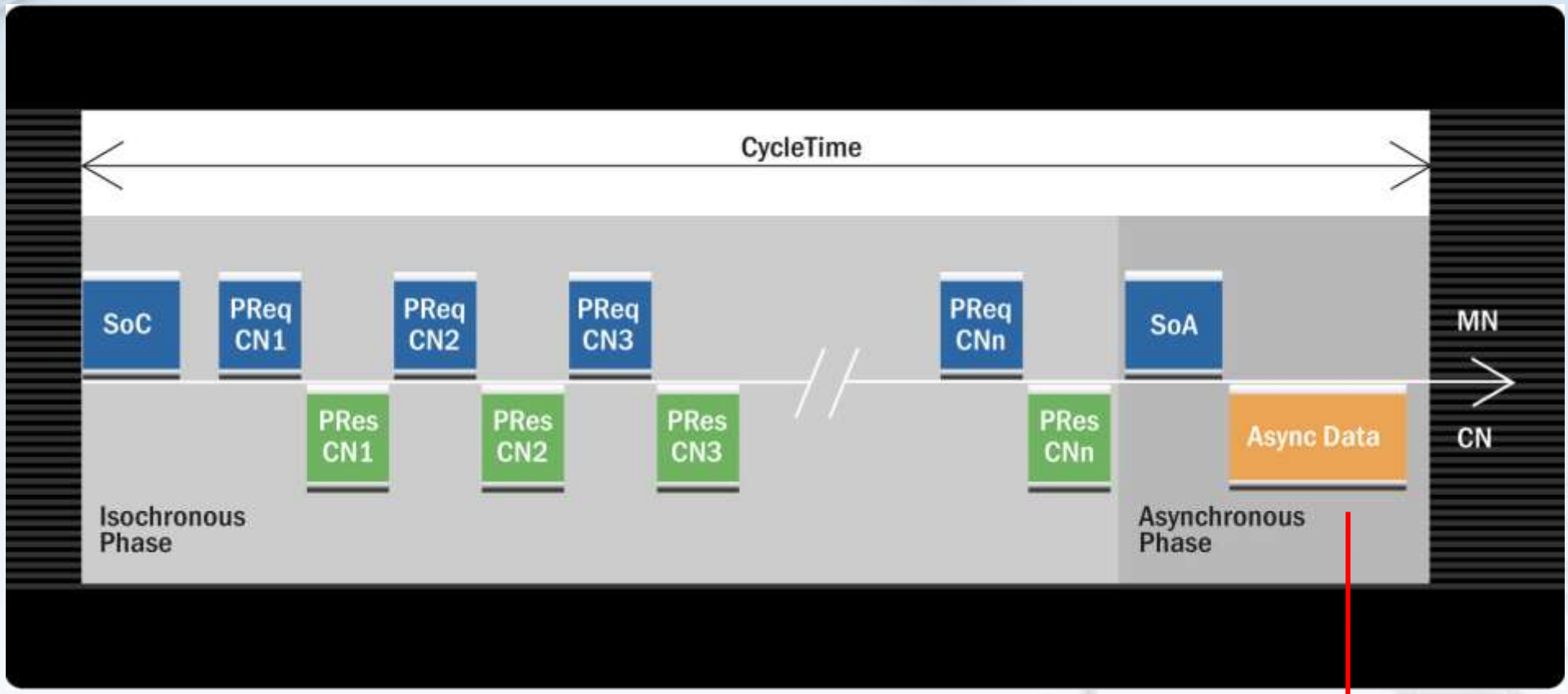
PRes: Poll Response from CN / MN
contains PDO payload and current NMT state

