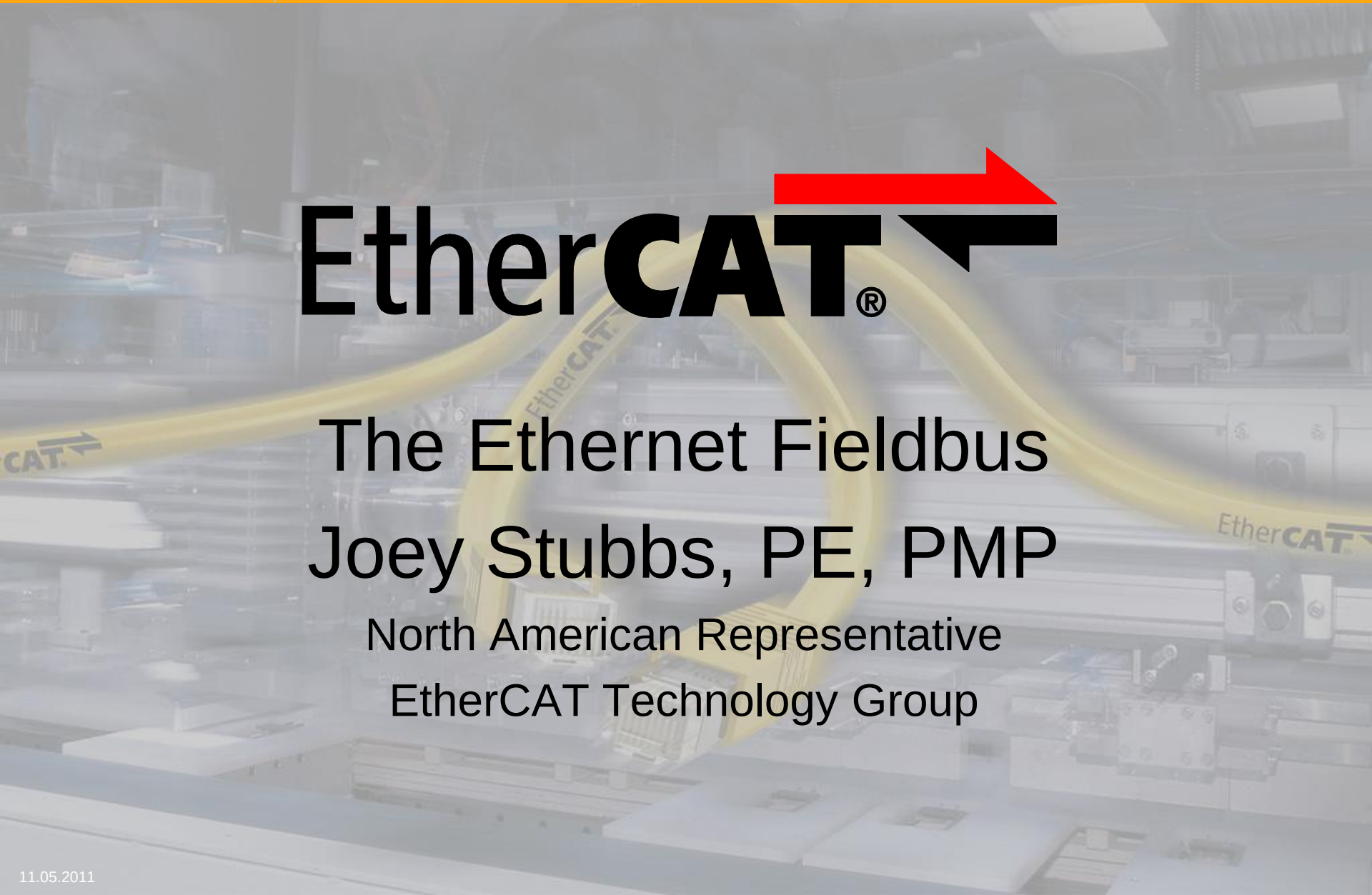
WELCOME!!!!!



The Ethernet Fieldbus

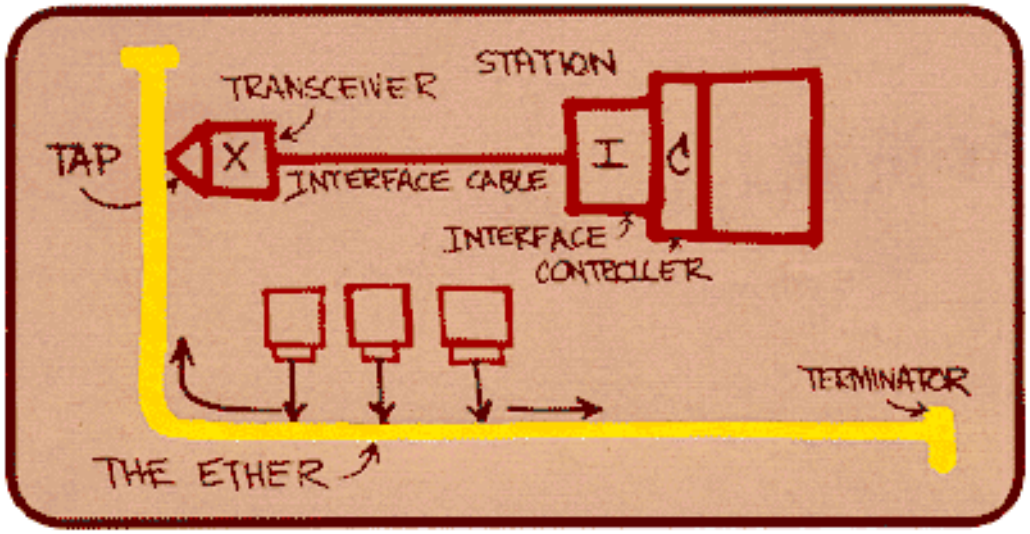
Joey Stubbs, PE, PMP

North American Representative

EtherCAT Technology Group

Ethernet Overview: CSMA/CD, TCP/IP & others

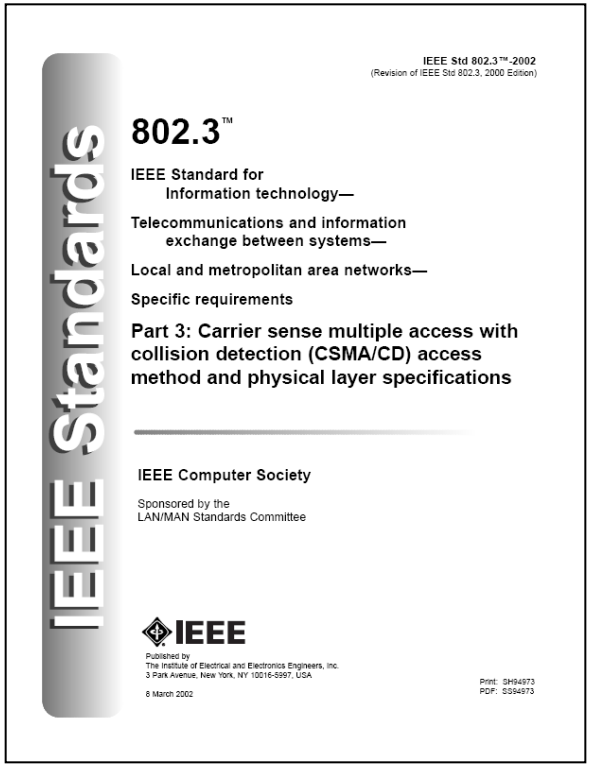
- Architecture
- Physical Layer: Signal, Cables + Wiring
- Media Access Control
- Name Resolution
- Routing
- IP, TCP + UDP



This diagram was hand drawn by Robert M. Metcalfe and photographed by Dave R. Boggs in 1976 to produce a 35mm slide used to present Ethernet to the National Computer Conference in June of that year. .

Ethernet Definition (Wikipedia)

- Ethernet is a frame-based computer networking technology for local area networks (LANs).
- It defines wiring and signaling for the physical layer, and frame formats and protocols for the media access control (MAC)/data link layer of the OSI model.
- Ethernet is mostly standardized as IEEE's 802.3.
- It has become the most widespread LAN technology in use during the 1990s to the present, and has largely replaced all other LAN standards such as token ring, FDDI, and ARCNET.



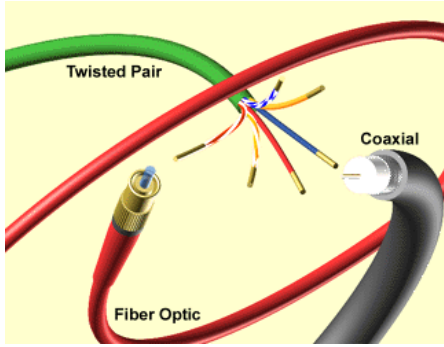
ISO/OSI, IEEE 802 and TCP/IP

ISO/OSI - Model		TCP/IP - Model	
7	**Application Layer** contains a variety of commonly used protocols, such as file transfer, virtual terminal, and email	5	**Application Layer:** **HTTP, FTP, rlogin, Telnet, DHCP,...**
6	**Presentation Layer** manages the syntax and semantics of the information transmitted between two computers		
5	**Session Layer** establishes and manages sessions, conversions, or dialogues between two computers		
4	**Transport Layer** splits data from the session layer into smaller packets for delivery on the network layer and ensures that the packets arrive correctly at the other end	4	**Transport Layer: TCP + UDP** Handles communication among programs on a network.
3	**Network Layer** controls the operation of a packet transmitted from one network to another, such as how to route a packet.	3	**Network Layer: IP (Internet Protocol),** This layer is used for basic communication, addressing and routing.
2	**Data Link Layer** transforms a stream of raw bits (0s and 1s) from the physical layer into an error-free data frame (packets) for the network layer	1/2	**Medium Access Control (MAC)** IEEE 802.3: CSMA/CD (Ethernet), 802.4 Token Bus (ARCnet), 802.5 Token Ring
1	**Physical Layer** transmits signals across a communication medium		Cables, cards and physical aspects: ISO/IEC 11801, parts also in IEEE 802.3

Ethernet Transmission Media (IEEE 802.3ak)

10BASE2	Thin coax
10BROAD36	Broadband DTE
10BASE-T	UTP, duplex mode unknown
10BASE-THD	UTP, half duplex mode
10BASE-TFD	UTP, full duplex mode
10BASE-FP	Passive fiber
10BASE-FB	Synchronous fiber
10BASE-FL	Asynchronous fiber, duplex mode unknown
10BASE-FLHD	Asynchronous fiber, half duplex mode
10BASE-FLFD	Asynchronous fiber, full duplex mode
100BASE-T4	Four-pair Category 3 UTP
100BASE-TX	**Two-pair Category 5 UTP, duplex mode unknown**
100BASE-TXHD	Two-pair Category 5 UTP, half duplex mode
100BASE-TXFD	Two-pair Category 5 UTP, full duplex mode
100BASE-FX	X fiber over PMD, duplex mode unknown
100BASE-FXHD	X fiber over PMD, half duplex mode
100BASE-FXFD	X fiber over PMD, full duplex mode
100BASE-T2	Two-pair Category 3 UTP, duplex mode unknown
100BASE-T2HD	Two-pair Category 3 UTP, half duplex mode
100BASE-T2FD	Two-pair Category 3 UTP, full duplex mode
1000BASE-X	X PCS/PMA over undefined PMD, duplex mode unknown
1000BASE-XHD	X PCS/PMA over undefined PMD, half duplex mode
1000BASE-XFD	X PCS/PMA over undefined PMD, full duplex mode
1000BASE-LX	X fiber over long-wavelength laser PMD, duplex mode unknown
1000BASE-LXHD	X fiber over long-wavelength laser PMD, half duplex mode
1000BASE-LXFD	X fiber over long-wavelength laser PMD, full duplex mode
1000BASE-SX	X fiber over short-wavelength laser PMD, duplex mode unknown
1000BASE-SXHD	X fiber over short-wavelength laser PMD, half duplex mode
1000BASE-SXFD	X fiber over short-wavelength laser PMD, full duplex mode
1000BASE-CX	X copper over 150-Ohm balanced cable PMD, duplex mode unknown
1000BASE-CXHD	X copper over 150-Ohm balanced cable PMD, half duplex mode
1000BASE-CXFD	X copper over 150-Ohm balanced cable PMD, full duplex mode
1000BASE-T	Four-pair Category 5 UTP PHY, duplex mode unknown
1000BASE-THD	Four-pair Category 5 UTP PHY, half duplexmode
1000BASE-TFD	Four-pair Category 5 UTP PHY, full duplex mode
10GBASE-X	X PCS/PMA over undefined PMD
10GBASE-LX4	X fibre over 4 lane 1310nm optics
10GBASE-CX4	X copper over 8 pair 100-Ohm balanced cable
10GBASE-R	R PCS/PMA over undefined PMD
10GBASE-ER	R fibre over 1550nm optics
10GBASE-LR	R fibre over 1310nm optics
10GBASE-SR	R fibre over 850nm optics
10GBASE-W	W PCS/PMA over undefined PMD
10GBASE-EW	W fibre over 1550nm optics
10GBASE-LW	W fibre over 1310nm optics
10GBASE-SW	W fibre over 850nm optics

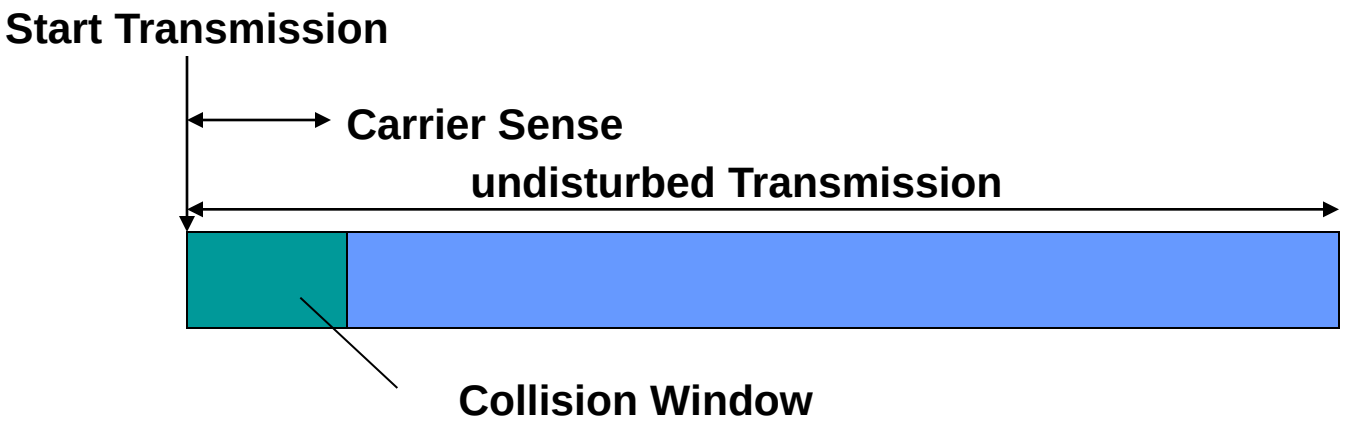
Large variety of physical layers



IEEE 802.3: Media Access Control CSMA/CD

"Carrier-Sense Multiple-Access with Collision-Detection“

- The node that wants to send checks if the media is available
  “Carrier-Sense“
- All nodes are equal and may send autonomously "Multiple-Access“
- The sender checks after sending if there was a collision
  "Collision-Detection“
- maximum Ethernet propagation delay: 25,6µs (10MBit/s)
  (determined by cable length & repeater delays)



