

Proposal for Nendica Study Item: Forwarding of Fieldbus CPF 12 on 802.1 Bridges

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Fieldbus CPF 12

- EtherCAT® is registered trademark of Beckhoff Automation GmbH.
- EtherCAT is represented as Communication Profile Family “CPF 12” in IEC 61784-2
 - ▣ [Industrial Ethernet Facts](#), Issue 2, Feb. 2013, p 17
- EtherCAT technology is defined in IEC 61158 series as type 12 and in the IEC 61784-2 as communication profile CPF 12.
 - ▣ https://www.ethercat.org/en/downloads/downloads_8C601C9A5BEF47E5976D95B7E4FE7F6E.htm
- See IEEE 61784-3-12: “Industrial communication networks – Profiles – Part 3-12: Functional safety fieldbuses – Additional specifications for CPF 12”

Proposal for Nendica Study Item

No Change!

➤ For Nendica to initiate a study item on **Forwarding of Fieldbus CPF 12 on 802.1 Bridges**

To be studied	<ul style="list-style-type: none">• Detail use case and practical requirements for intermixed EtherCAT and Ethernet forwarding• Feasibility of operation• Impact on functionality, including latency, compared to independent networks• Feasibility of assuring QoS for EtherCAT and Ethernet• This study item excludes aspects that are covered by project IEC/IEEE 60802
Deliverable	<p>An informal report documenting</p> <ul style="list-style-type: none">• Summary requirements according to industrial scenarios• Potential benefits• Summary of feasibility issues• Impact & optimization of evolving technologies• Possible standardization needs• Possible recommendation to initiate a work item
Leader	<ul style="list-style-type: none">• Huajie Bao (Huawei), or other volunteers
Timeline	<ul style="list-style-type: none">• Start in June 2022, finish in Nov 2022• Draft version Aug 2022• Call for comments Sept 2022• Complete Study Item Report Nov 2022
Work schema	<ul style="list-style-type: none">• Weekly meeting or on-demand meeting• Encourage all contributions• Provide ongoing reporting to IEC/IEEE 60802

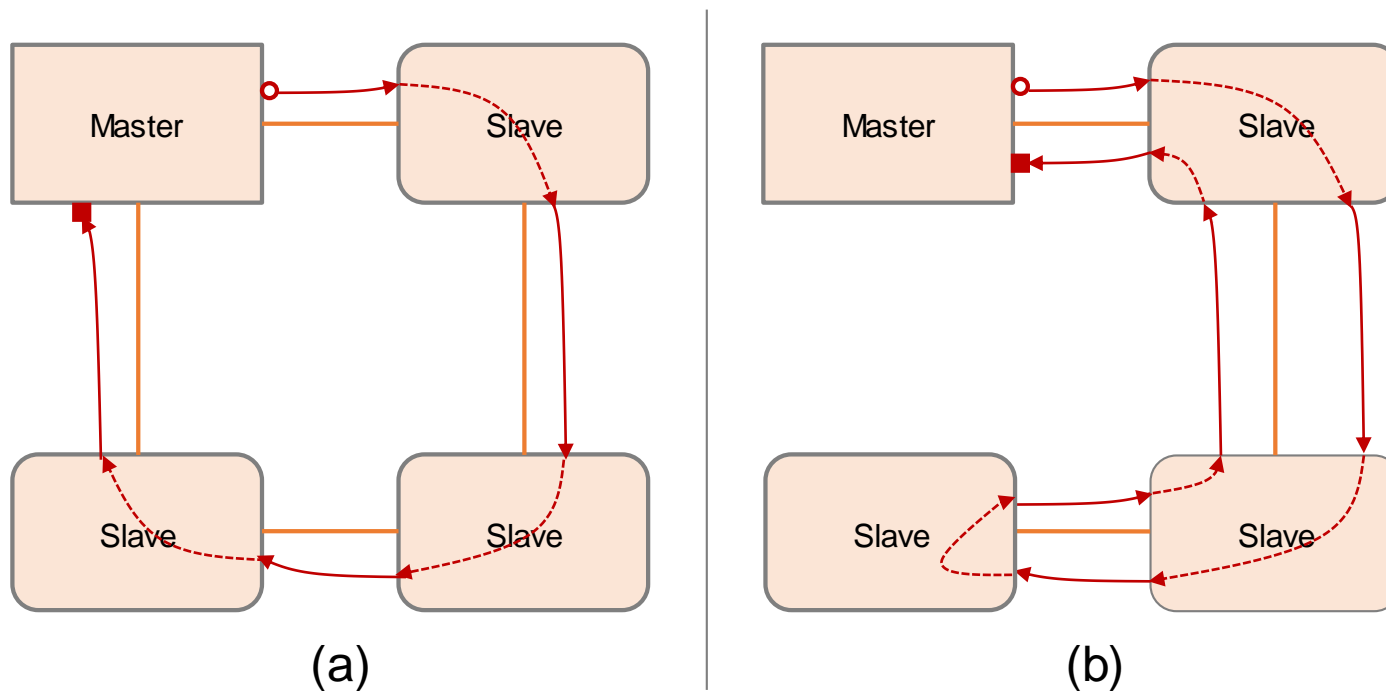
Thank you.