SoA Frame



SoA: Start of Asynchronous
assigns asynchronous phase to specific node

ASnd Frame

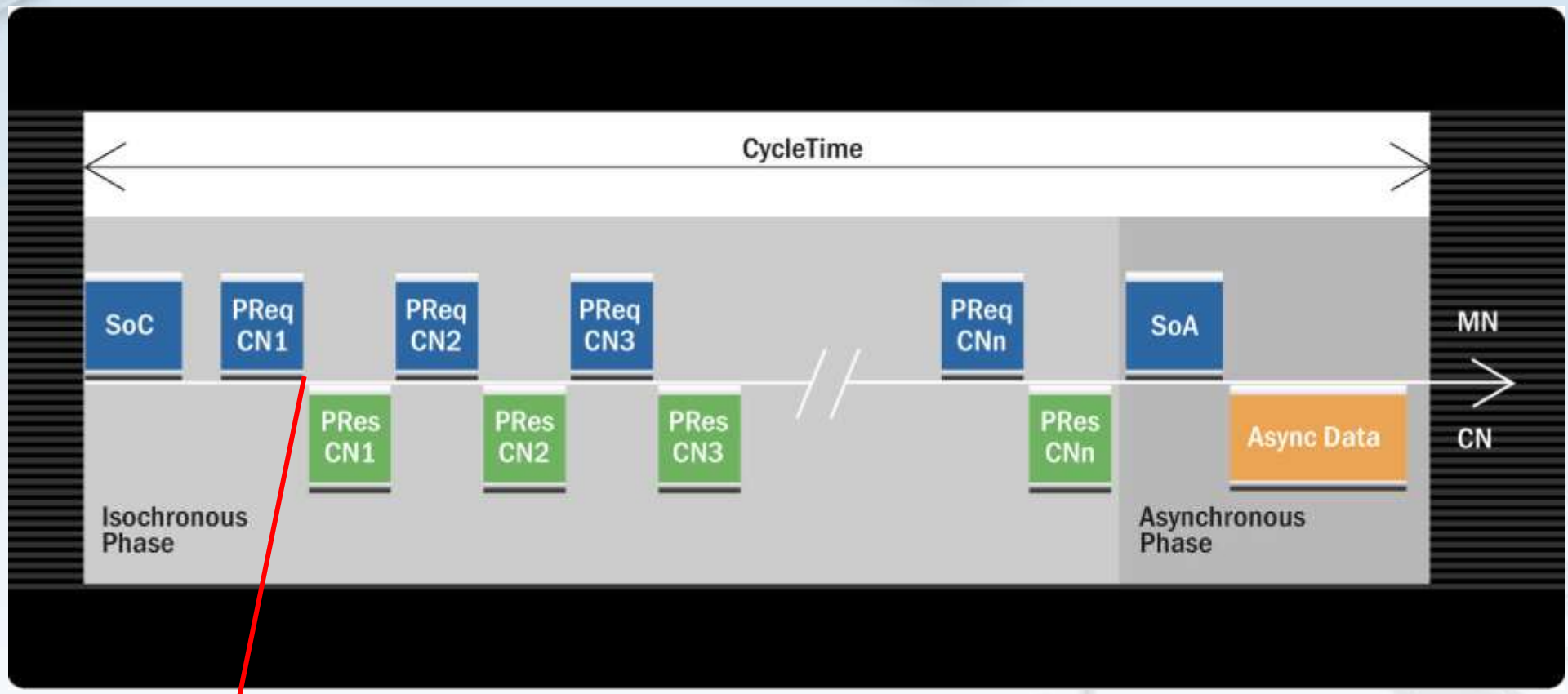


ASnd: Asynchronous Send

TCP/IP

NMT commands, SDO, IdentResponse, StatusResponse

Crucial Point on CN



Latency between PReq and PRes

Solution Idea

- Ethernet controller with auto-response feature
- PRes frame is sent on reception of PReq by HW
- No intervention of SW necessary
- Deterministic response time (inter frame gap = 96 bit)

➔ TI AM335x with Programmable Real-Time Unit and Industrial Communication Subsystem