Media Access Control CSMA/CD

Carrier

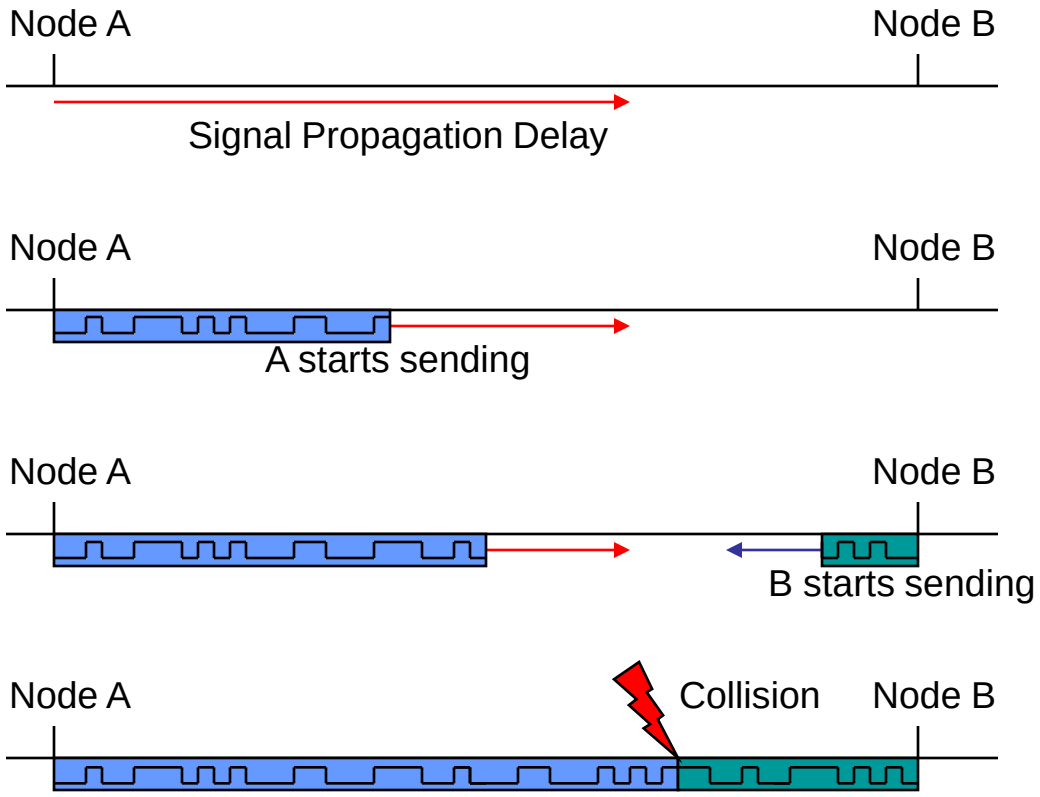
Sense

Multiple

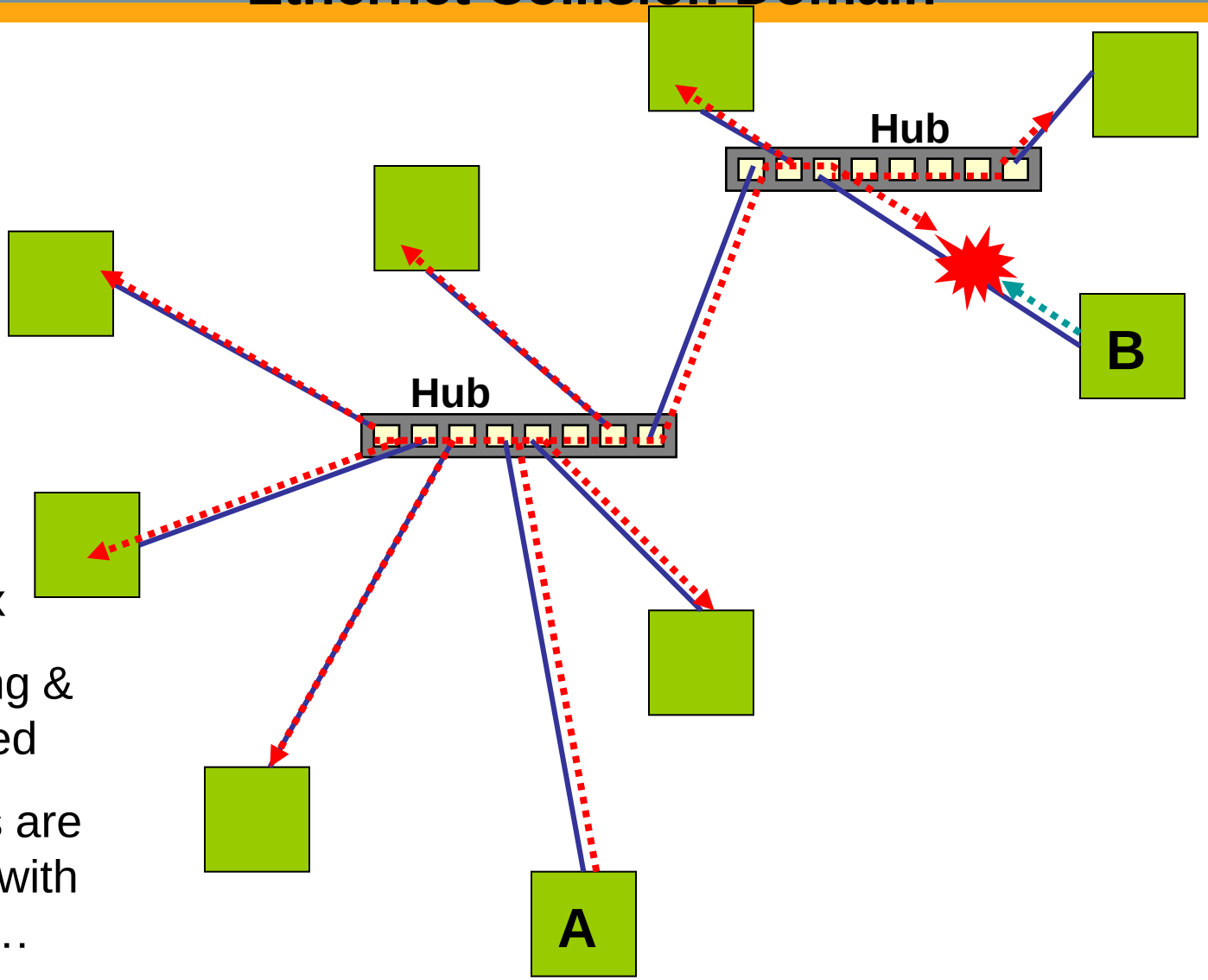
Access /

Collision

Detection



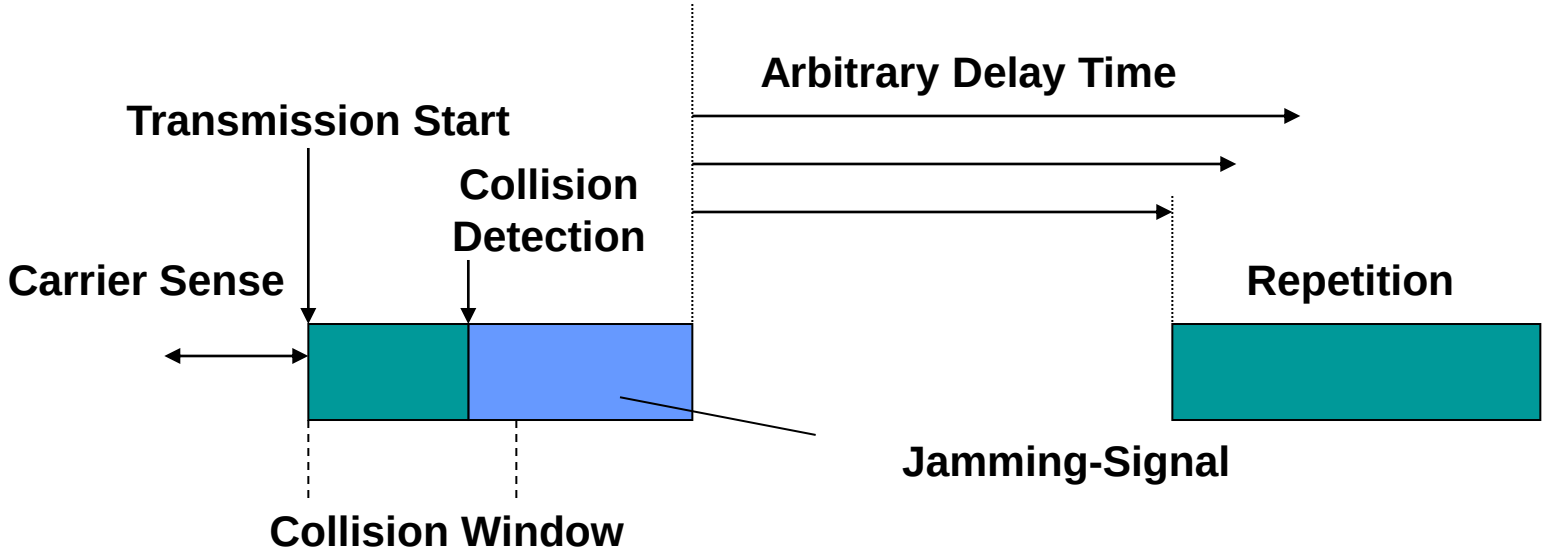
Ethernet Collision Domain



- Hubs
- half duplex
- Hub Cascading & Length limited
- Some vendors are not compliant with these rules…

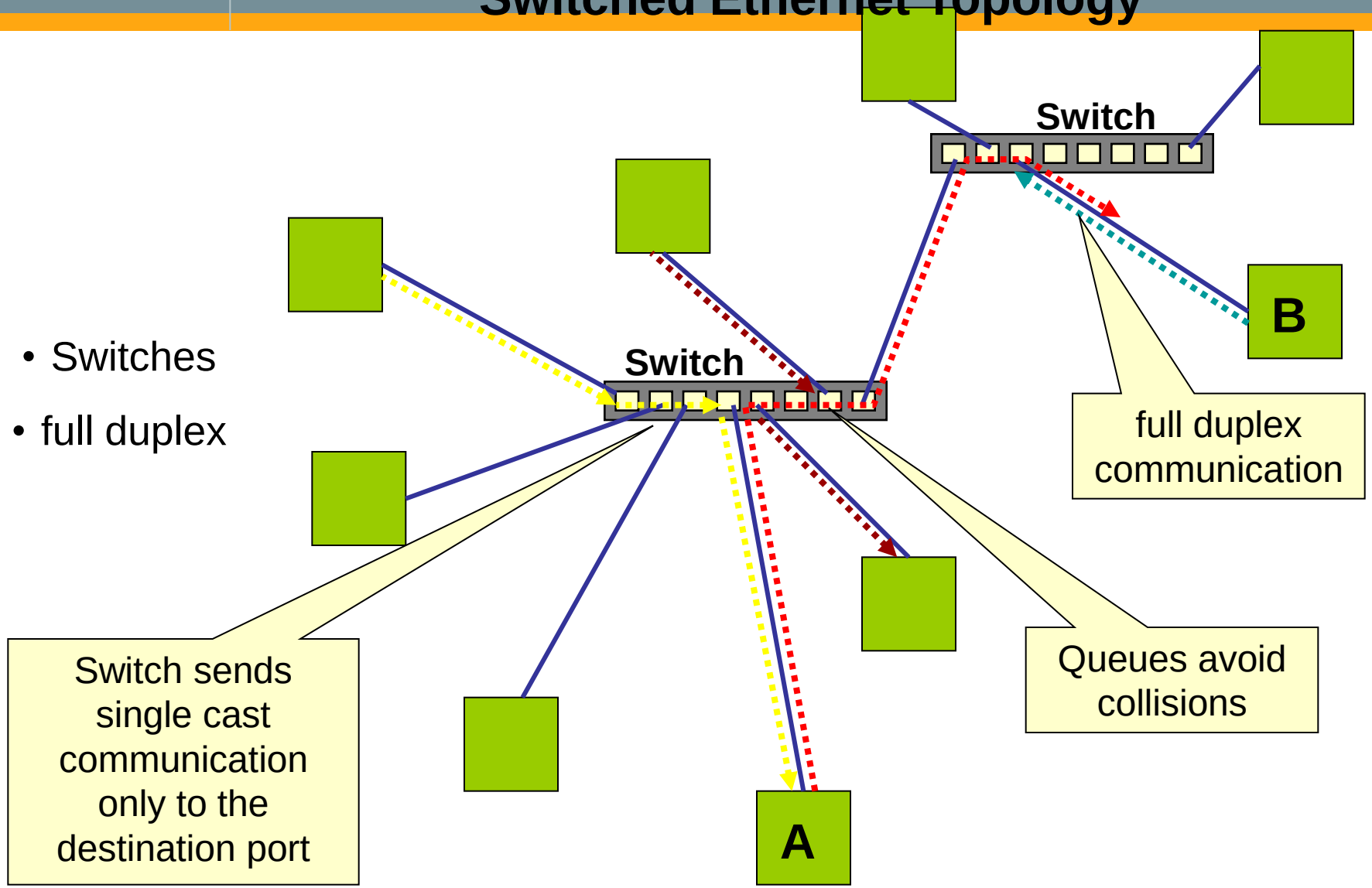
Collision Recovery

- “Jamming Signal“
  consists of 4-6 Byte 0xFF and is sent after detecting a collision
- Delay time before repetition:
  - First Collision 9,6us + x * 51,2us [x=0 ,1] 50%
  - Second Collision 9,6us + x * 51,2us [x=0 ,1, 2, 3] 75%
  - ...Sixth Collision 9,6us + x * 51,2us [x=0 ,1, 2,...1023] 99,9%

