Layering with TSN and EtherCAT
- A contribution regarding document exchange

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EtherCAT® Technology Group

EtherCAT is the open technology of

- ETG = EtherCAT Technology Group (www.ethercat.org)
- Foundation: November 2003
- Tasks: Support, Advancement and Promotion of EtherCAT
- The worlds largest fieldbus organization
- More than 4500* member companies from 65 countries in 6 continents:
  - Device Manufacturers
  - End Users
  - Technology Providers
- Membership is open to everybody

* as of Sept 2017

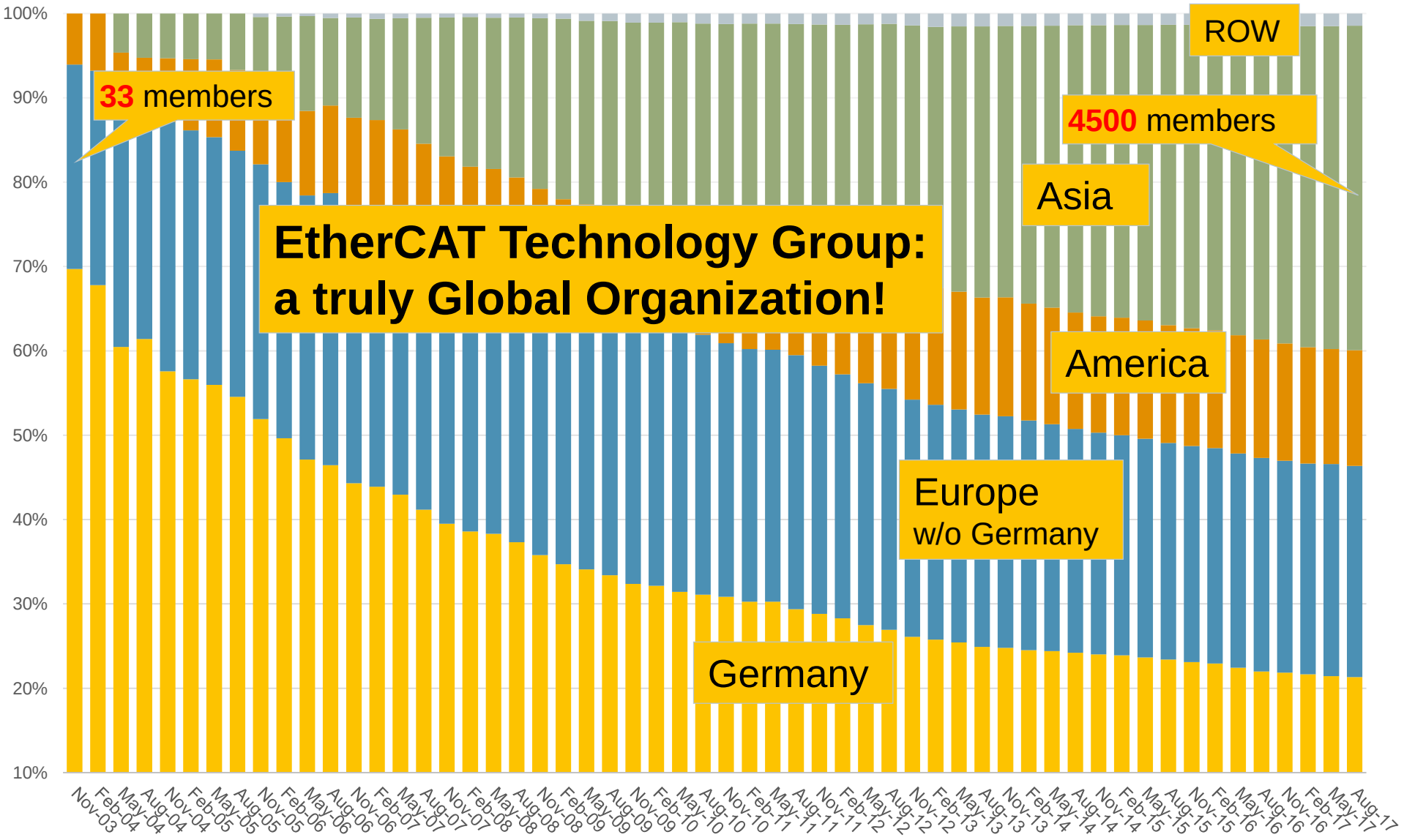
ETG Members worldwide

As of Oct 27, 2017:

ETG members from

65 countries and 6 continents

ETG Membership Distribution



Members from 65 Countries, 6 Continents

© EtherCAT Technology Group

EtherCAT is Standard and Open

- Protocol specifications open:
  - EtherCAT is IEC Standard (IEC 61158, IEC 61784 und IEC 61800-7)
  - EtherCAT is ISO Standard (ISO 15745-4)
  - EtherCAT is SEMI Standard

Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

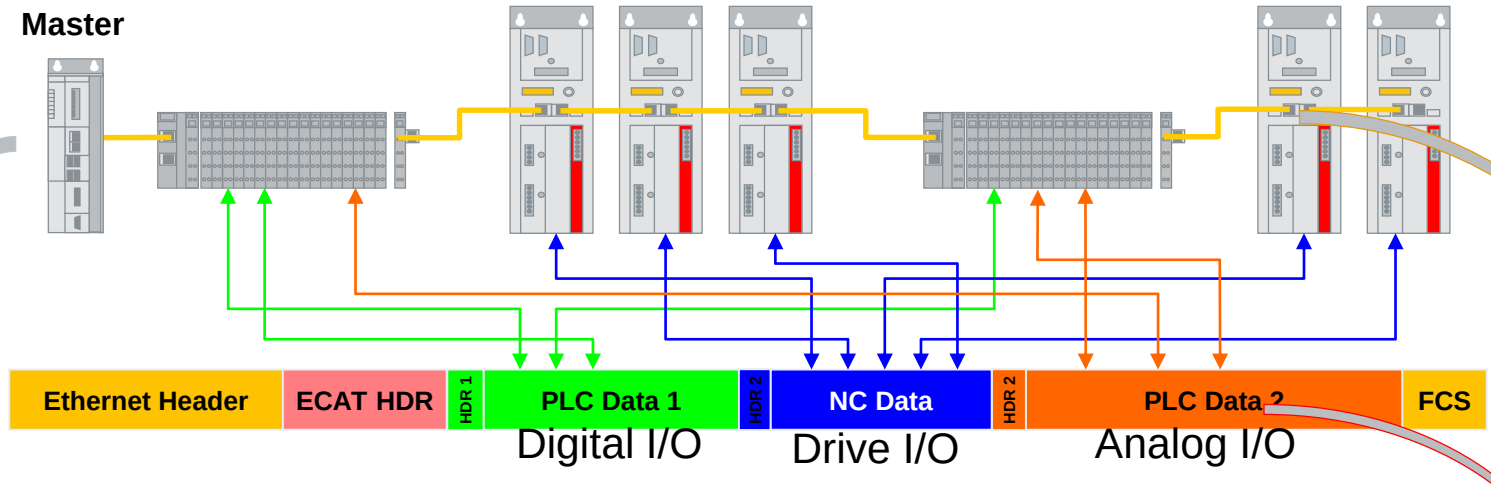
- Slave Controller Chips (ESC) from several vendors
- ESC provides high level of interoperability