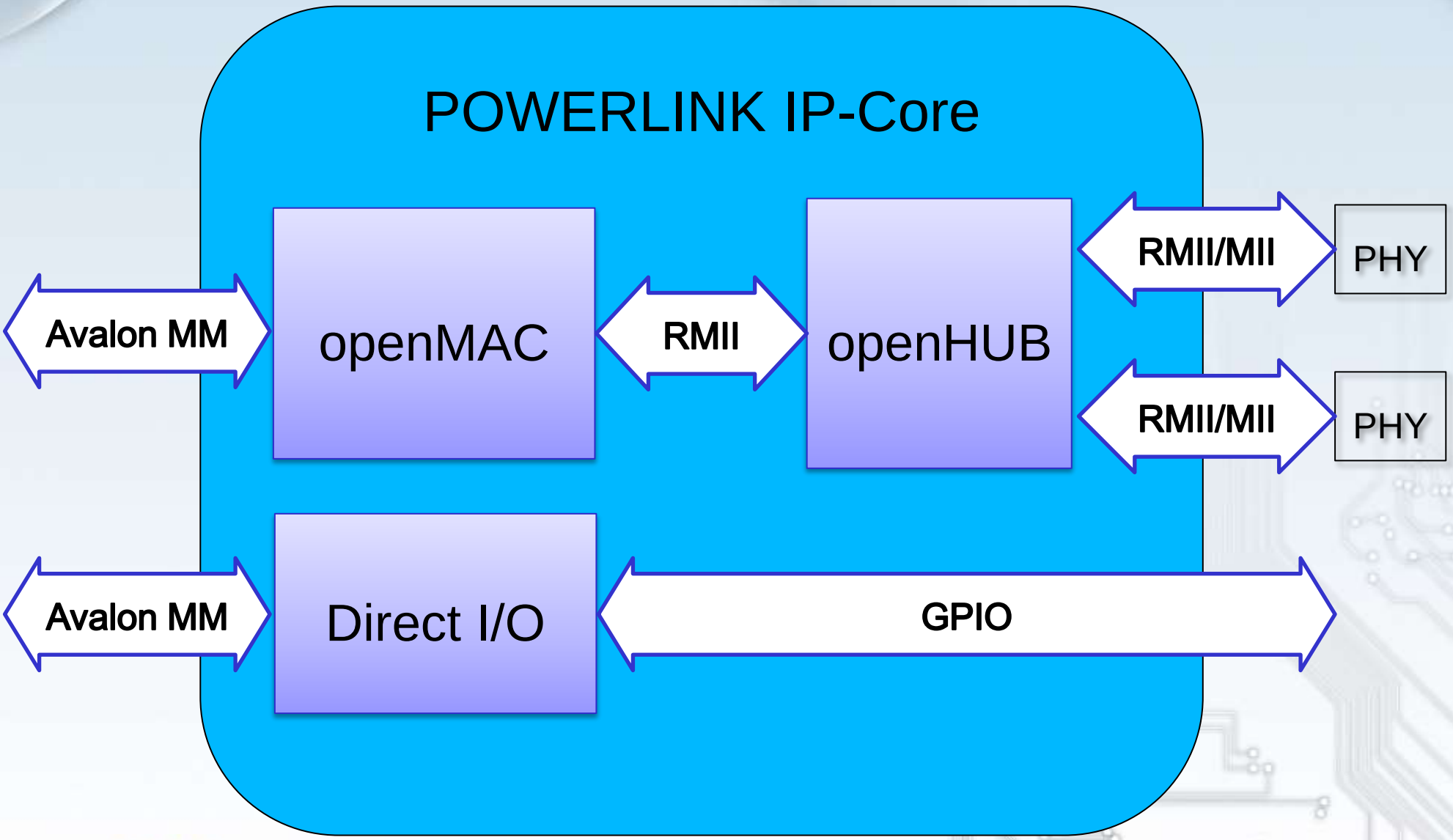
➔ Hilscher netX (integrated proprietary communication controller)