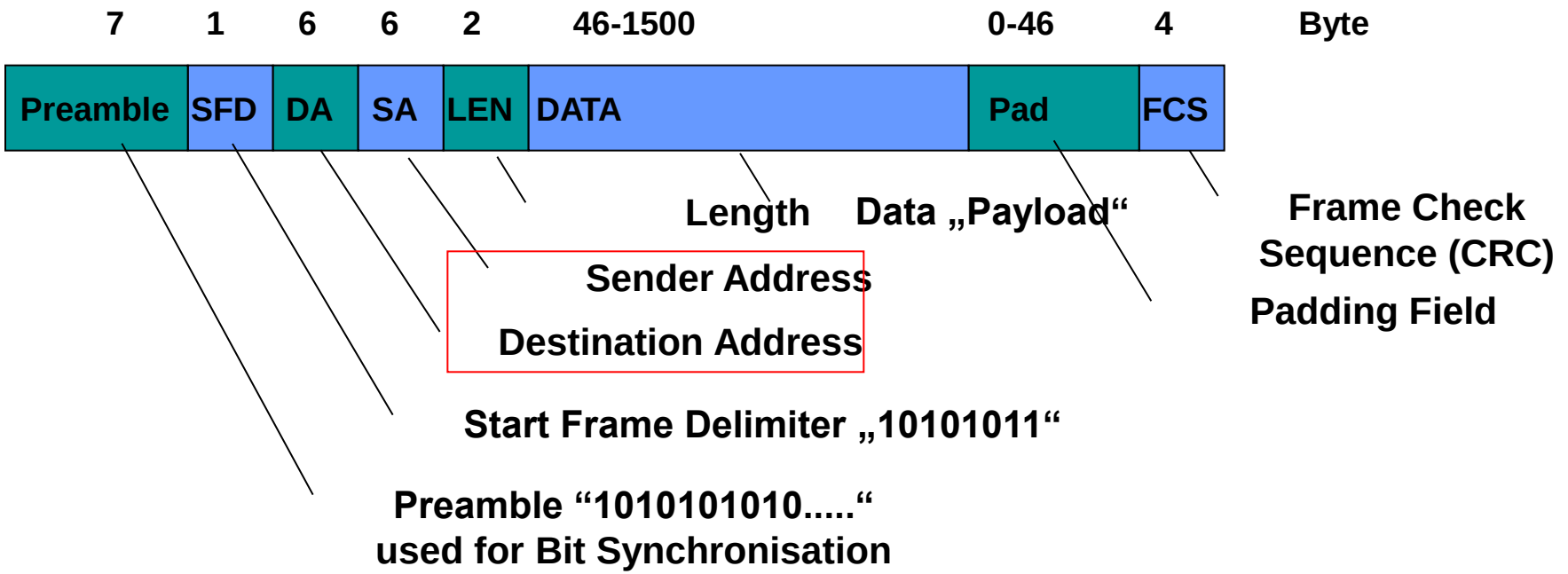


Switched Ethernet Topology

- Switches
- full duplex



Ethernet Packet



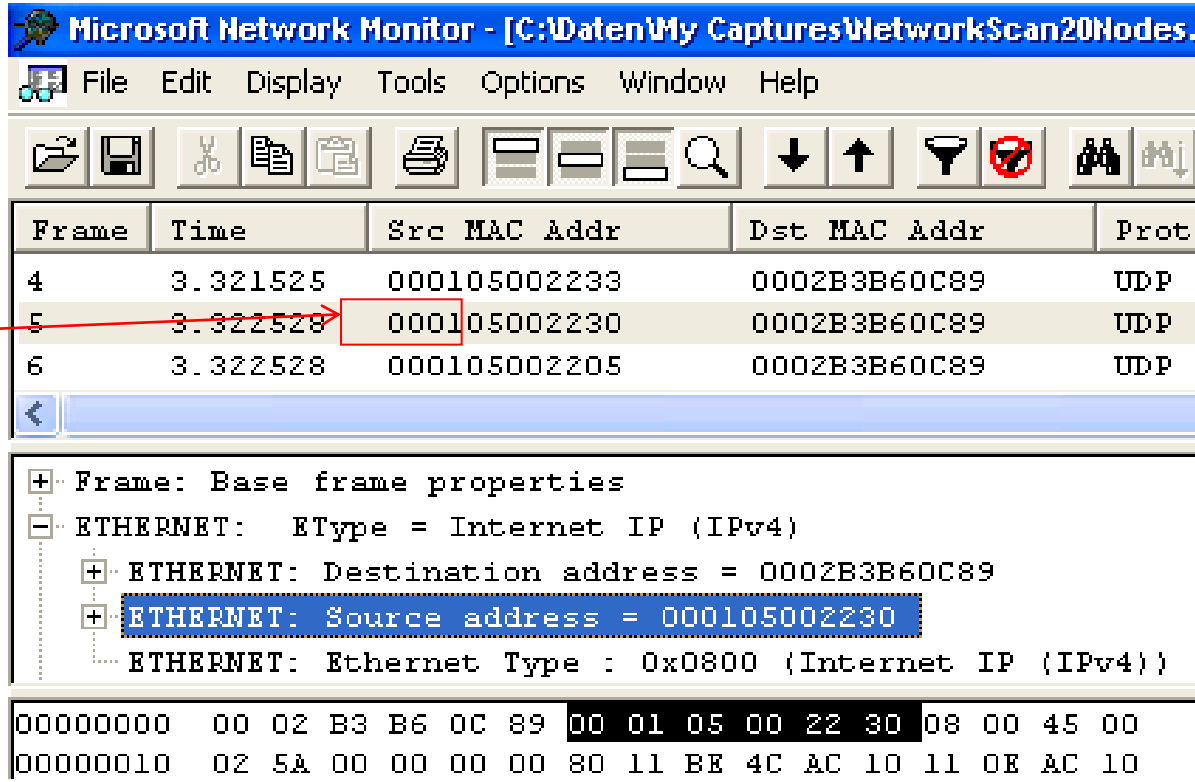
- The Length Byte has two meanings: if it is >0x5DC then it describes the type of the “payload“ (Ethertype. e.g. IP 0x0800 or ARP 0x0806 or EtherCAT 0x88A4)
- If the data length is <46 Byte, Padding Bytes are introduced to achieve a minimum length of 46 Bytes (for collision detection)

Ethernet MAC-ID

„Medium Access Control Address“

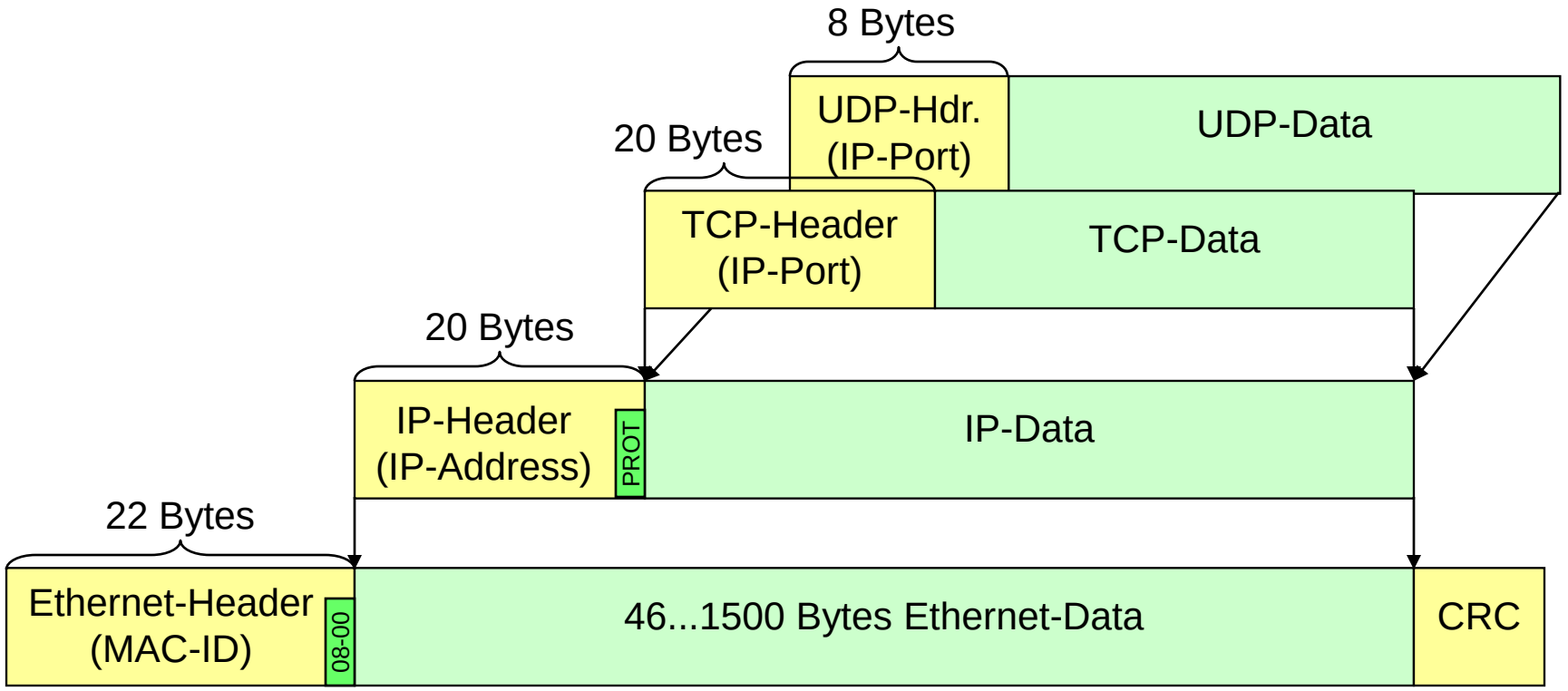
- MAC-ID has to be unique
- Two Fields of 3 Bytes:
  - 1. OUI (Organizationally Unique Identifier)
  - 2. Serial Number
- The OUI is assigned by the IEEE Standards Department (USA)
- e.g. Beckhoff OUI :
  - 00 01 05 -

  http://standards.ieee.org/regauth/oui/index.shtml



Ethernet -TCP/IP Stack

- Structure allows one to exchange protocol layers



Transport Layer Protocols

These protocols are assigned an IP Protocol number .

- AH, IP Authentication Header.
- AX.25.
- CBT, Core Based Trees.
- DVMRP, Distance Vector Multicast Routing Protocol.
- EGP, Exterior Gateway Protocol.
- ESP, Encapsulating Security Payload.
- GGP, Gateway to Gateway Protocol.
- GRE, Generic Routing Encapsulation.
- HMP, Host Monitoring Protocol.
- ICMP, Internet Control Message Protocol.
- ICMPv6, Internet Control Message Protocol for IPv6.
- IDPR, Inter-Domain Policy Routing Protocol.
- IFMP, Ipsilon Flow Management Protocol.
- IGAP, IGMP for user Authentication Protocol.
- IGMP, Internet Group Management Protocol.
- IGRP, Interior Gateway Routing Protocol.
- IP in IP Encapsulation.
- IPPCP, IP Payload Compression Protocol.
- IRTP, Internet Reliable Transaction Protocol.
- ISO-IP.
- L2TP, Level 2 Tunneling Protocol.
- Minimal Encapsulation Protocol.
- MLD, Multicast Listener Discovery.
- Mobility Header
- MOSPF, Multicast Open Shortest Path First.
- MTP, Multicast Transport Protocol.
- NARP, NBMA Address Resolution Protocol.
- NETBLT, Network Block Transfer.
- NVP, Network Voice Protocol.
- OSPF, Open Shortest Path First Routing Protocol.
- PGM, Pragmatic General Multicast.
- PIM, Protocol Independent Multicast.
- PTP, Performance Transparency Protocol.
- RDP, Reliable Data Protocol.
- RSVP, Resource ReSerVation Protocol.
- SCTP, Stream Control Transmission Protocol.
- SEND, SEcure Neighbor Discovery.
- SDRP, Source Demand Routing Protocol.
- SKIP, Simple Key management for Internet Protocol.
- ST, Internet Stream Protocol.
- TCP, Transmission Control Protocol.
- TMux, Transport Multiplexing Protocol.
- TP/IX.
- UDP, User Datagram Protocol.
- UDP-Lite, Lightweight User Datagram Protocol.
- VMTP, Versatile Message Transaction Protocol.
- VRRP, Virtual Router Redundancy Protocol.

Application Layer Protocols (I)

These protocols are assigned one or more SCTP, TCP or UDP port numbers.

- ACAP, Application Configuration Access Protocol.
- AgentX.
- AODV, Ad hoc On-Demand Distance Vector.
- APEX, Application Exchange Core.
- ATMP, Ascend Tunnel Management Protocol.
- AURP, AppleTalk Update-based Routing Protocol.
- Authentication Server Protocol.
- BFTP, Background File Transfer Program.
- BGP, Border Gateway Protocol.
- BOOTP, Bootstrap Protocol.
- CFDP, Coherent File Distribution Protocol.
- Chargen, Character Generator Protocol.
- CLDAP, Connection-less Lightweight X.500 Directory Access Protocol.
- COPS, Common Open Policy Service.
- CRANE, Common Reliable Accounting for Network Element.
- Daytime, Daytime Protocol.
- DCAP, Data Link Switching Client Access Protocol.
- DHCP, Dynamic Host Configuration Protocol.
- DHCPv6, Dynamic Host Configuration Protocol for IPv6.
- DIAMETER.
- DICT, Dictionary Server Protocol.
- Discard, Discard Protocol.
- DIXIE.
- DMSP, Distributed Mail Service Protocol.
- DNS, Domain Name System.
- DRAP, Data Link Switching Remote Access Protocol.
- DTCP, Dynamic Tunnel Configuration Protocol.
- Echo.
- EMSD, Efficient Mail Submission and Delivery.
- EPP, Extensible Provisioning Protocol.
- ESRO, Efficient Short Remote Operations.
- ETFTP, Enhanced Trivial File Transfer Protocol.
- Finger.
- FTP, File Transfer Protocol.
- GDOI, Group Domain of Interpretation.
- Gopher.
- HOSTNAME.
- HSRP, Hot Standby Router Protocol.
- HTTP, HyperText Transfer Protocol.
- ICAP, Internet Content Adaptation Protocol.
- ICP, Internet Cache Protocol.
- iFCP, Internet Fibre Channel Protocol.
- IKE, Internet Key Exchange.
- IMAP, Interactive Mail Access Protocol.

Application Layer Protocols (II)

- IPFIX, IP Flow Information Export.
- IPP, Internet Printing Protocol.
- IRC, Internet Relay Chat.
- ISAKMP, Internet Security Association and Key Management Protocol.
- iSCSI.
- IUA, ISDN Q.921-User Adaptation.
- Kerberos.
- Kermit.
- L2F, Layer 2 Forwarding.
- L2TP, Level 2 Tunneling Protocol.
- LDAP, Lightweight Directory Access Protocol.
- LDP, Label Distribution Protocol.
- LDP, Loader Debugger Protocol.
- LFAP, Light-weight Flow Admission Protocol.
- LMTP, Local Mail Transfer Protocol.
- LPR.
- MADCAP, Multicast Address Dynamic Client Allocation Protocol.
- MASC, Multicast Address-Set Claim.
- MATIP, Mapping of Airline Traffic over Internet Protocol.
- Mbus, Message Bus.
- MGCP, Multimedia Gateway Control Protocol.
- Mobile IP.
- MPP, Message Posting Protocol.
- MSDP, Multicast Source Discovery Protocol.
- MTP, Mail Transfer Protocol.
- MTQP, Message Tracking Query Protocol.
- MUPDATE, Malbox Update.
- NAS, Netnews Administration System.
- NFILE.
- NFS, Network File System.
- NNTP, Network News Transfer Protocol.
- NTP, Network Time Protocol.
- ODETTE-FTP, ODETTE File Transfer Protocol.
- OLSR, Optimized Link State Routing.
- Ph.
- Photuris.
- POP, Post Office Protocol.
- Portmapper.
- PPTP, Point to Point Tunneling Protocol.
- PWDGEN, Password Generator Protocol.
- Quote, Quote of the Day Protocol.
- RADIUS, Remote Authentication Dial-In User Service.
- RAP, Internet Route Access Protocol.
- RIP, Routing Information Protocol.

Application Layer Protocols (III)

- RIPng.
- Rlogin.
- RLP, Resource Location Protocol.
- RMCP, Remote Mail Checking Protocol.
- RSIP, Realm Specific IP.
- RTCP, RTP Control Protocol.
- RTP, Real-Time Transport Protocol.
- RTSP, Real Time Streaming Protocol.
- RWhois, Referral Whois Protocol.
- SACRED, Securely Available Credentials.
- Send, Message Send Protocol.
- SFTP, Simple File Transfer Protocol.
- SGMP, Simple Gateway Monitoring Protocol.
- SIFT/UFT, Sender-Initiated/Unsolicited File Transfer.
- SIP, Session Initiation Protocol.
- SLP, Service Location Protocol.
- SMTP, Simple Mail Transfer Protocol.
- SMUX.
- SNMP, Simple Network Management Protocol.
- SNPP, Simple Network Paging Protocol.
- SNTP, Simple Network Time Protocol.
- SOCKS.
- SRTCP, Secure RTCP.
- SRTP, Secure Real-time Transport Protocol.
- SSP, Switch-to-Switch Protocol.
- STATSRV, Statistics Server.
- STUN, Simple Traversal of UDP Through NAT.
- SUA, Signalling Connection Control Part User Adaptation Layer.
- Syslog.
- SYSTAT.
- TACACS.
- TBRPF, Topology Broadcast based on Reverse-Path Forwarding.
- Telnet.
- TFTP, Trivial File Transfer Protocol.
- Time, Time Protocol.
- TRIP, Telephone Routing over IP.
- TSP, Time Stamp Protocol.
- TUNNEL.
- UMSP, Unified Memory Space Protocol.
- UUCP.
- VEMMI, VErsatile MultiMedia Interface.
- WebDAV, Web Distributed Authoring and Versioning.
- Whois.
- Whois++.
- Z39.50.