- ETG provides Technical Support
  by Phone oder via Forums
  by Training classes

- ETG organizes Plug Fests
- ETG provides Conformance Testing procedures

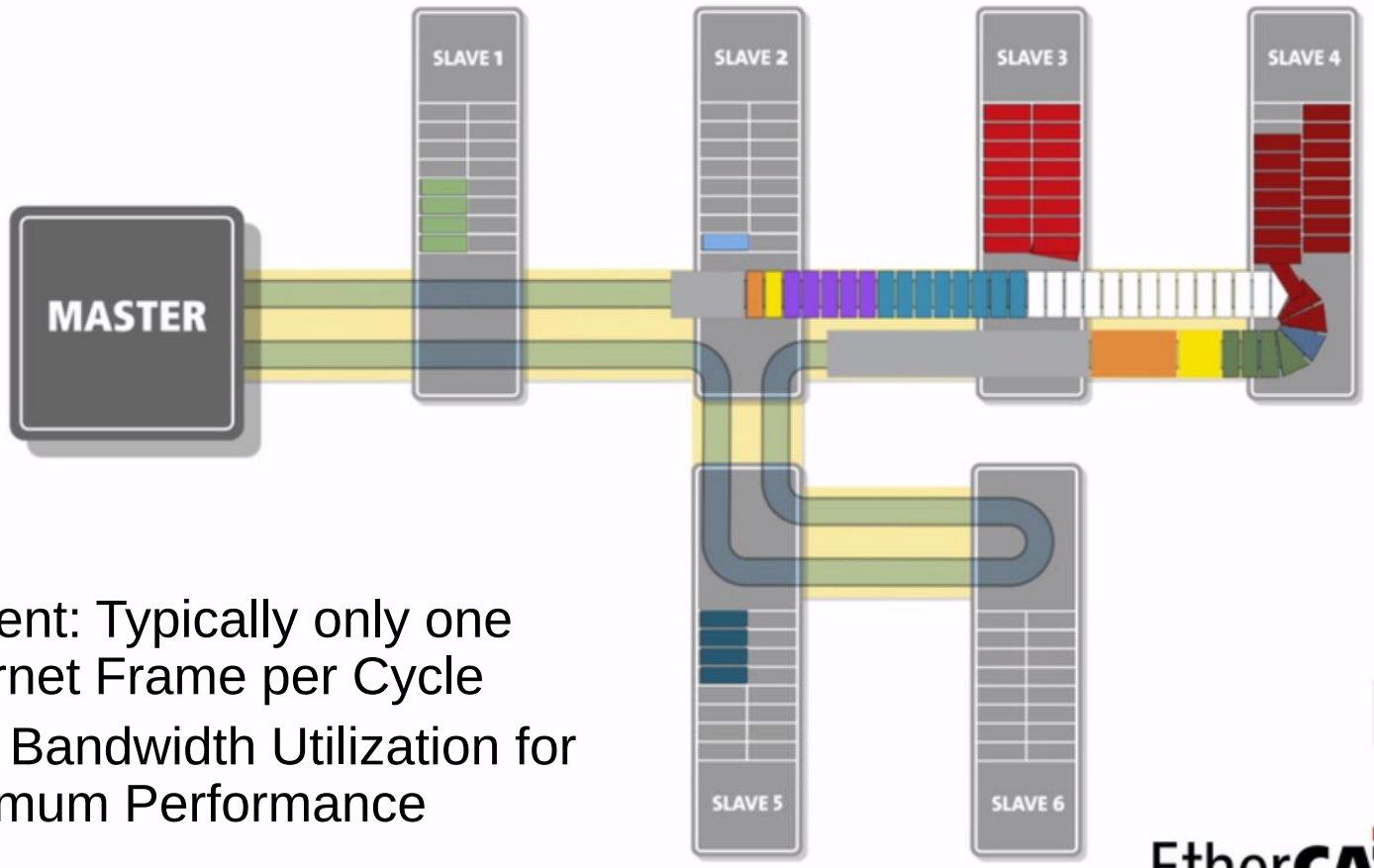
EtherCAT Conformance tested

Functional Principle | Ethernet „on the fly“



- Ethernet-compatibility maintained
  - Master Implementation on standard Ethernet interface
  - Standard PC or Embedded PC sufficient - no dedicated plug in card on-board Ethernet Port is fine
- Minimal overhead (= shared frame)
  - Optimized frame structure for I/O modules connected
  - L2 Communication in hardware: maximum predictable(!)performance
  - No bridging, just forward to next station in the loop …….

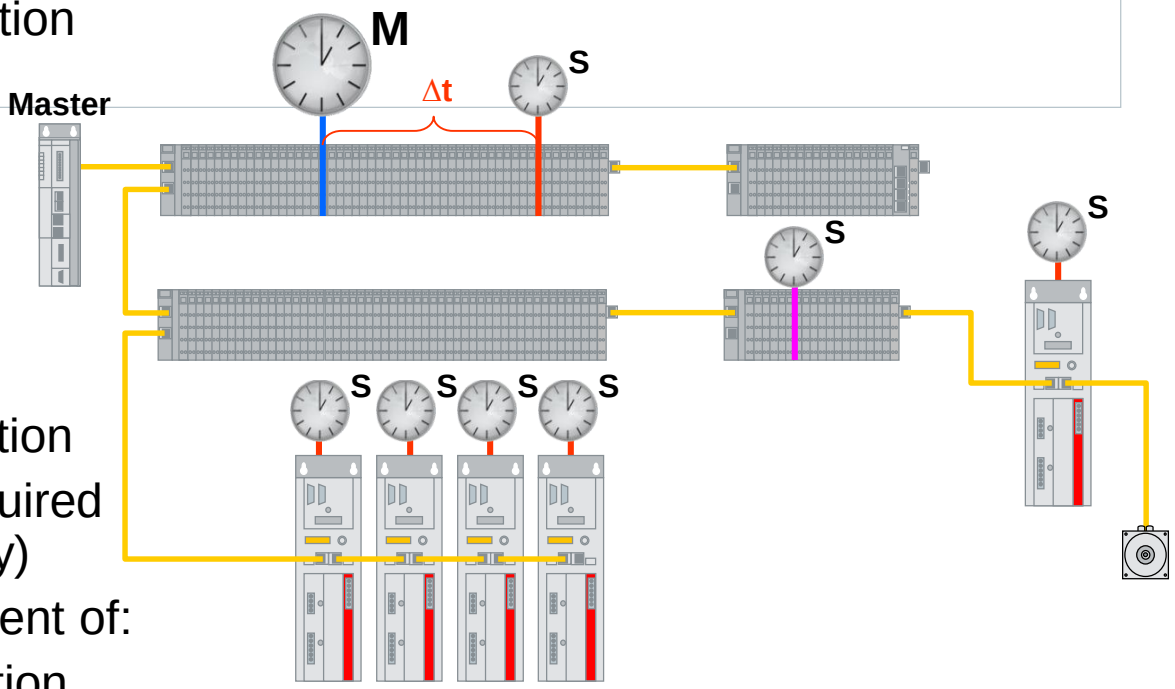
Functional Principle: Ethernet “on the fly”