➔ VHDL implementation as open source available

FPGA

- Field Programmable Gate Array
  = coll. “programmable hardware”
- Vendors: Altera, Lattice, Xilinx, …
- Programming languages: VHDL and Verilog
- Higher level design tools for entire System-on-Chips with Soft CPUs and peripherals:
  e.g. Altera SOPC Builder / Qsys with NIOS II,
  Xilinx ISE with Microblaze

POWERLINK IP-Core



openMAC

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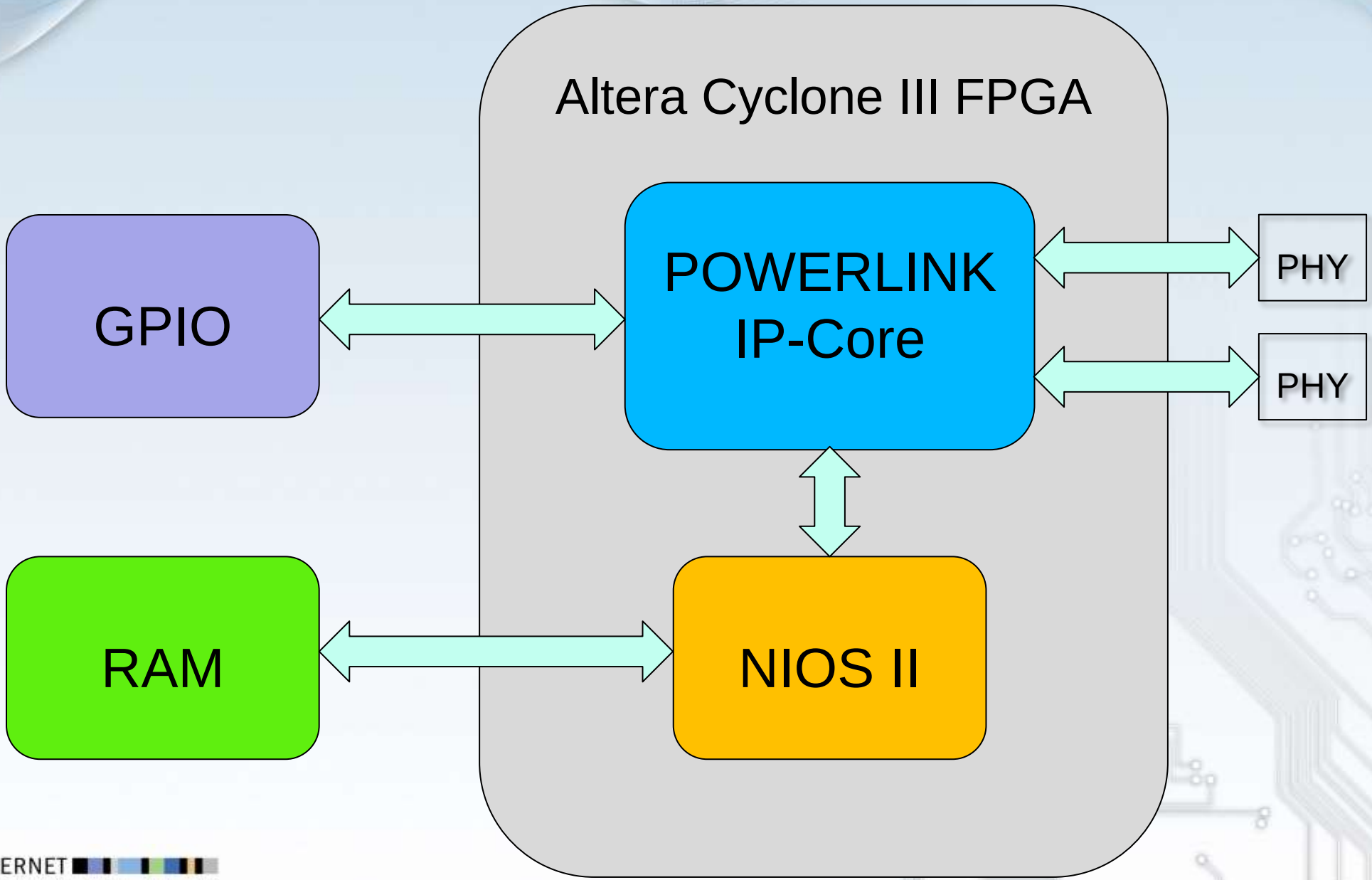
- VHDL source under BSD license
- 100 Mbit/s Ethernet controller with RMII
- 50 MHz clock design
- 16 Rx filters with 31 bytes value and mask
- 16 Rx descriptors
- 16 Tx descriptors
- Time stamping of Rx frames with 20 ns clock