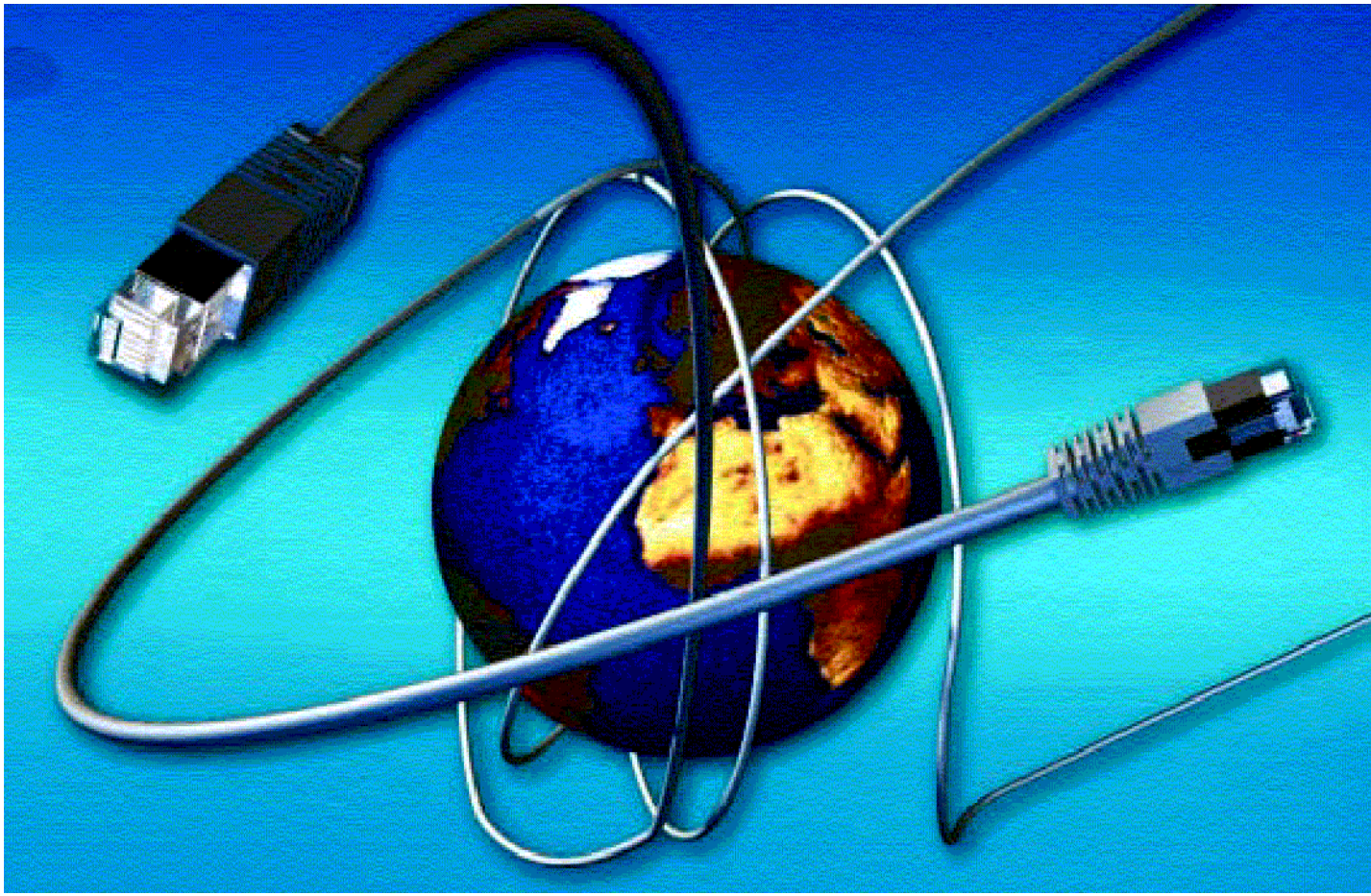
Ethernet Introduction: Summary

- Ethernet is the technology described in the IEEE 802.3 standards
- The term “Ethernet“ is mistakingly used for a suite of network technologies: Ethernet, IP, TCP, UDP, FTP, HTTP and more, which are also referred to as the “Internet Technologies“
- Stacking of protocol layers – and thus tunneling of protocols – is a key feature of the Internet Technologies.
- Ethernet is used on a large variety of physical layers.
- Switching topologies have replaced collision domains – CSMA/CD is legacy technology, hubs are outdated.
- TCP/IP is a powerful protocol implemented in rather complex software stacks.

Okay, Let's talk about EtherCAT

EtherCAT is:

- Faster
- Synchronization
- Industrial Ethernet
- Flexible
- Easier to configure
- Cost effective
- Easier to implement
- Well proven
- Open
- Conformance
- Safety
- Redundancy
- Versatile



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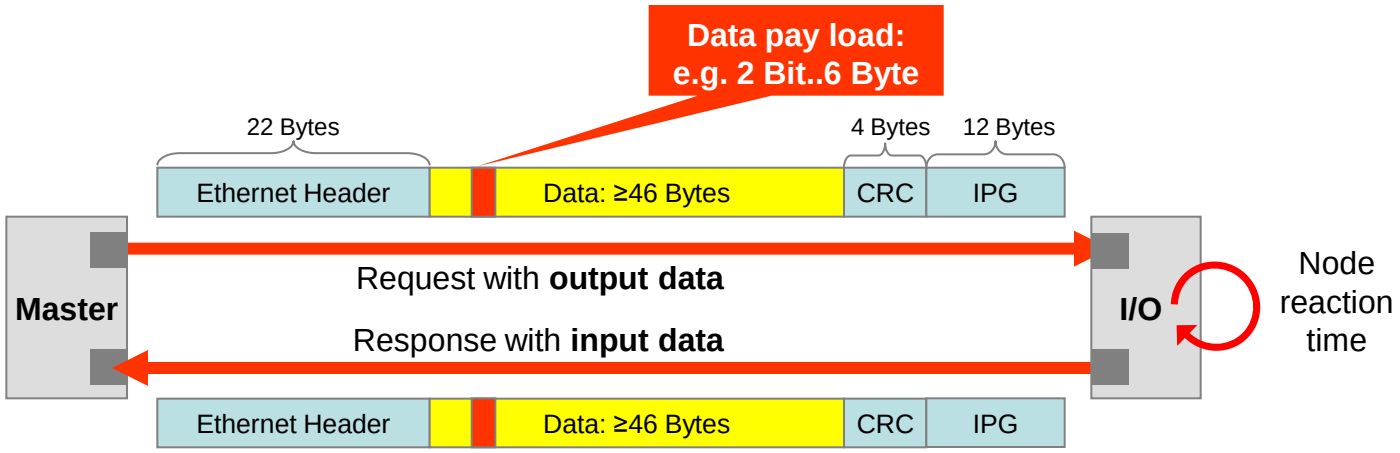
- Bandwidth Usage of Ethernet for I/O and Drives:
  - Ethernet Frame: ≥ 84 Bytes
    incl. Preamble + IPG (interpacket gap)



  - with 4 Byte input + 4 Byte output per node:
    - **4.75%** application data ratio at **0 µs** reaction time/node
    - **1.9%** application data ratio at **10 µs** reaction time/node

Polling: Functional Principle (Modbus TCP example)

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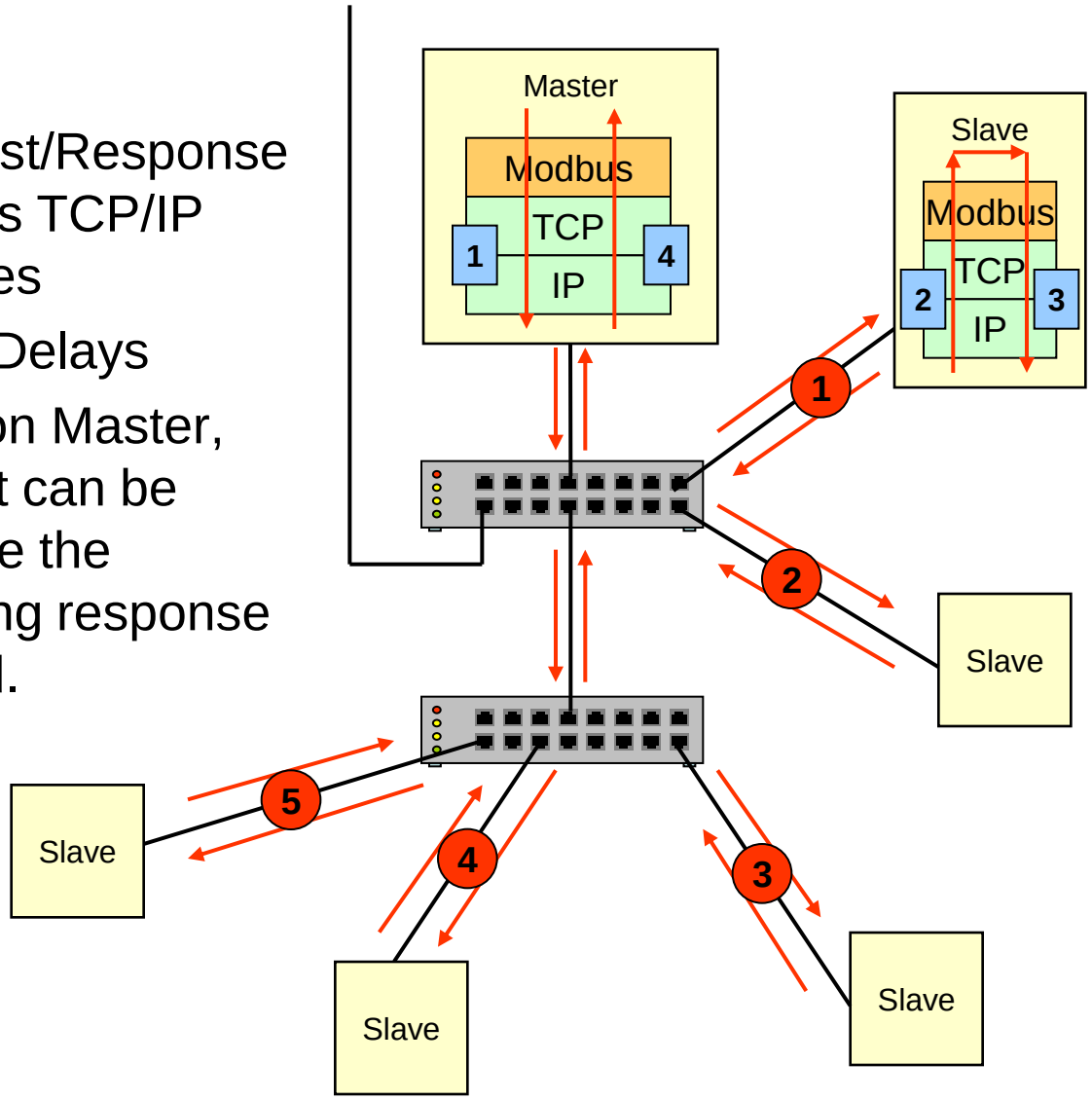
- Polling
- Each Request/Response Cycle passes TCP/IP Stack 4 Times
- plus Switch Delays
- Depending on Master, Poll Request can be issued before the corresponding response has returned.



Frame Processing within each node

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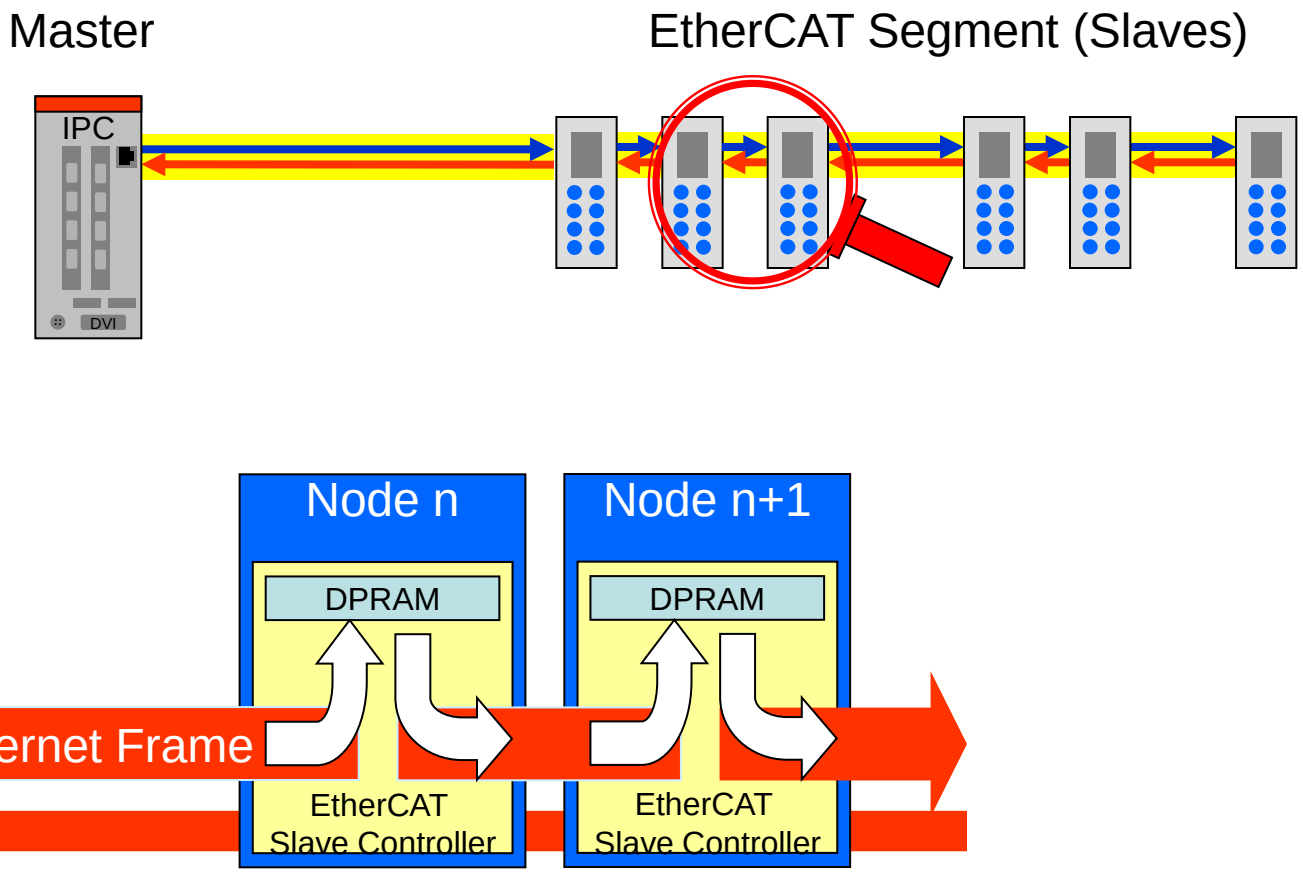

Functional Principle: Ethernet “on the fly”

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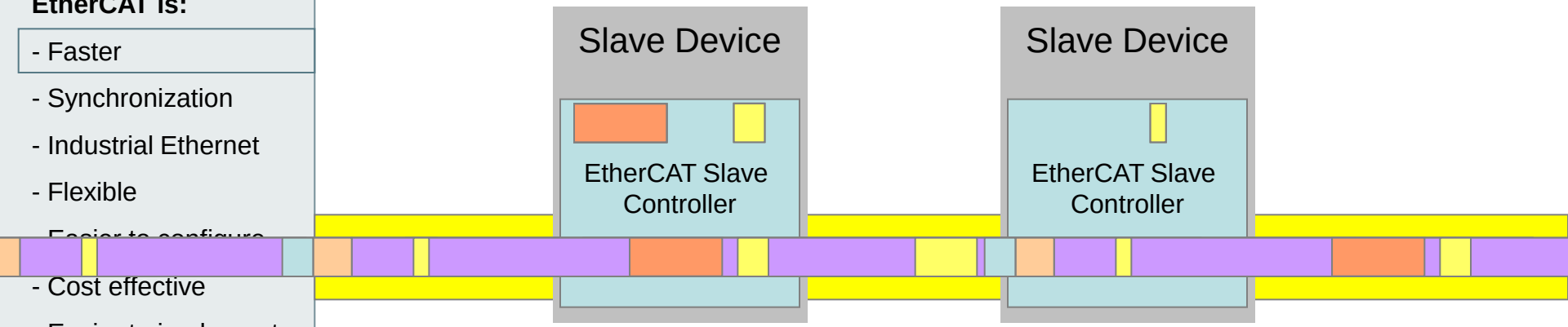