Background

- Regarding Elastic Ethernet, several presentations were discussed:
 - ❑ [Converged Elastic Ethernet Network](#) (rev 0, presented to Nendica, 2022-06-16, 2022-06-09)
 - ✓ Highlighted the contrast to P60802
 - ✓ Highlighted the contrast to IEEE Project P2971 and prospective P2972
 - ❑ [Elastic Ethernet based on Converged Switch](#) (presented to Nendica, 2022-06-02, 2022-05-26)
 - ✓ Converged switch
 - ✓ On 2022-06-02, possible relationship to IEEE Project P2971 and prospective P2972 was raised
 - ❑ [Industrial Network based on Convergent & Elastic Ethernet](#) (presented to P60802, 2022-05-16)
 - ✓ Weak determinism
 - ✓ Centralized management
 - ✓ Extreme low latency / jitter
 - ❑ [Convergent & Elastic Ethernet Networking for Industry](#) (presented to P60802, 2022-05-06)
 - ✓ Convergent industrial network based on Ethernet
 - ❑ [Elastic Ethernet Networking for Industry](#) (presented to Nendica, 2022-04-07)
 - ✓ Elastic Ethernet framework
 - ❑ [Low Latency Discussion for Ethernet Networking](#) (presented to Nendica, 2021-11-18)
 - ✓ Extreme low latency / jitter analysis
- This presentation elaborates the EtherCAT network connected with Ethernet and proposes to proceed with initiation of the Study Item.