FPGA Design


Altera Cyclone III FPGA
GPIO
POWERLINK
IP-Core
PHY
PHY
RAM
NIOS II

Advantages of FPGAs

- Determinism by clocked HW design
- Parallel processing
- Simple PCB with few components
- Flexibility: programmable hardware

References

[1] EPSG Draft Standard 301 Ethernet POWERLINK Communication Profile Specification, Version 1.1.0, Ethernet POWERLINK Standardisation Group, 2008

[2] EPSG Working Draft Proposal 302-C, Ethernet POWERLINK, Part C: PollResponse Chaining, Version 0.0.3, Ethernet POWERLINK Standardisation Group, 2009

[3] Ethernet POWERLINK Standardisation Group, http://www.ethernet-powerlink.org/

[4] openPOWERLINK, http://openpowerlink.sourceforge.net/

[5] openCONFIGURATOR, http://sourceforge.net/openconf

[6] CAN in Automation (CiA), http://www.can-cia.org/

[7] EPSG, Industrial Ethernet Facts – The 5 Major Technologies, Nov 2011, http://www.ethernet-powerlink.org/

The End

Any questions about FPGAs,
POWERLINK or
openPOWERLINK?

Thanks for your attention!

Backup Slides

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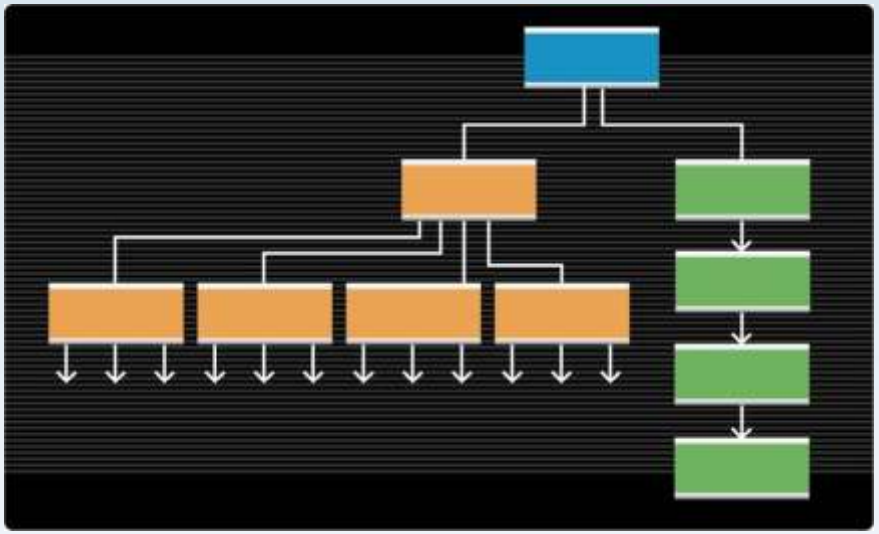
Topology



Possible Topologies:

- Star
- Line (daisy chain)
- Tree
- Mixed

Connectors:

- RJ45
- M12

Equipmer

- Hubs
- Switche