- Process data is extracted and inserted on the fly:
  - Process data size per slave almost unlimited (1 Bit…60 Kbyte, if needed using several frames)
  - Compilation of process data can change in each cycle, e.g. ultra short cycle time for axis, and longer cycles for I/O update possible
  - in addition asynchronous, event triggered communication

Frame Processing Order on the System

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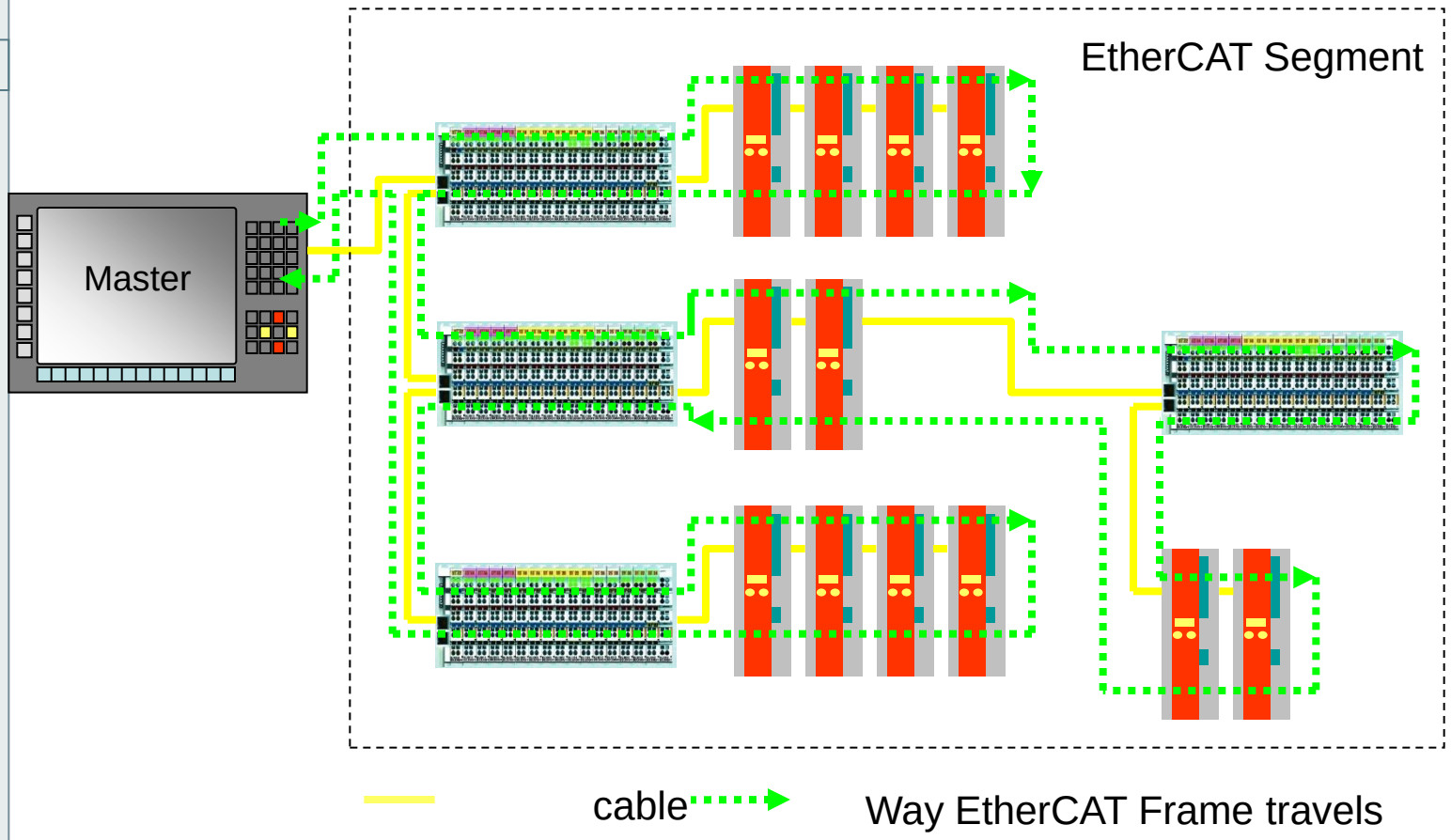

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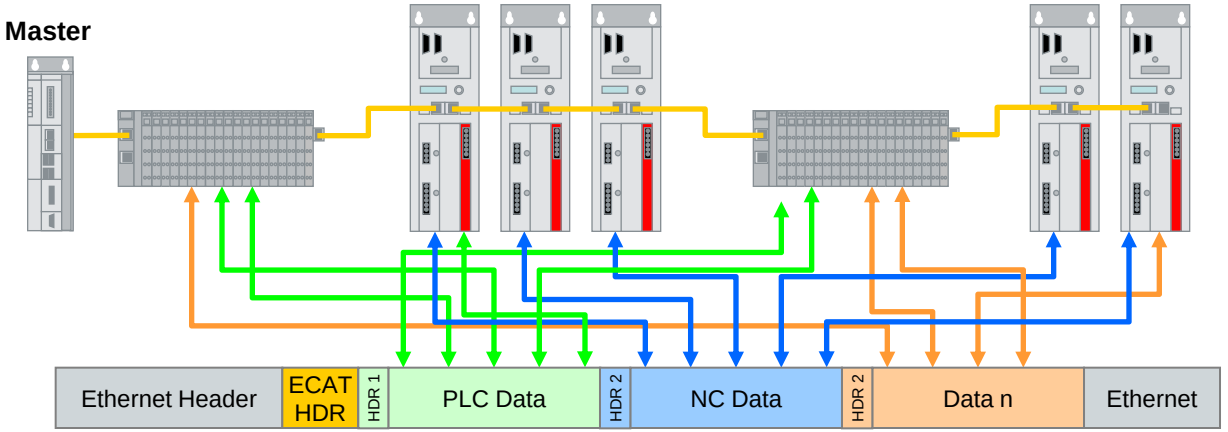

- Minimal protocol overhead via implicit addressing
  - Optimized telegram structure for decentralized I/O
  - Communication completely in hardware: maximum (+ predictable!) performance
  - No switches needed if only EtherCAT devices in the network
  - Outstanding diagnostic features
  - Ethernet-compatibility maintained

EtherCAT - The Ethernet Fieldbus.

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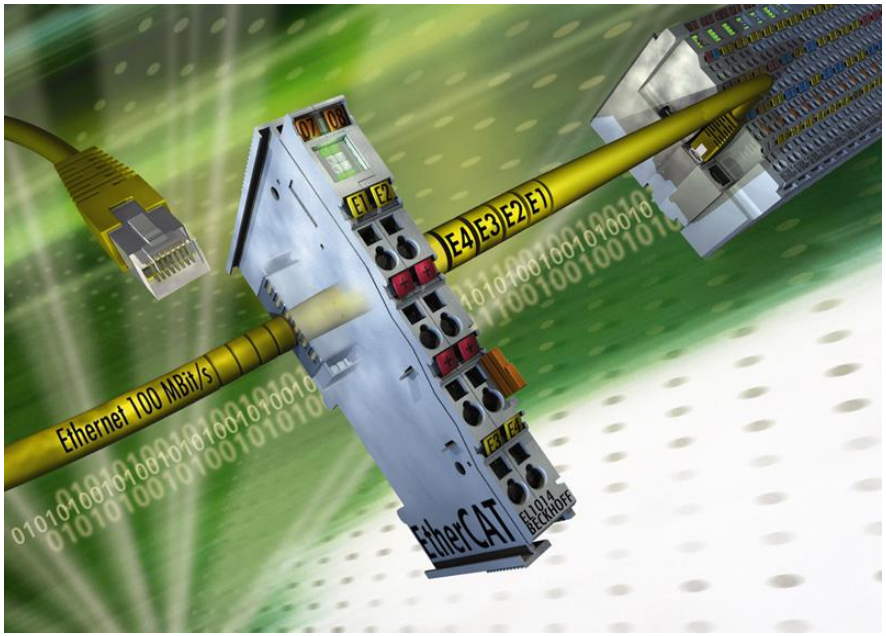
- EtherCAT is real time down to the I/O level
- No underlying sub-systems any more
- No delays in gateways
- In- and outputs, sensors, actuators, drives, displays: **everything in one system!**



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- Transmission Rate:
  - 2 x 100 Mbit/s (Fast Ethernet, Full-Duplex)

- Update Times:
  - 256 digital I/O in 11 µs
  - **1000 digital I/O** distributed to 100 nodes in **30 µs** = 0.03 ms
  - 200 analog I/O (16 bit) in 50 µs, 20 kHz Sampling Rate
  - **100 Servo-Axis** (each 8 Byte In + Out) in **100 µs** = 0.1 ms
  - 12000 digital I/O in 350 µs

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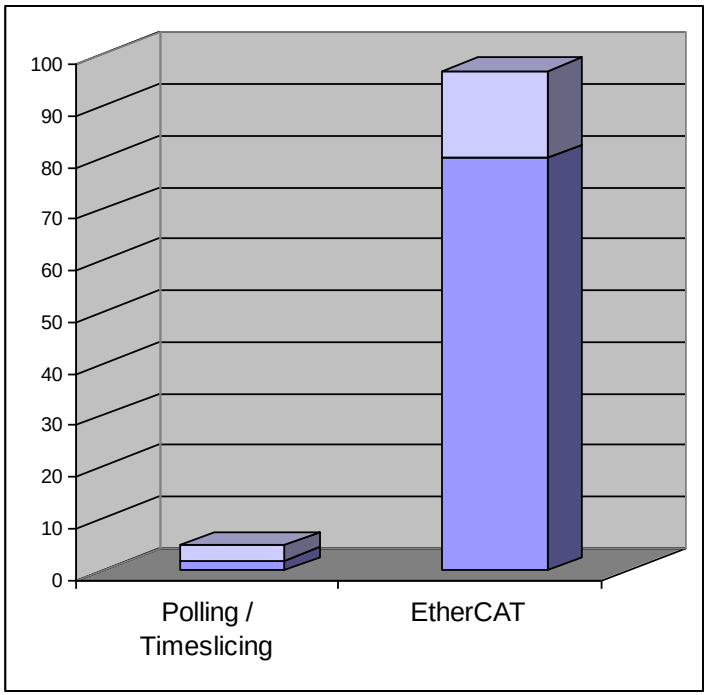
- Cost effective
- Easier to implement
- Well proven
- Open
- Conformance
- Safety
- Redundancy
- Versatile

- Bandwidth Usage Comparison:
  - At 4 Byte user data per node:
    - Polling / Timeslicing: ~ 2..5 %
  - From 2 Bit user data per node:
    - **EtherCAT: ~ 80..97 % (Full Duplex, 2 x 100 MBit/s)**



Performance: Application Example

EtherCAT is:

- Faster
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- Industrial Ethernet
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- Cost effective
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- Redundancy
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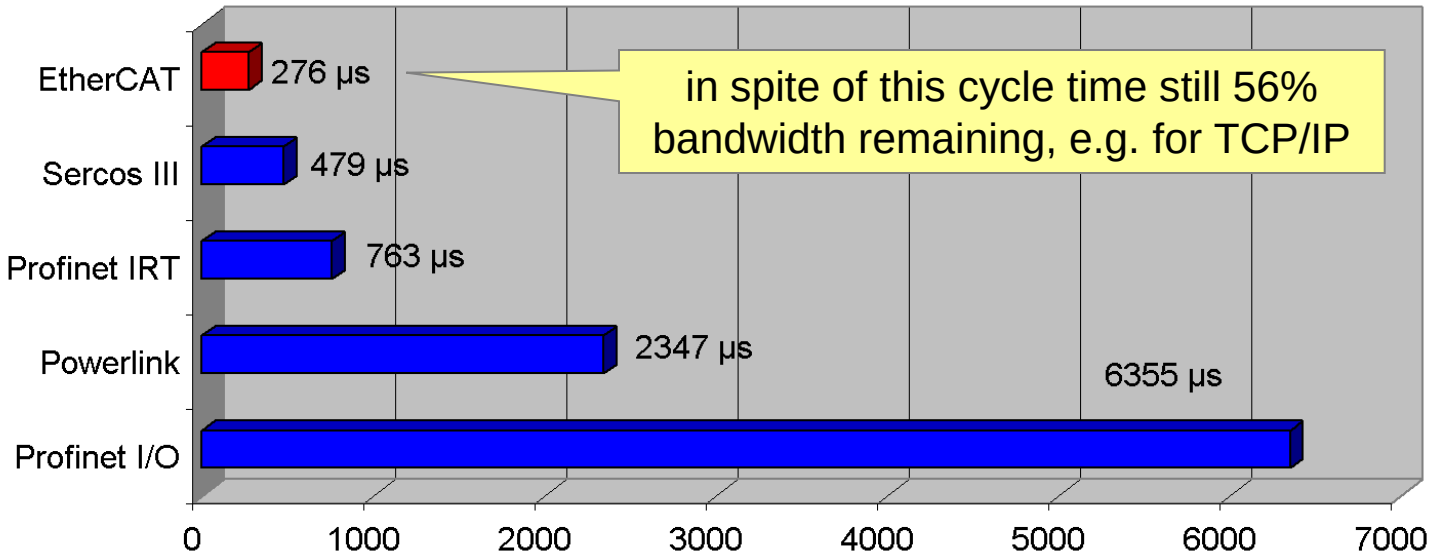
- 40 Axis (each 20 Byte Input- and Output-Data)
- 50 I/O Station with a total of 560 EtherCAT Bus Terminals
- 2000 Digital + 200 Analog I/O, Bus Length 500 m
- Performance EtherCAT: **Cycle Time = 276 µs** at 44 % Bus Load, **Telegram Length = 122 µs**



EtherCAT Distributed Clocks

EtherCAT is:

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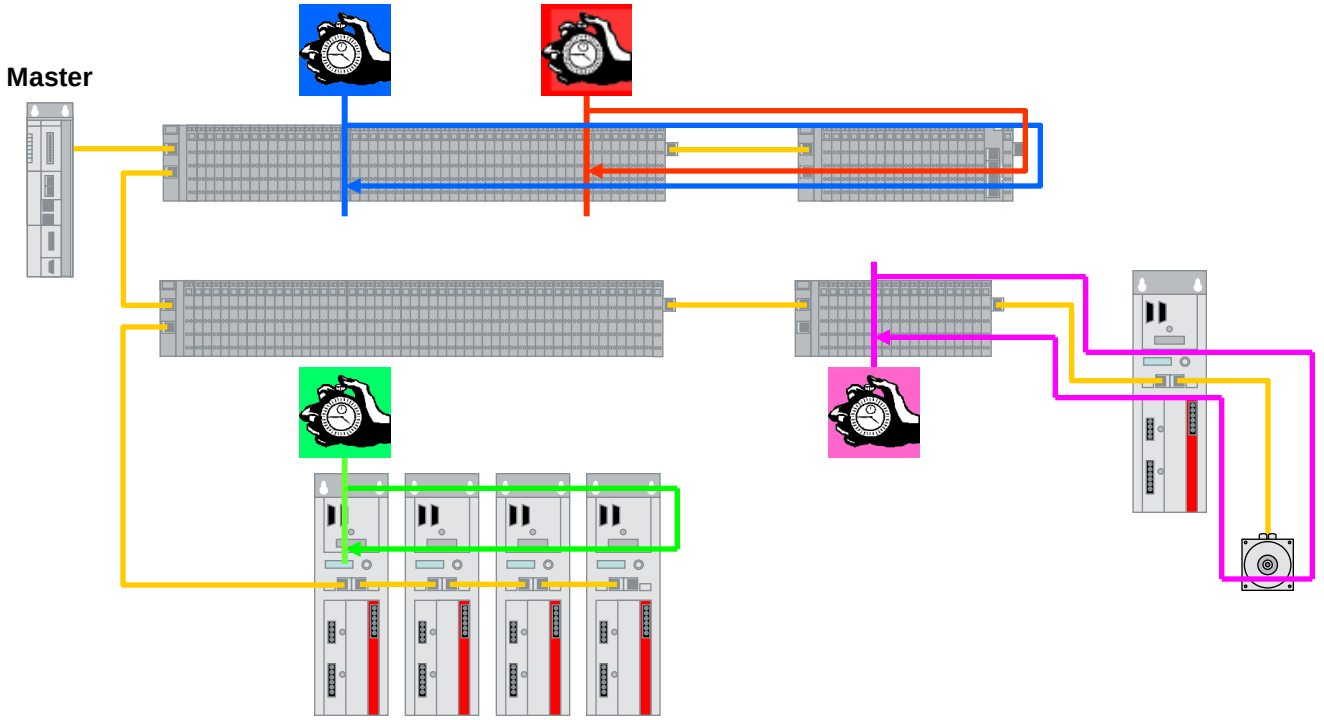
- EtherCAT Node measures time difference between leaving and returning frame



Distributed Clocks

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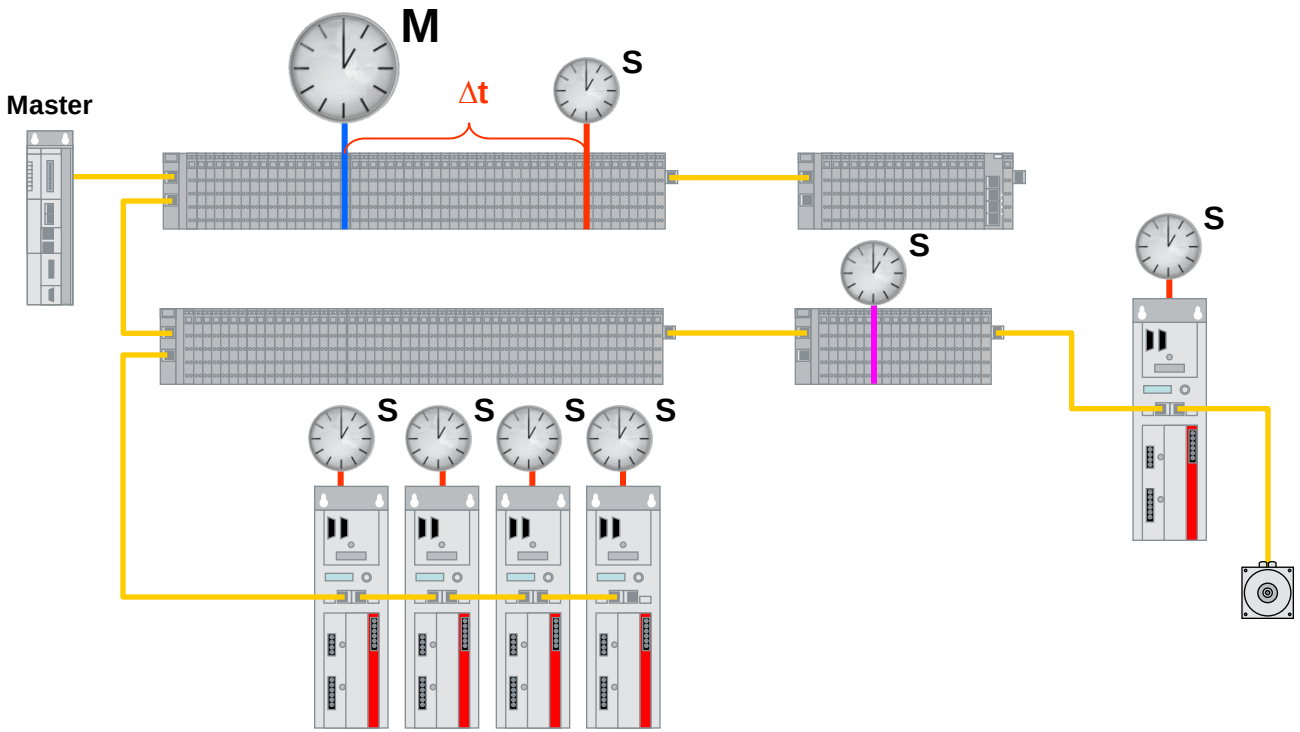
- Precise Synchronization (<< 1 µs!) by exact adjustment of Distributed Clocks



Distributed Clocks

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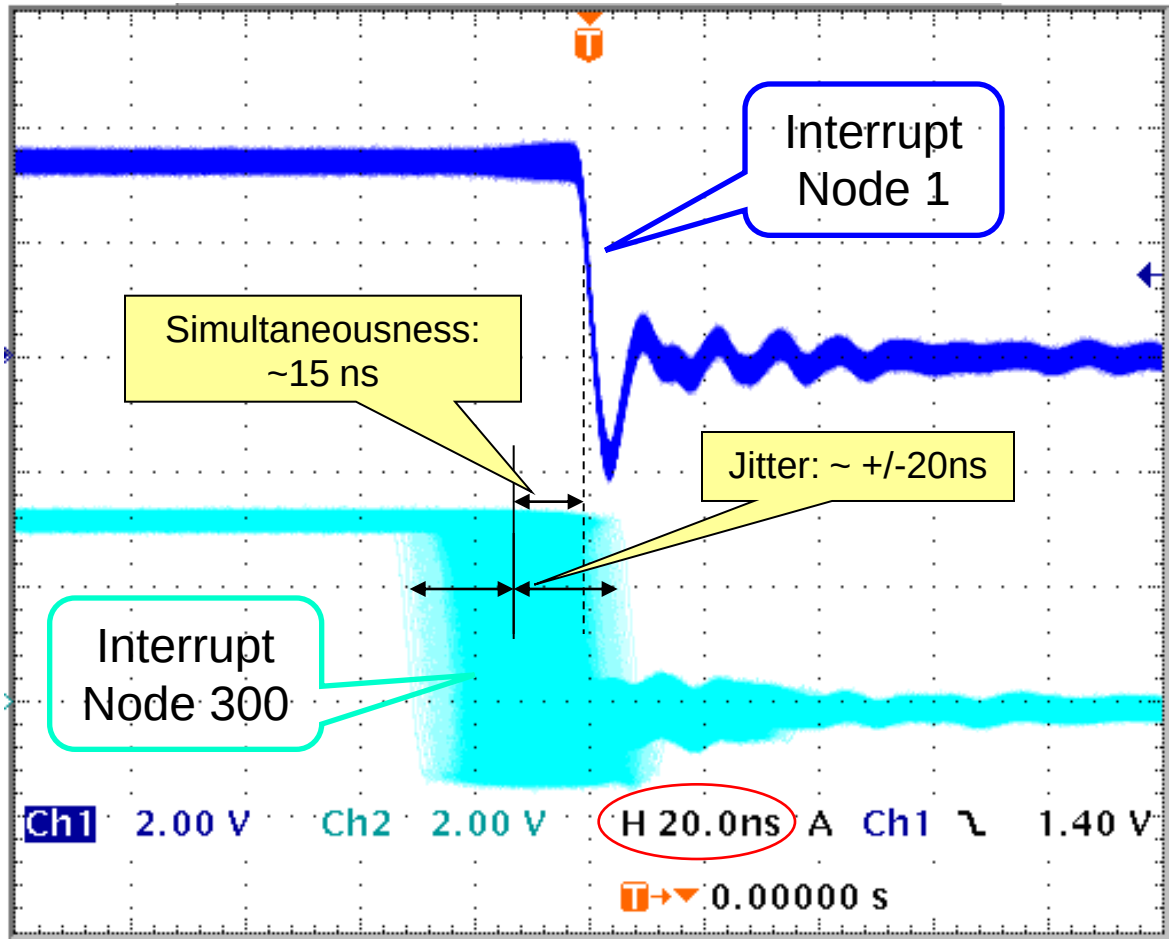
- Long Term Scope View of two separated devices
- 300 Nodes in between, 120m Cable Length



EtherCAT is Industrial Ethernet!

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- Easier to implement
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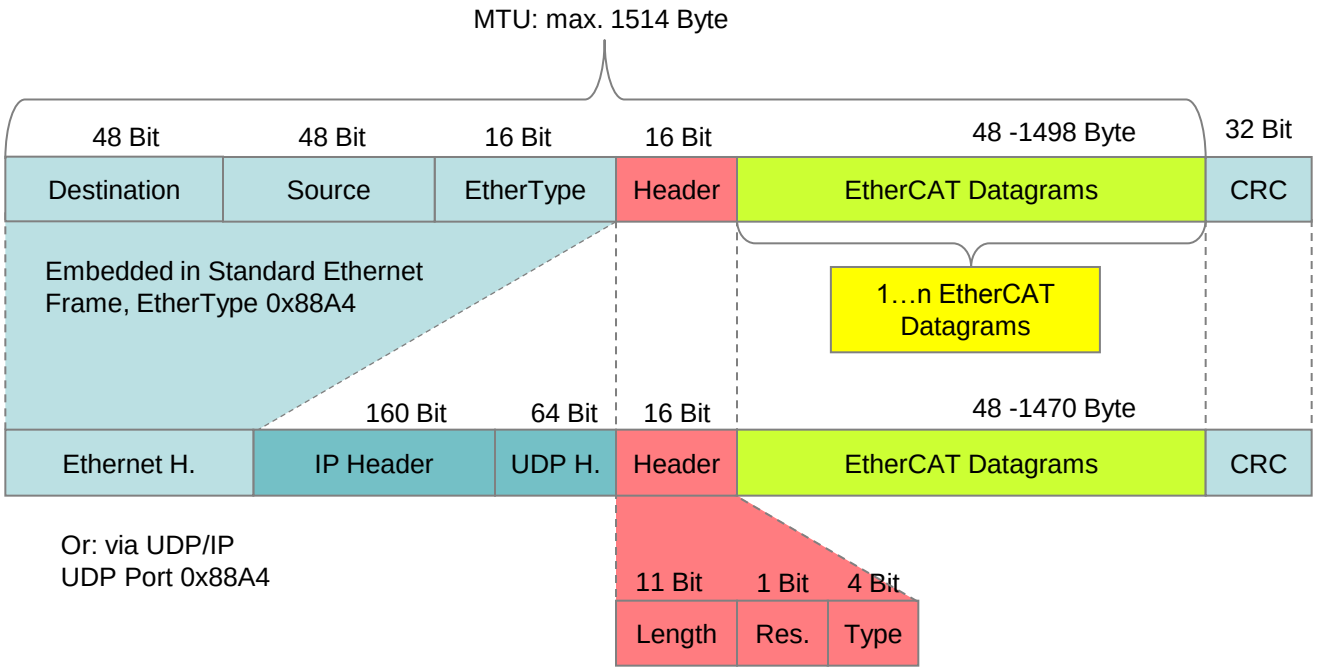
- EtherCAT uses Standard Ethernet Frames: IEEE 802.3
- Alternatively via UDP/IP (if IP Routing is needed)
- no shortened frames



EtherCAT is Industrial Ethernet!

EtherCAT is:

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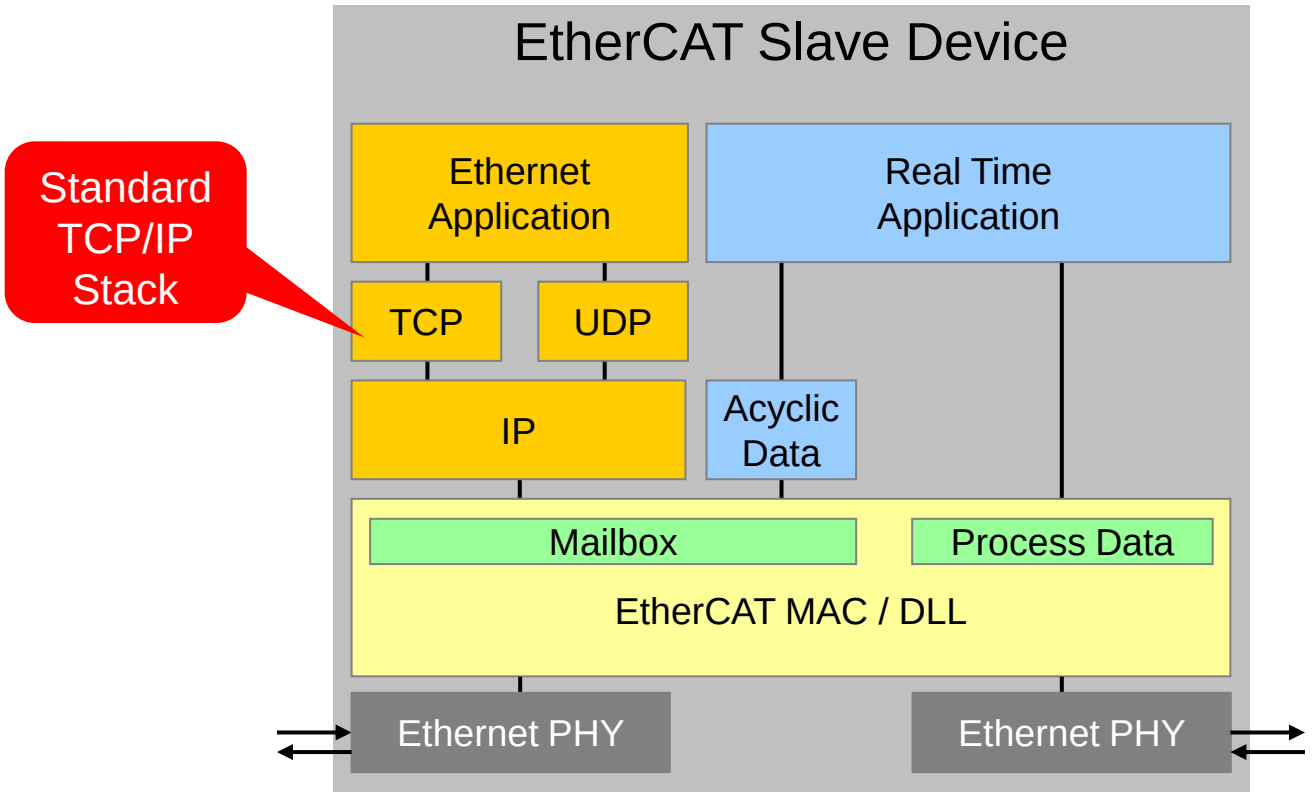
- Redundancy
- Versatile

- fully transparent for TCP/IP
- all Internet technologies (HTTP, FTP, Webserver,…) available without restricting the real time capabilities!