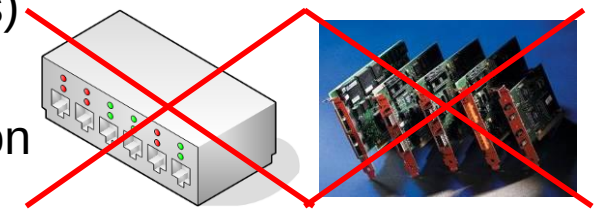


- Efficient: Typically only one Ethernet Frame per Cycle
- Ideal Bandwidth Utilization for maximum Performance

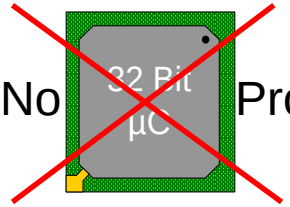
Precise, Robust, Ease of use

- High precision Synchronization DC=Distributed Clocks
- Safe Operation
  ➔ Errors will switch I/O in safe operational mode
- Minimum Configuration
  - Automatic topology
  - Diagnosis with localization
  - No address setting required (assigned automatically)
  - Performance independent of:
    - Slave implementation
    - Network components (no Switches/Hubs)





- No dedicated extra components for communication



- Simple Slave Controller, No Processor@Application<=>Communication

EtherCAT Application examples

- packaging
- cars
- tyres
- high speed presses
- test beds
- measurement

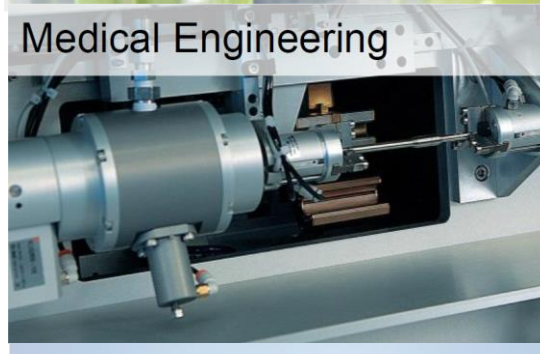
… also

- Semiconductor
- Medical
- Wind turbine
- Stage control
- Mobile machines
- Data acquisition
- Solar panels
- Race sailing

- injection molding
- woodworking
- printing press
- machine tooling (CNC)
- robotics

ETG congratulates Emirates Team New Zealand for winning the America's Cup 2017

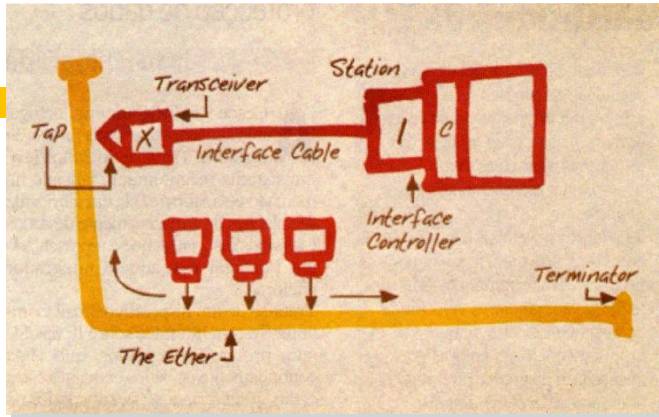
06/2017 | The world's largest fieldbus user organization, the EtherCAT Technology Group (ETG), congratulates its member Emirates Team New Zealand for winning the America's Cup ...With a 7-1 scoreline the New Zealanders dominated the final …in Bermuda. The high-tech America's Cup Class catamarans used … employ sophisticated hydraulics to control ... Super-fast and reliable bus communication is a key element of the hydraulic control system, and the EtherCAT Technology Group is thrilled that its technology has been of help for taking the Cup back to NZ.

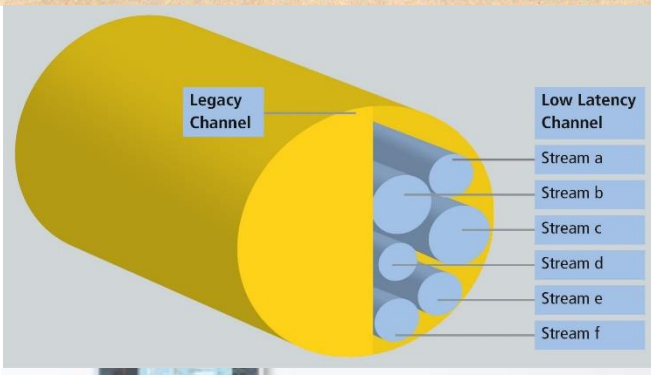


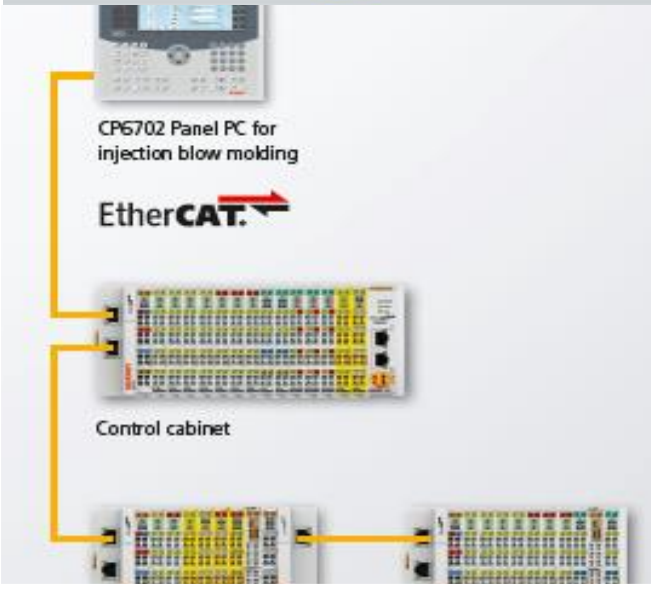
IEEE 802 and Fieldbus

- Ethernet started over **40 years ago**
  - Establish flexible computer interconnections
    - Workstations to servers
  - **= Best-effort** + client-server connection
    Introduction of bridging in IEEE 802.1
  - Enable different speeds
  - Large Network dimensions, scalable(!)
  - **= Still Best effort**
- **Change of this paradigm in AVB**
  (introduction of streaming)