Switchport: Any Ethernet Protocol

EtherCAT is:

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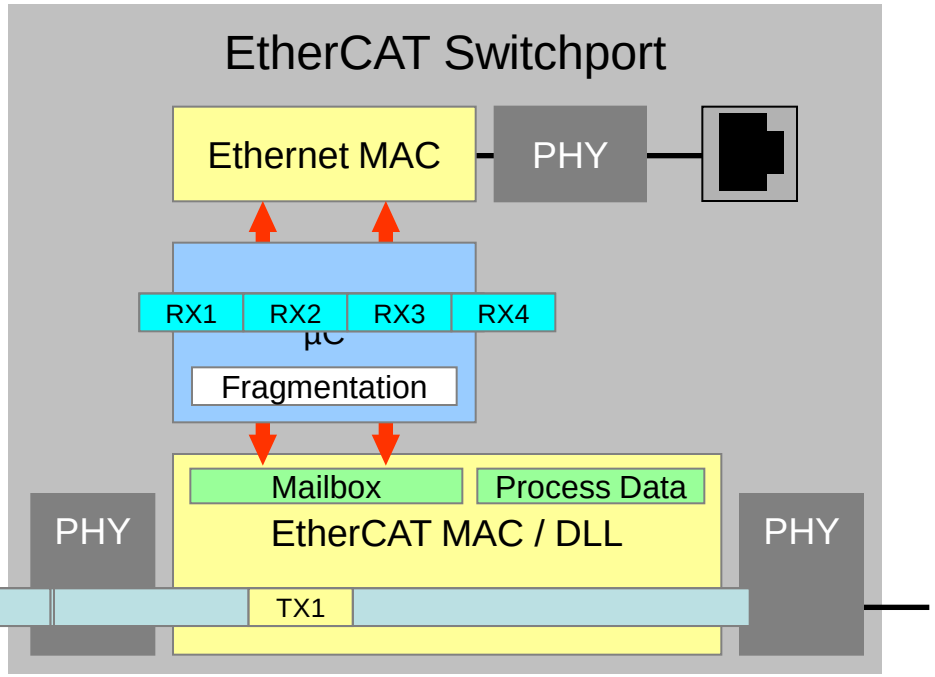
- Interface to any Ethernet Device or Network
- Ethernet Frames are inserted into EtherCAT Protocol:
  - 'Ethernet over EtherCAT'



EtherCAT wiring is more flexible

EtherCAT is:

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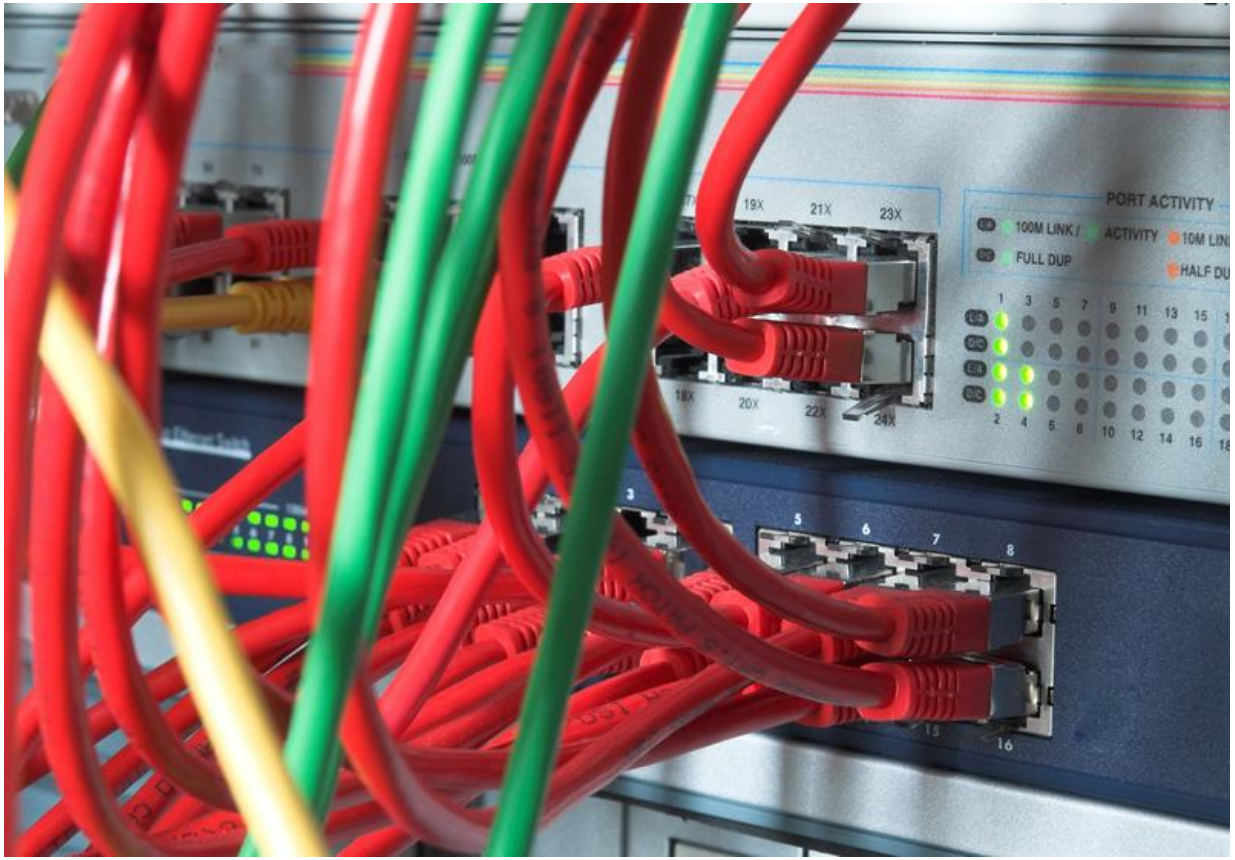
- Standard Ethernet Topology: Star



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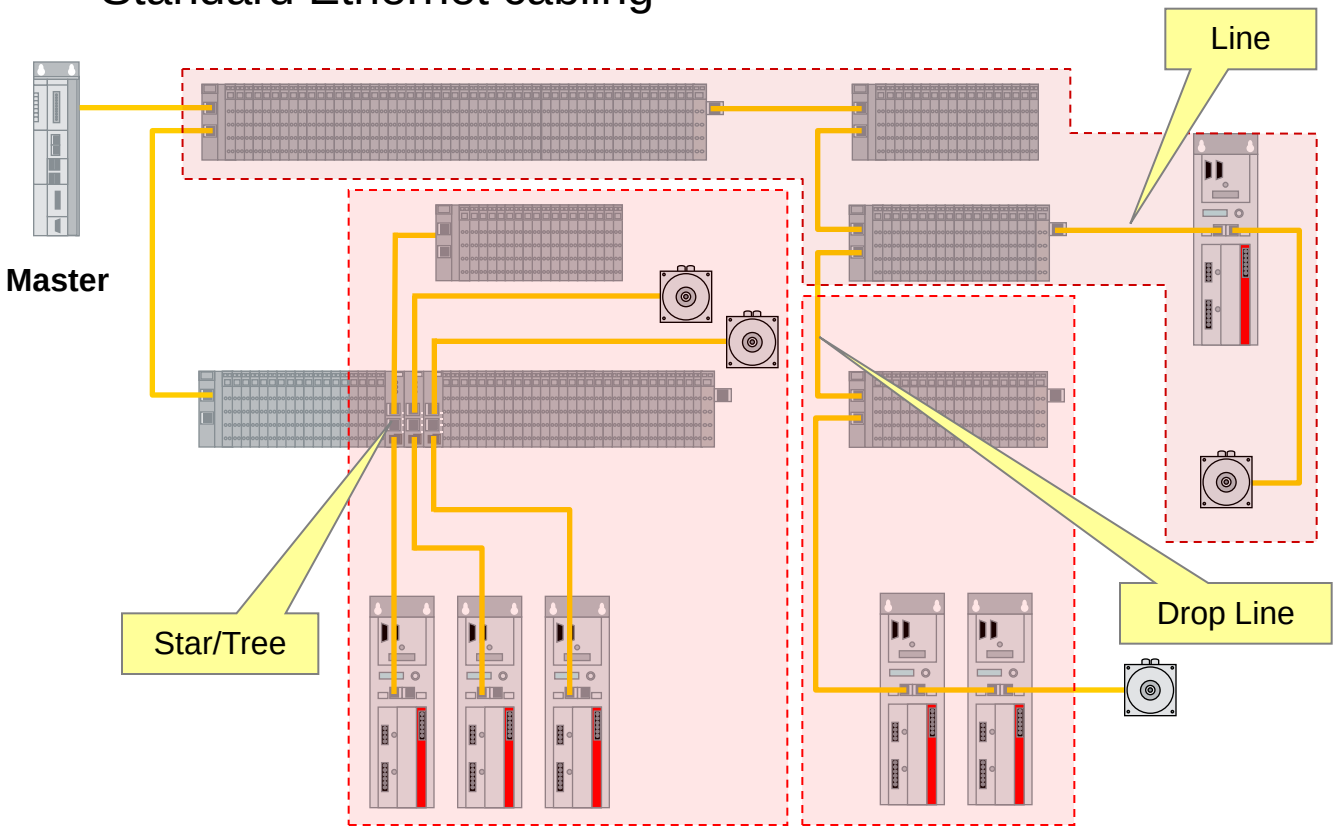
- Flexible tree structures – arbitrarily extendable
  - Topology variants like Line, Star, Tree, Daisy Chain + Drop Lines possible; can be used in any combination!
  - Up to 65,535 nodes for each EtherCAT segment
  - Standard Ethernet cabling



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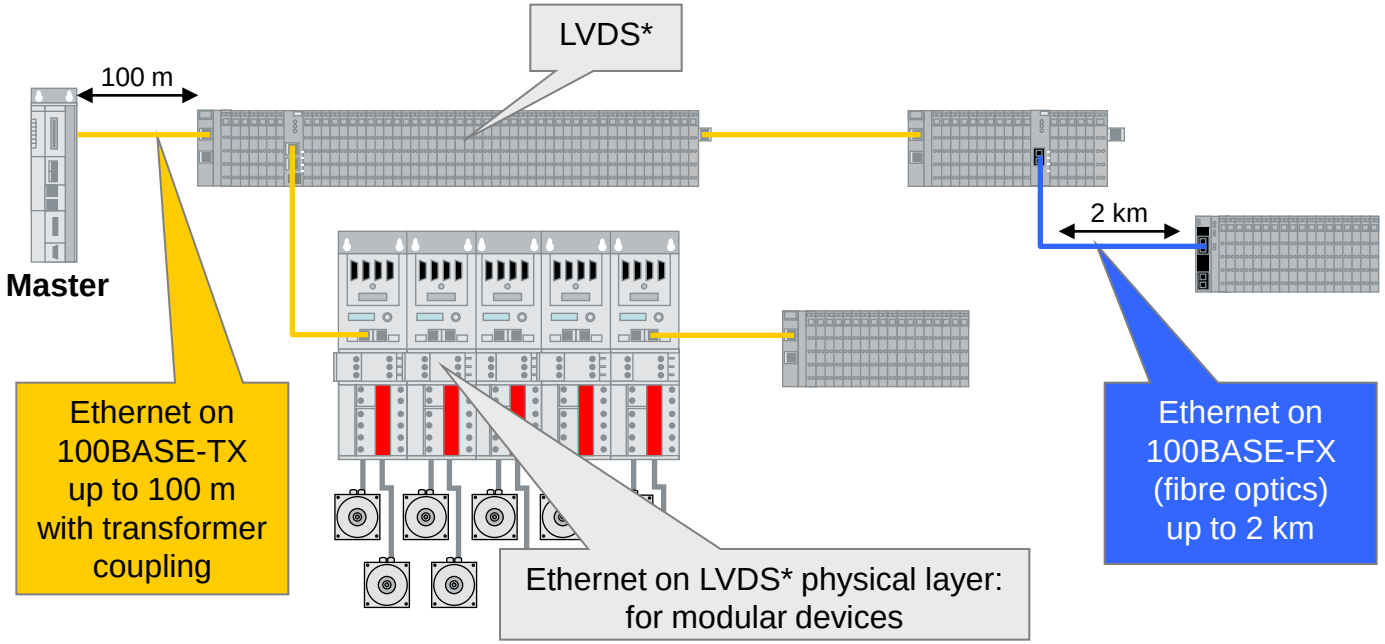
- Ethernet Signal Variants of EtherCAT:
  - 100BASE-TX (up to 100 m between 2 nodes)
  - 100BASE-FX (up to 2 km between 2 nodes)
  - LVDS (for modular devices)



- Any number of physical layer changes allowed

*LVDS: Low Voltage Differential Signaling according to ANSI/TIA/EIA-644, also used in IEEE 802.3ae (10Gigabit Ethernet)

EtherCAT Extra Large System Test

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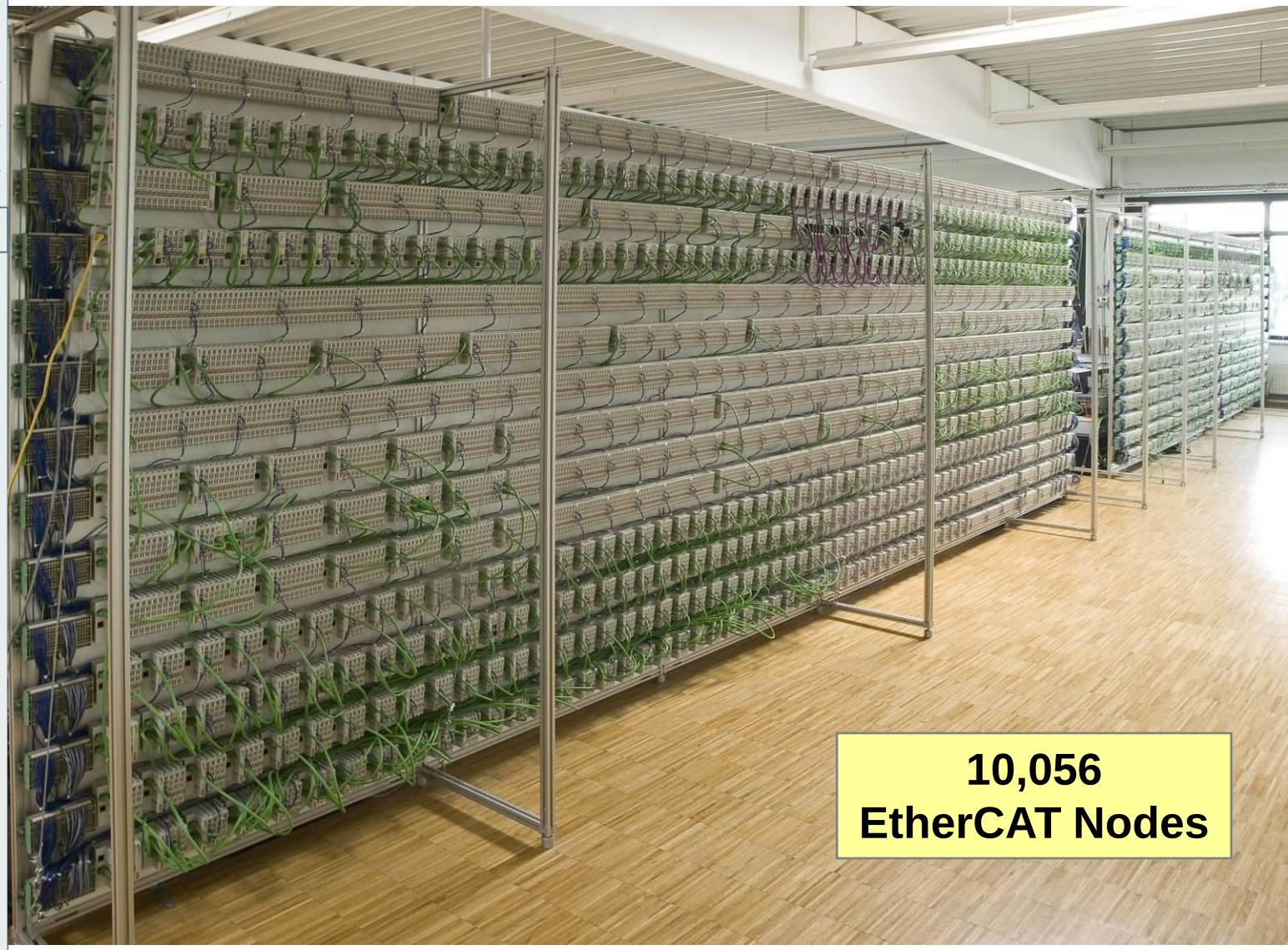