- **30 Years ago: Fieldbusses➔service quality**
  - Efficient bandwidth use
  - Low frame drop rate
  - Limited communication delay
- Later: **Ethernet** qualified for fieldbus as well



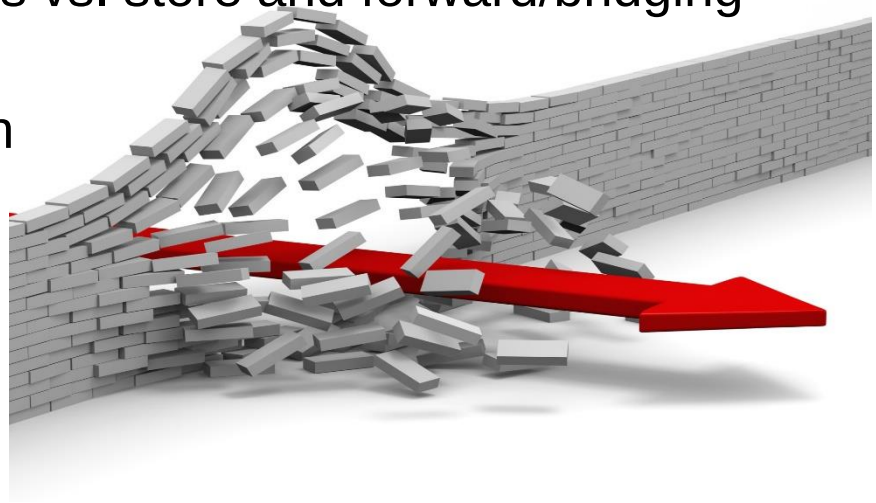




But IEEE 802 is a challenge at I/O level

- Efficiency: low byte count (8 bytes) vs. 84 octets minimum for IEEE 802.3
- Forwarding: line speed for fieldbusses vs. store and forward/bridging

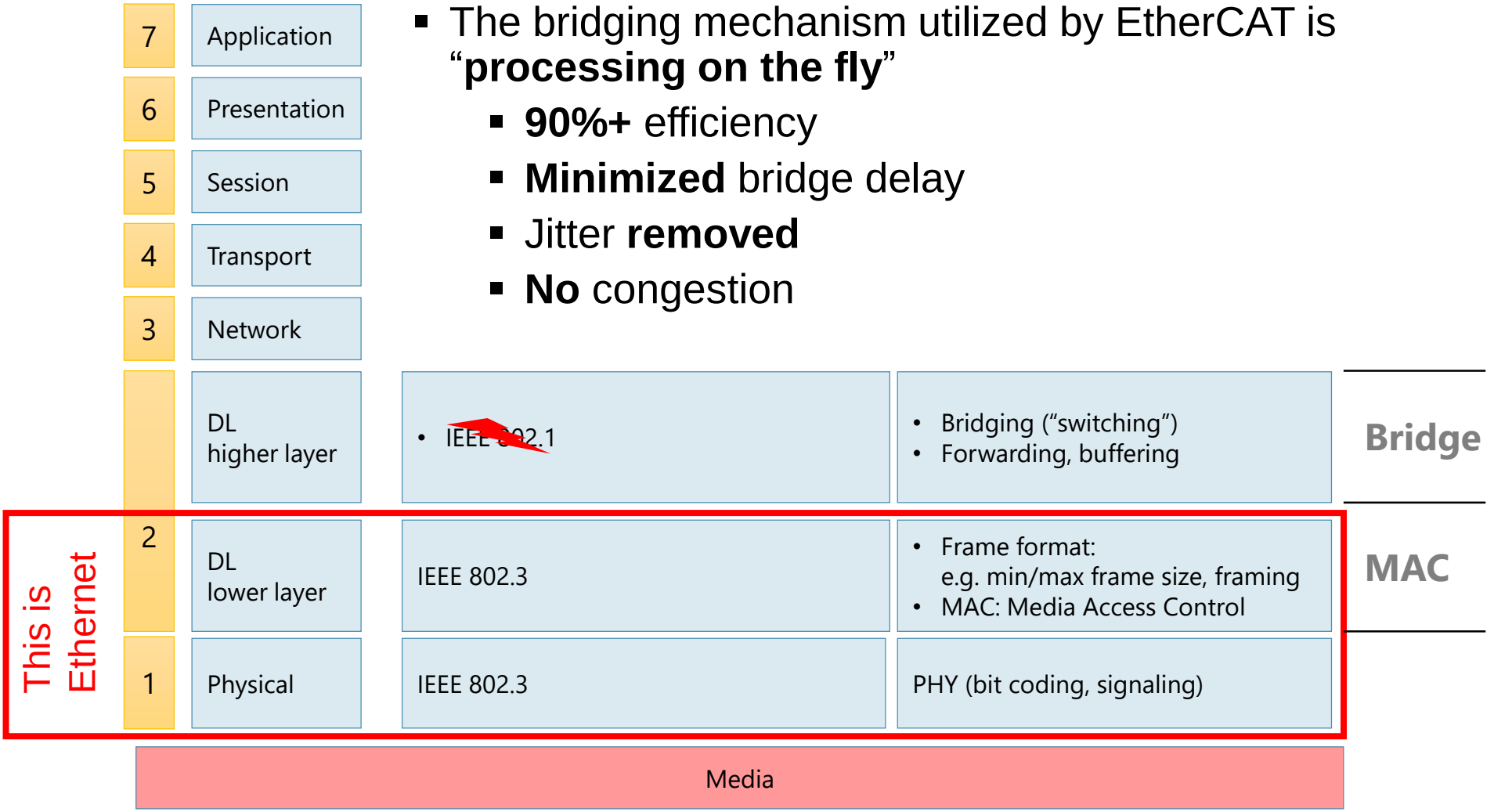
- This leads to the **EtherCAT** approach



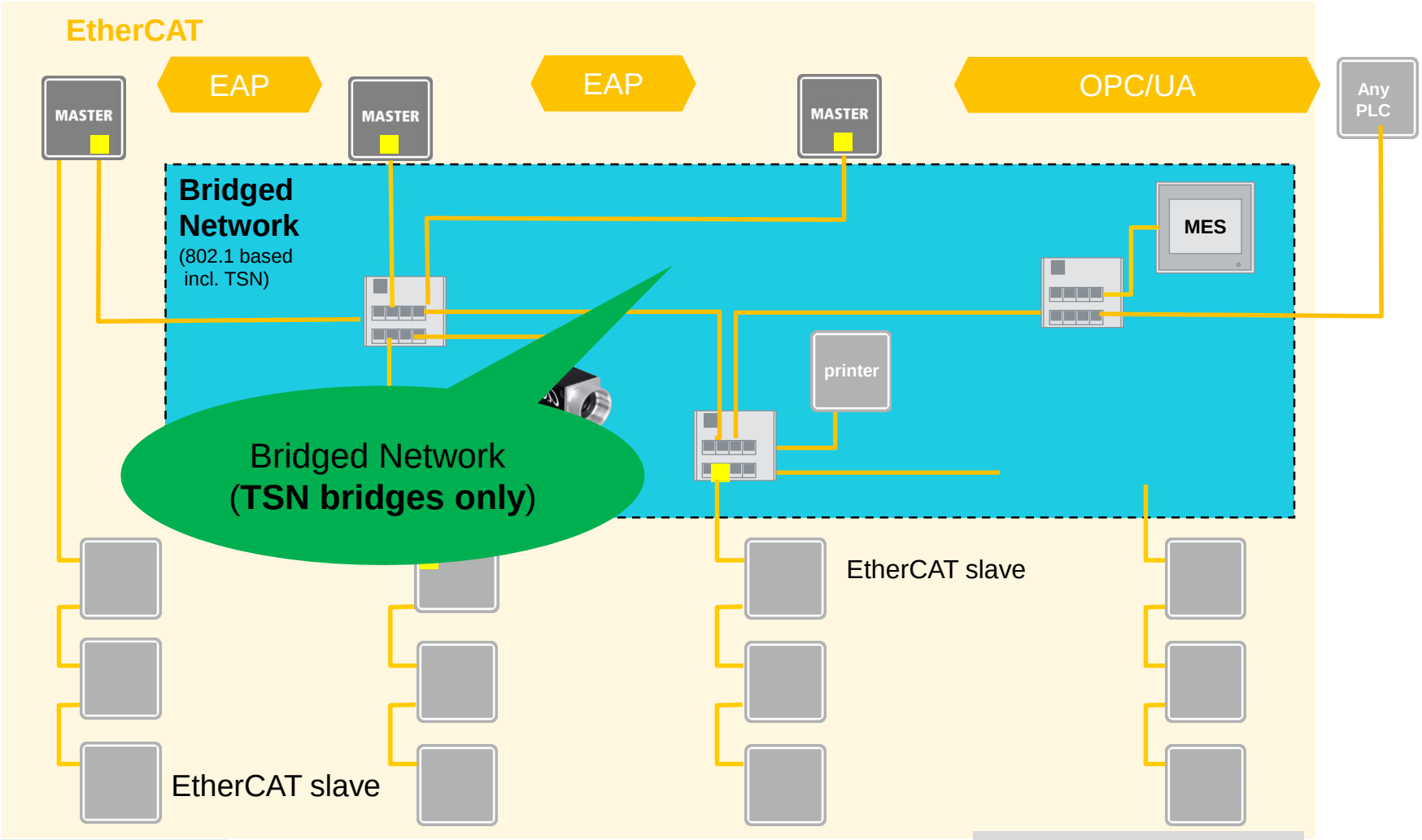
- Efficiency **Shared frame** instead of individual frame
  ➔ performance improvement: overhead 50 Bytes instead of 750/1500
  … in a network of 10/20 I/O stations
- **Processing on the fly** with topological forwarding (automatic)
  Instead of address based forwarding
  ➔ performance improvement: 0,7µs instead of >3µs (7µs/store&forward)

EtherCAT architecture model

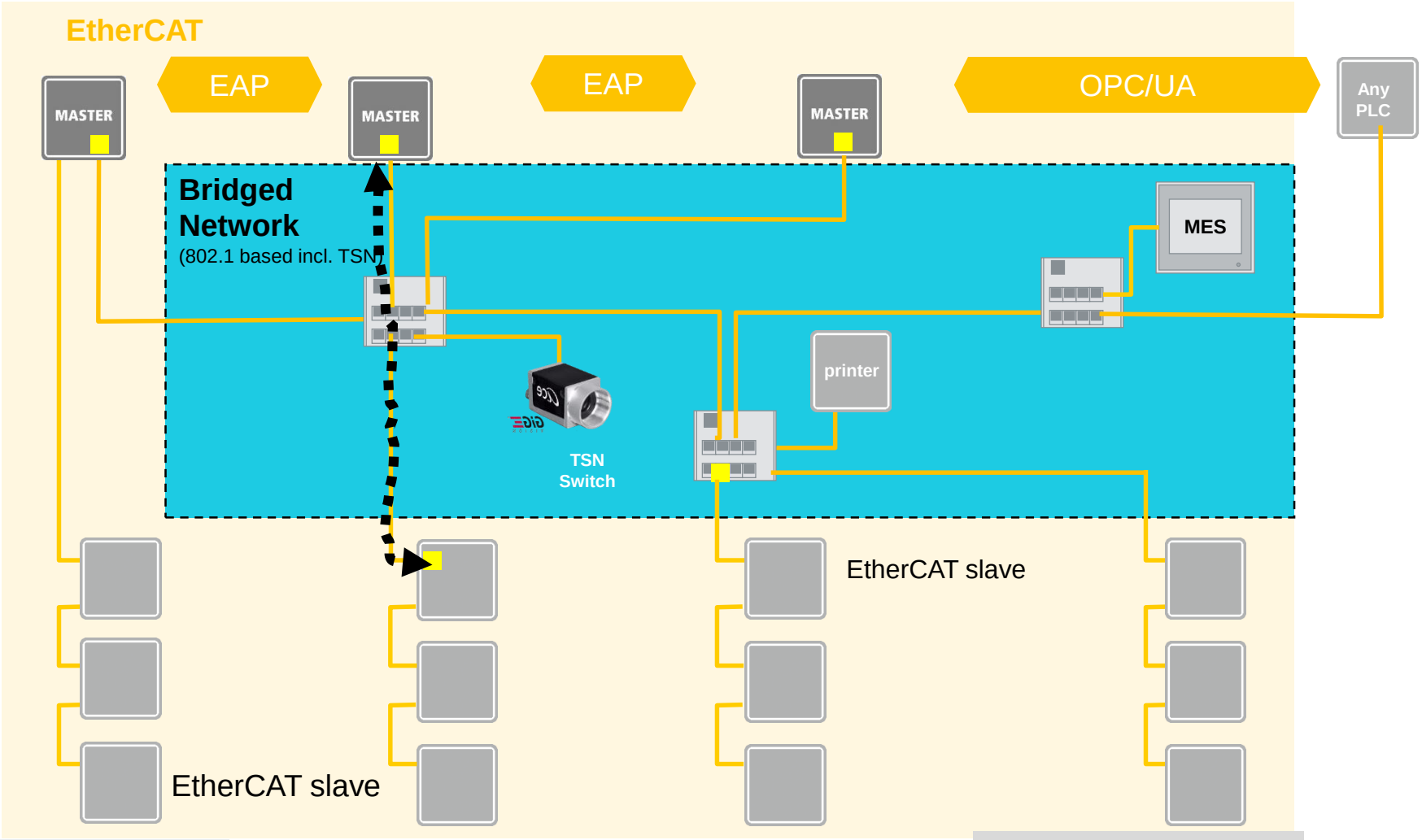
- The bridging mechanism utilized by EtherCAT is "**processing on the fly**"
  - **90%+** efficiency
  - **Minimized** bridge delay
  - Jitter **removed**
  - **No** congestion