EtherCAT instead of PCI

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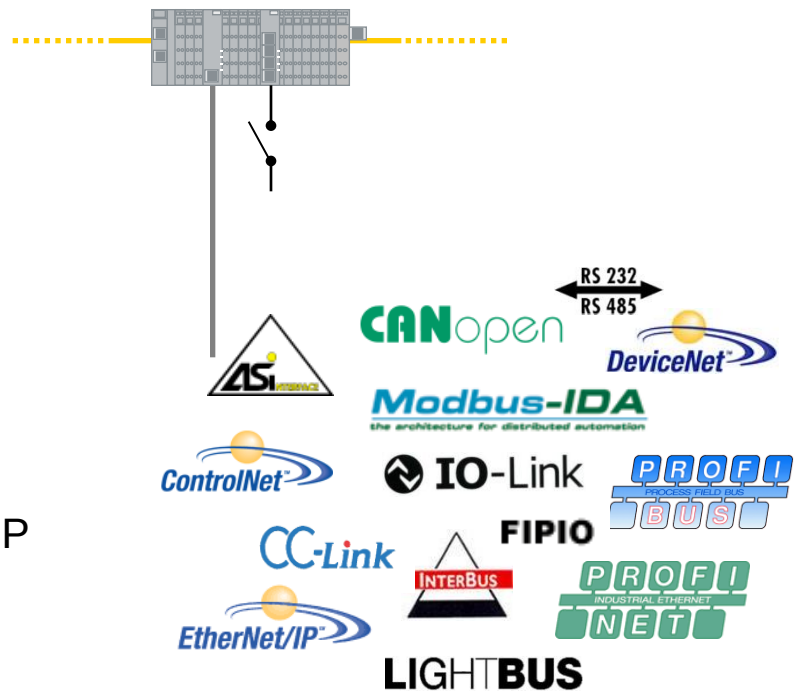
- Protection of your investment
- smooth migration path from legacy fieldbus to EtherCAT
- seamless integration of existing fieldbus devices, e.g.:
  - AS-Interface
  - CANopen
  - CC-Link
  - ControlNet
  - DeviceNet
  - Ethernet/IP
  - FIPIO
  - Interbus
  - IO-Link
  - Lightbus
  - LonWorks
  - Modbus Plus, RTU, TCP
  - PROFIBUS
  - PROFINET IO
  - …



- maximum system expandability with low cost fieldbus gateways

EtherCAT is easier to configure

EtherCAT is:

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- Industrial Ethernet ✓
- Flexible ✓
- Easier to configure
- Cost effective
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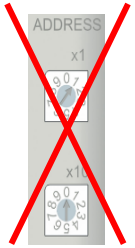
- Topology:
  - Automatic topology target/actual comparison
- Diagnosis:
  - Diagnosis with exact localization
- Network planning:
  - Performance independent of:
    - Slave implementation
    - Topology (no Switches/Hubs)
- Addressing
  - No manual address setting required
  - Addresses can be assigned automatically
  - Addresses can be kept
    - no new addressing if nodes are added



EtherCAT is lower costs (1): Engineering

EtherCAT is:

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- Implementation / Tools:
  - Standard Network Monitor Tools,
    e.g. MS Network Monitor or Wireshark: free of charge
  - Parser Software: free of charge
- Less effort for Network planning:
  - Simplified configuration
  - Default settings will work, no network tuning
- Improved Diagnosis:
  - Faster error handling leads to less downtime
- Faster Setup:
  - No address setting required

EtherCAT is lower costs (2): Hardware

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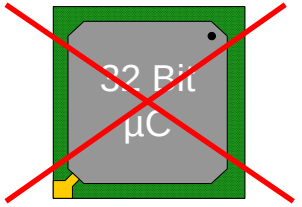
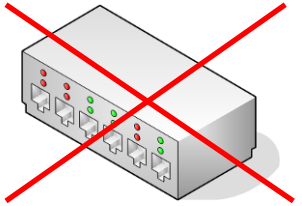
- Master:
  - no special plug in card (co-processor)
  - on-board Ethernet Port is fine

- Slave:
  - low cost Slave Controller
    - FPGA or ASIC
  - for simple devices: no µC needed
  - no powerful µC needed



- Infrastructure:
  - no Switches/Hubs required
  - Standard Ethernet Cabling + Connectors



EtherCAT is easier to implement: Slave

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- Easier to implement
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- Slave Implementation:
  - All time critical functions implemented on ASIC or FPGA
    - ESC handles Real-time Protocol in Hardware
  - Integrated Communication State Machine
  - Network Performance independent of
    - Slave-µC Performance
    - Protocol Stack
  - For usage with or without µC (Host CPU)
    - Integrated DPRAM (1…8kByte)
    - Integrated Distributed Clock Handling
    - Ultra precise interrupts to µC

EtherCAT is an open technology

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- Cost effective ✓
- Easier to implement ✓
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- Protocol is disclosed completely:
  - EtherCAT is IEC, ISO and SEMI Standard (IEC 61158, IEC 61784, ISO 15745, SEMI E54.20)

IEC Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

ISO

- Slave Controller from several sources available
- Slave Controller provides interoperability
- ETG organizes Interoperabilitly Testing ("Plug Fests"), Workshops and Seminars
- Conformance Testing + Certificates

Conformance and Interoperability

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EtherCAT Conformance tested

- Conformance and interoperability are very important factors for the success of a communication technology
  - Conformity to the specification is an obligation to all users of the EtherCAT technology
  - Therefore the **EtherCAT Conformance Test Tool** (CTT) is used
  - Test Cases for the CTT are provided by the Working Group “Conformance“ within the ETG community
  - The **EtherCAT Conformance Test** proves conformance with issuing a certificate after passing the test at an official **EtherCAT Test Center** (ETC)

Safety over EtherCAT: Features (1)

EtherCAT is:

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- Easier to implement ✓
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- Open ✓
- Conformance ✓
- Safety
- Redundancy
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Safety over EtherCAT®

- Safety over EtherCAT (FSoE) defines a safety communication layer for the transportation of safety process data between Safety over EtherCAT devices.
- FSoE is an open technology within the EtherCAT Technology Group (ETG).
- The protocol is developed according to IEC 61508
  - It meets the Safety Integrity Level (SIL) 3
  - Residual Error Probability R(p) < 10^{-9}
- The protocol is approved by an independent Notified Body (TÜV)

Safety over EtherCAT: Implementation Example

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- Easier to implement ✓
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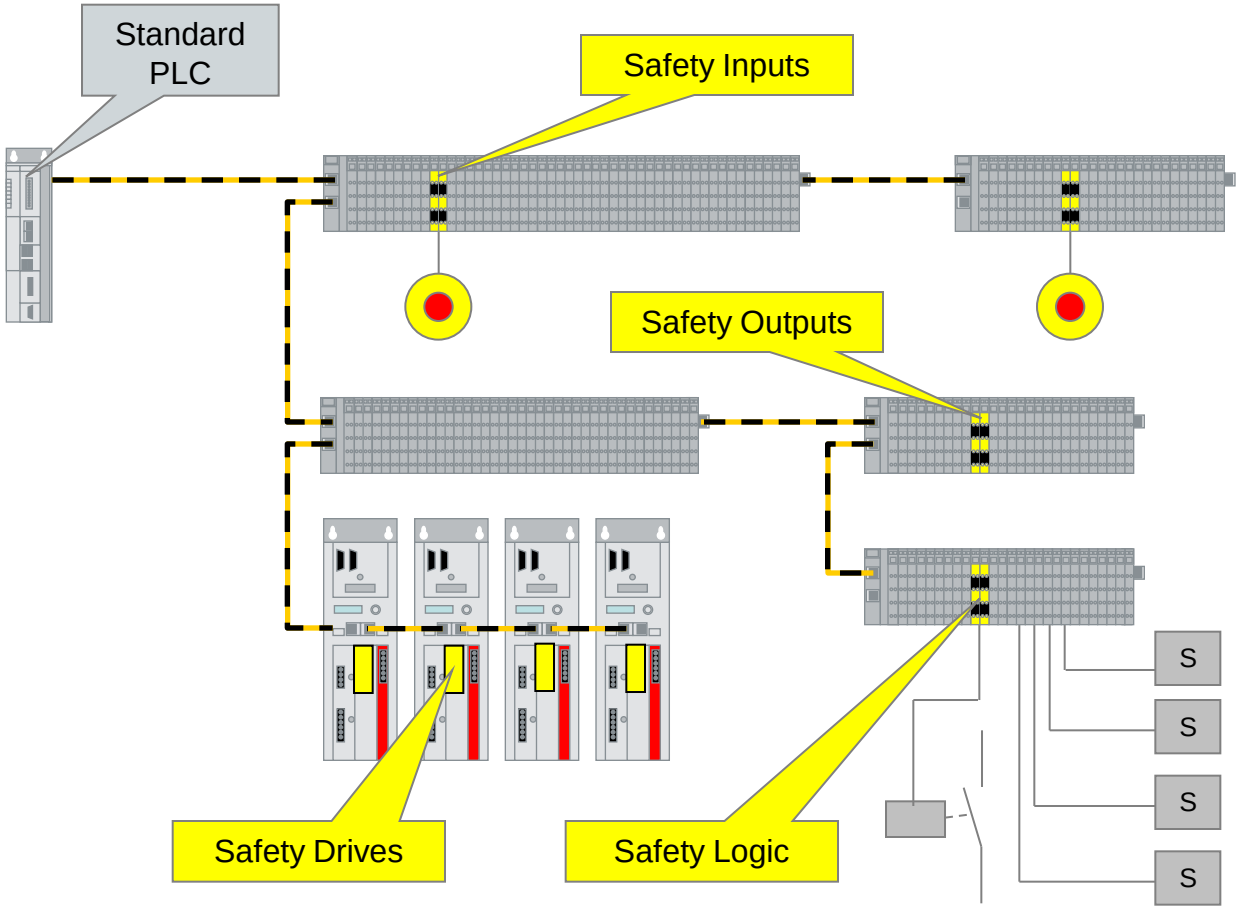
- Decentralized Safety-Logic
- Standard PLC routes the safety messages



EtherCAT: High availability

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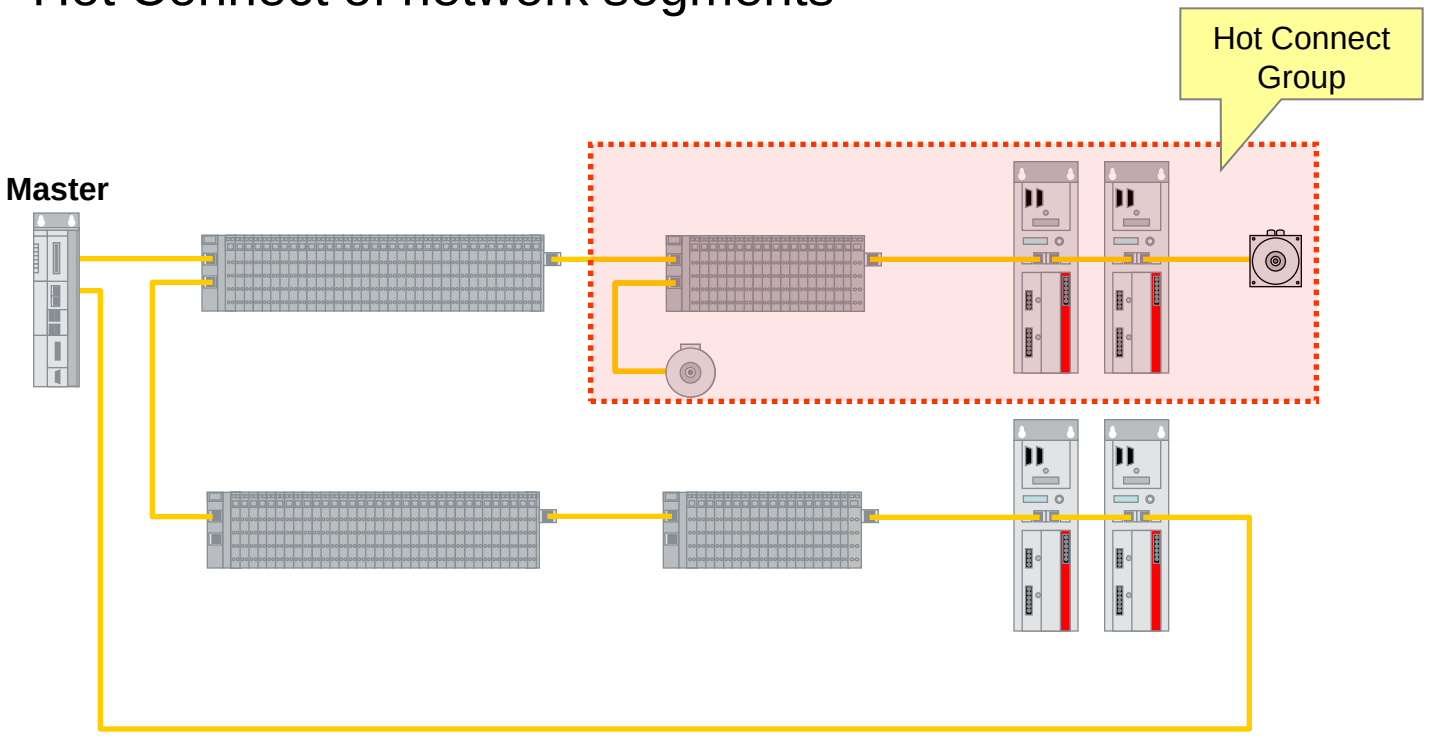
- Cabling redundancy
  - 2nd Ethernet port needed on master side only
- Hot Swap of devices
- Hot Connect of network segments



Why do Companies choose EtherCAT?

EtherCAT is:

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- Industrial Ethernet ✓
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- Easier to configure ✓
- Cost effective ✓
- Easier to implement ✓
- Well proven ✓
- Open ✓
- Conformance ✓
- Safety ✓
- Redundancy ✓
- Versatile

- High Performance
  - EtherCAT is the fastest Industrial Ethernet technology
- Flexible Topology
  - Benefit not only for widely distributed applications
- Ease of Use
  - Easy configuration and maintenance
- Low Cost
  - Inexpensive implementation & infrastructure
- Functional Safety
  - Safety communication integrated
- Product Variety
  - Great variety of available EtherCAT products

EtherCAT - The Ethernet Fieldbus.

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- Versatile ✓

Why go for something slower, just because it is more expensive?

EtherCAT - The Ethernet Fieldbus.

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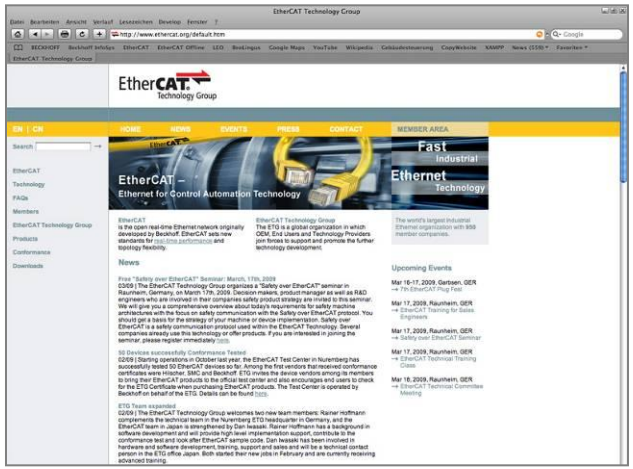
Please visit

www.ethercat.org

for more information



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