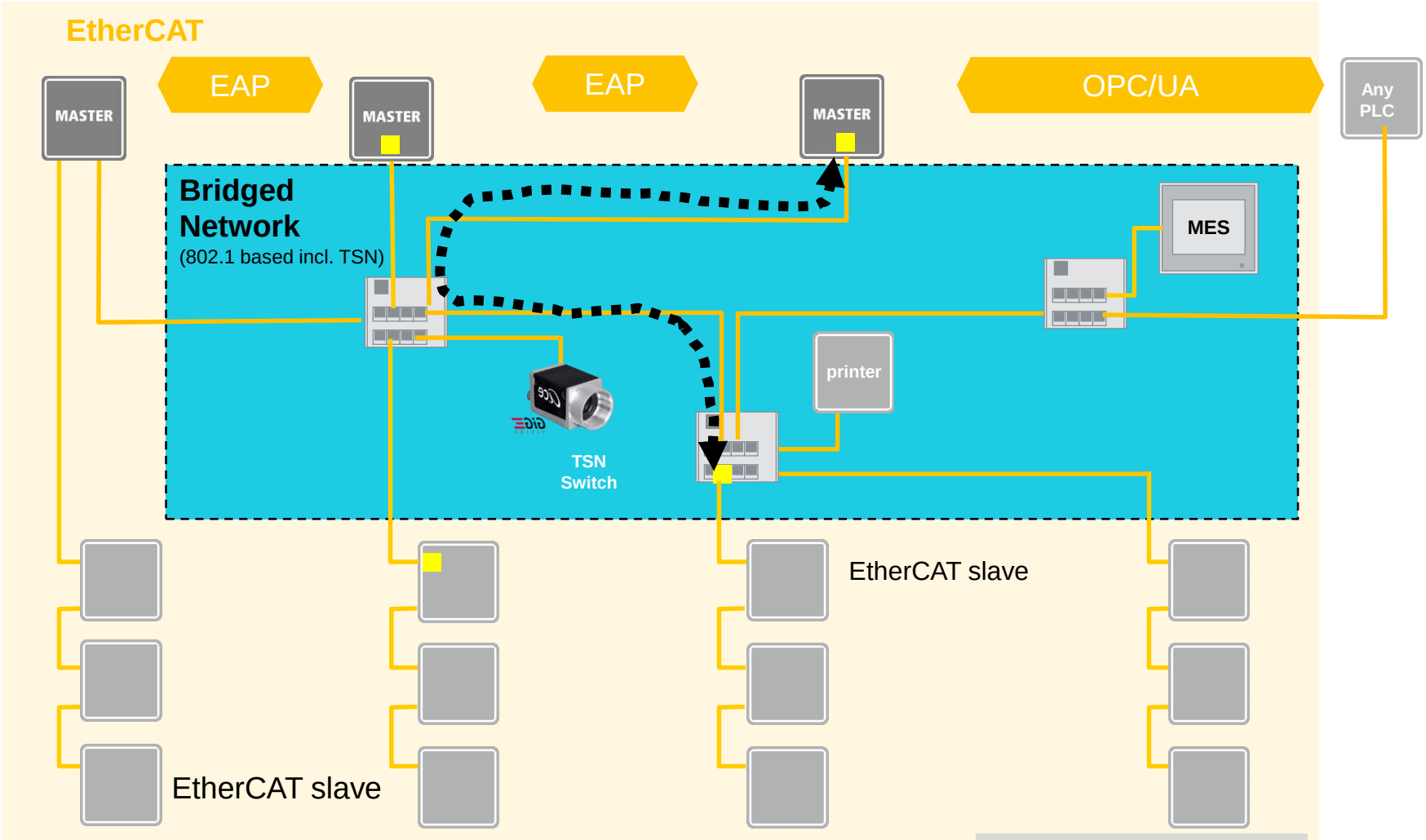
Possible Application Scenarios: TSN network between master and EtherCAT segment



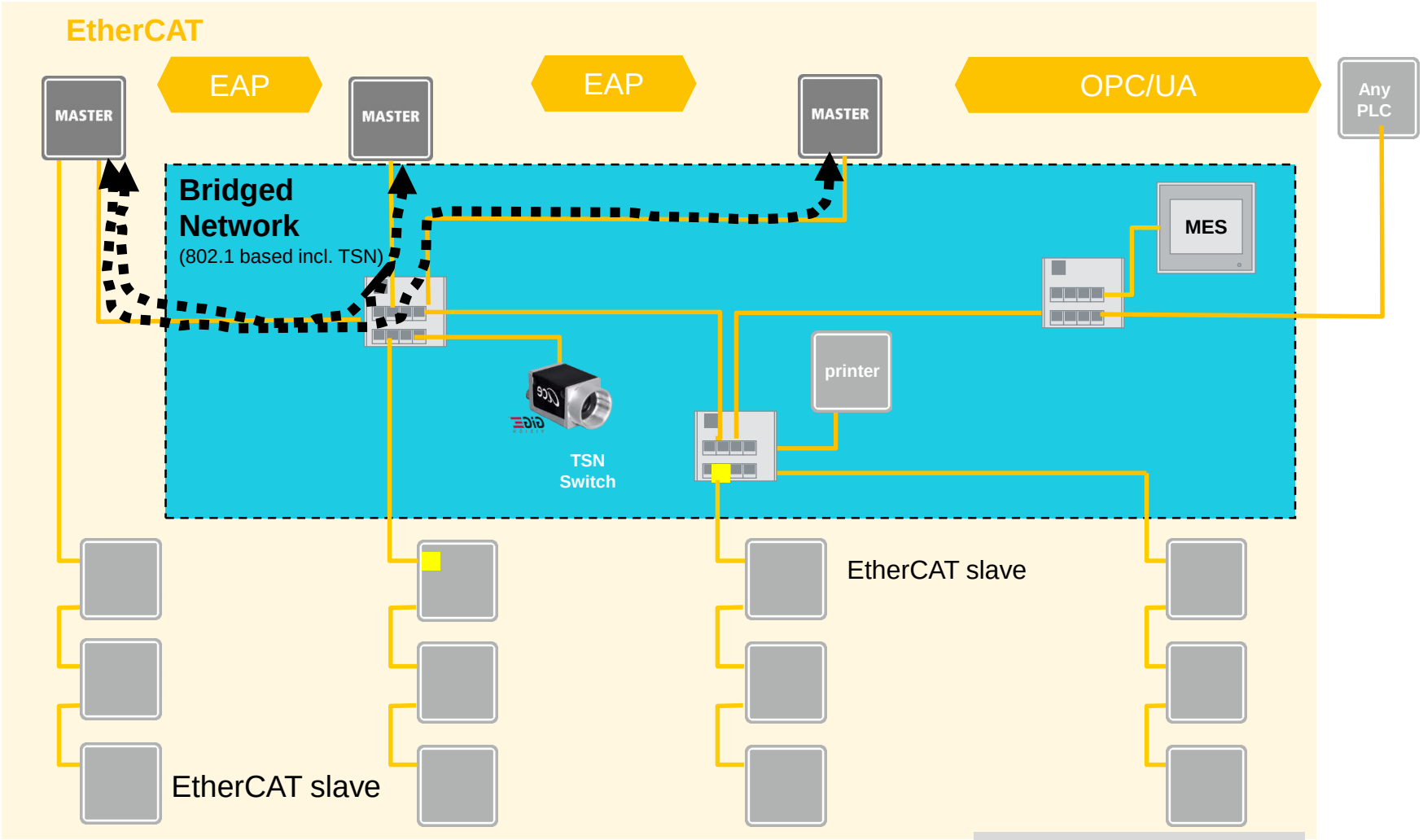
Application Scenarios: Adaption of TSN stream to EtherCAT segment in first EtherCAT slave



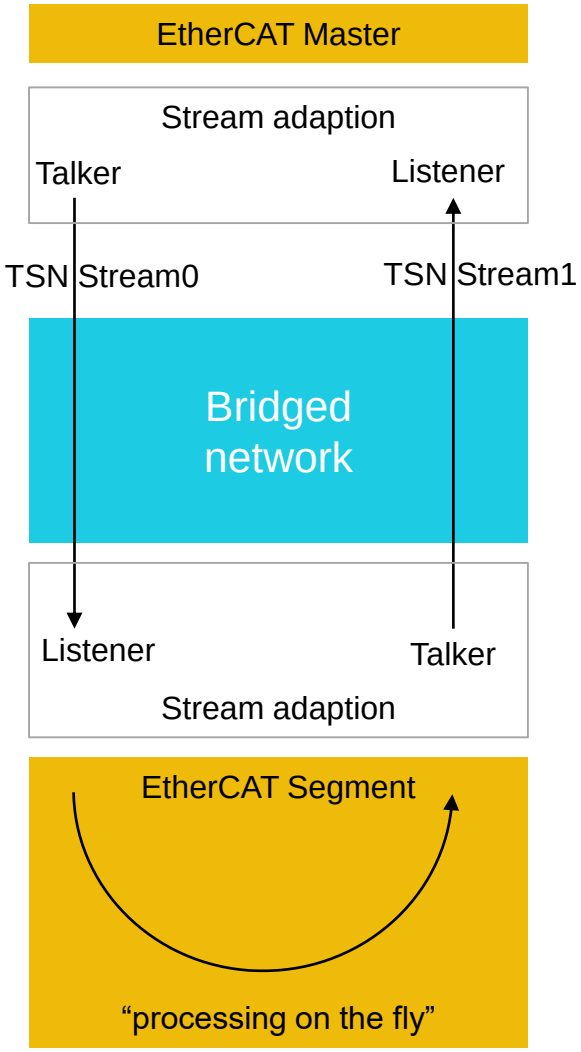
Application Scenarios: Adaption of TSN stream to EtherCAT segment in Switch



Possible Application Scenarios: EAP transferred on TSN-enhanced 802.1 network

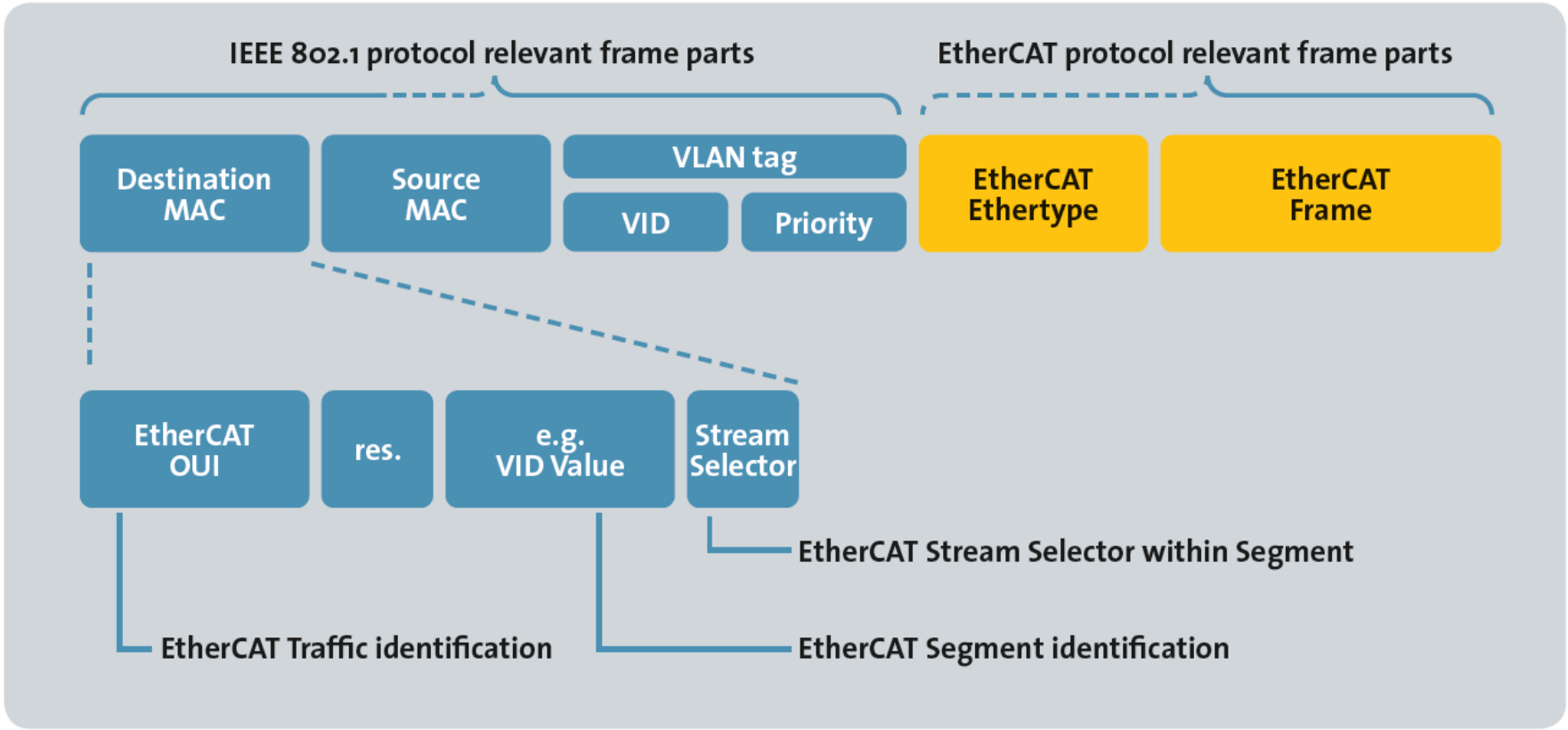


Stream Adaption: Details



- Always a pair of streams is set up
- Minimum one pair, but more might be set up, e.g.
  - One for cyclic
  - One for acyclic (strict priority)
  - for additional transfers
- Traffic class for pair of stream always the same
- Maintain Traffic Class (VLAN Prio)
- Maintain length
  (EtherCAT Rx/TX frame length identical)

Protocols use different fields



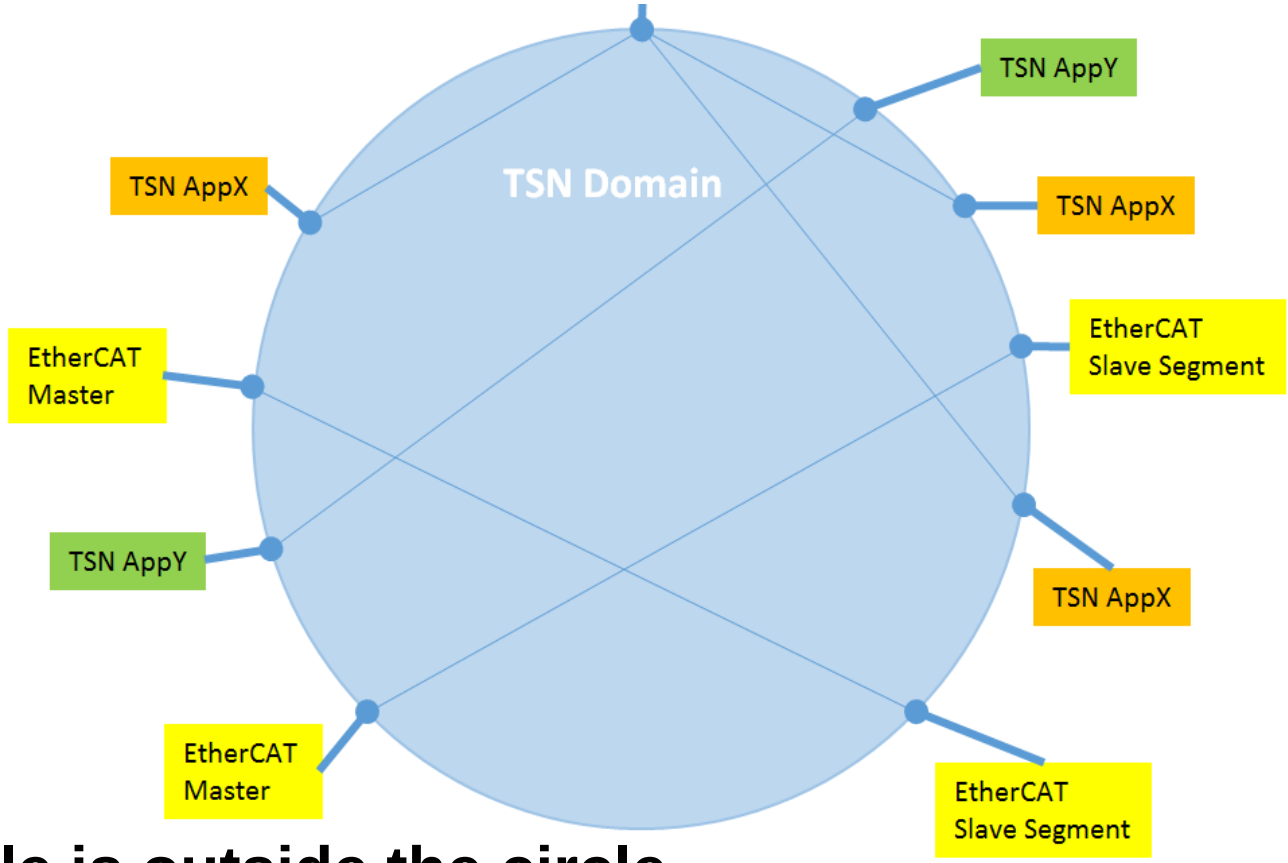
- EtherCAT Master – EtherCAT segment corresponds to a Identifier (VID)
- Corresponds to Identification ExplDeviceID of EtherCAT
- MAC addresses (StreamDA) constructed of
  - A unique EtherCAT address part registered by IEEE
  - The VLAN / ExplDeviceID
  - Stream selector

EtherCAT and TSN

If you have the choice, take both!

Stream adaption uses TSN but does not modify it!

Stream adaption uses EtherCAT but does not modify it!



Profile is outside the circle.