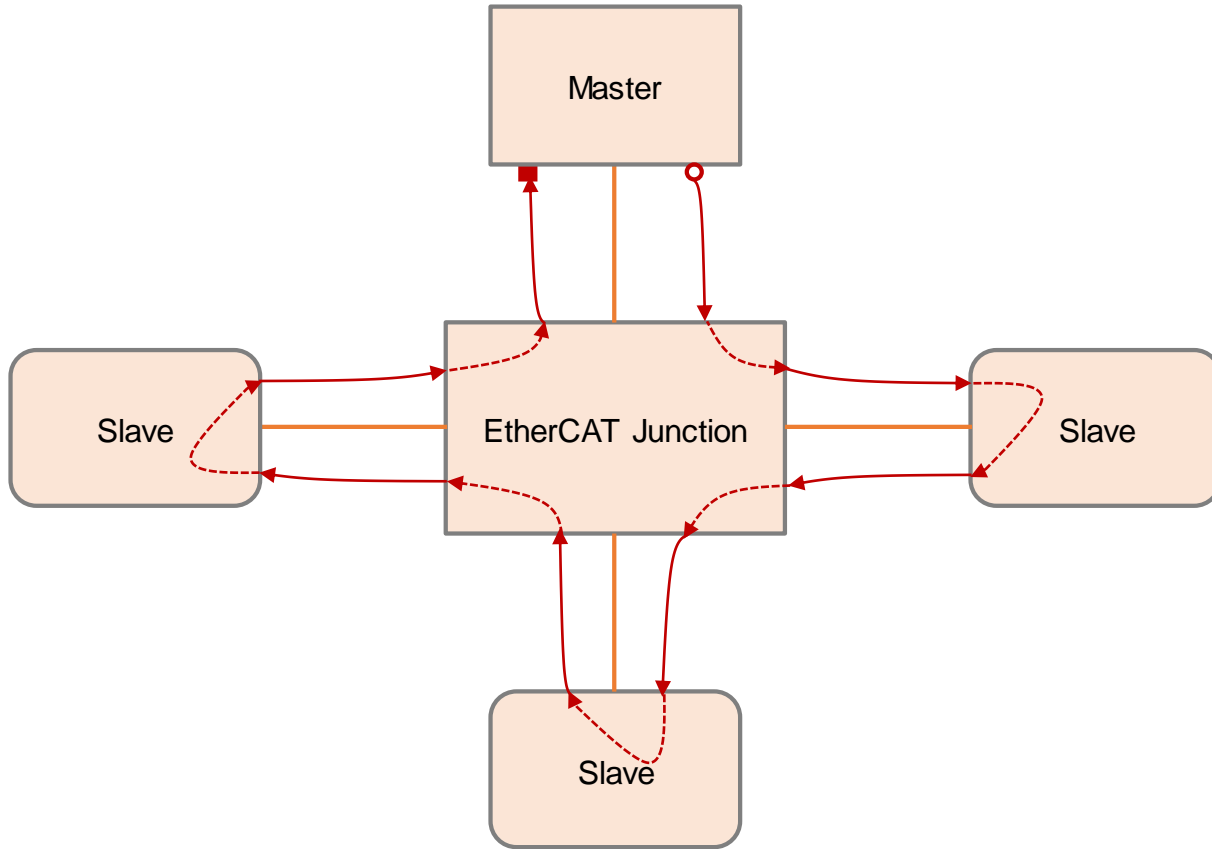
EtherCAT Logical-Ring Forwarding

The Type 12 fieldbus in IEC 61158-3/4/5/6-12 is also known as EtherCAT. An EtherCAT network can be understood as a railway network where slave devices are treated as stations, data are treated as passengers, and EtherCAT frames are treated as trains. While the EtherCAT frames move through the slave devices, the slave devices can off-load and re-load data into EtherCAT frames.



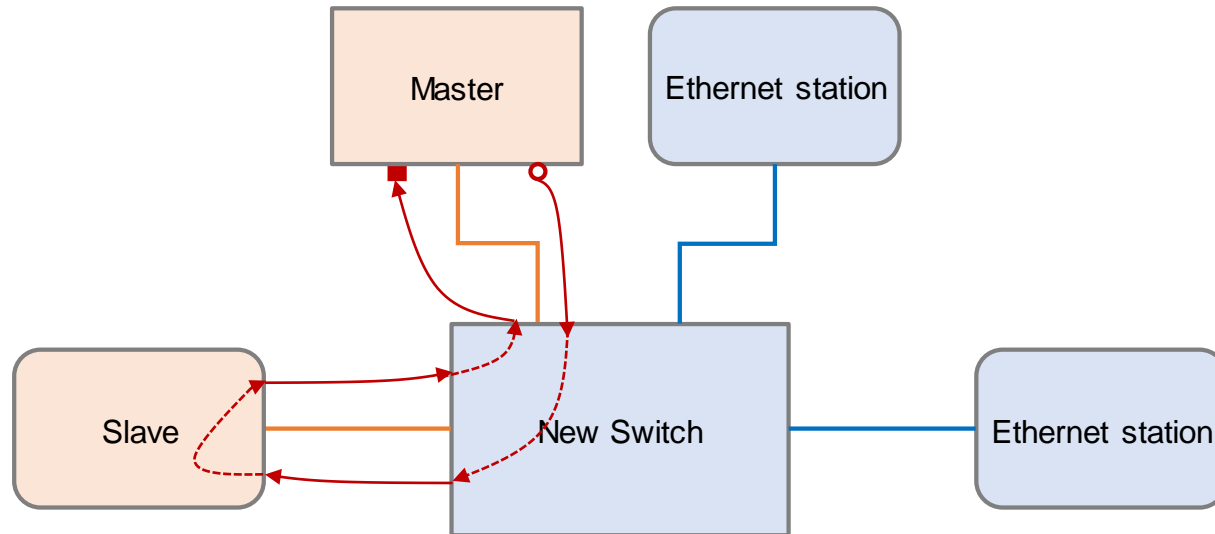
- EtherCAT frame MAC & PHY follow Ethernet specs
 - ▣ with distinct EtherType
- Frame originates at master, passes each slave (which may modify it) and is returned to master
- Logical topology is a ring
 - a) physical ring topology
 - b) physical line topology
 - ✓ Single-port slave forwards frame back to sender

EtherCAT Junction



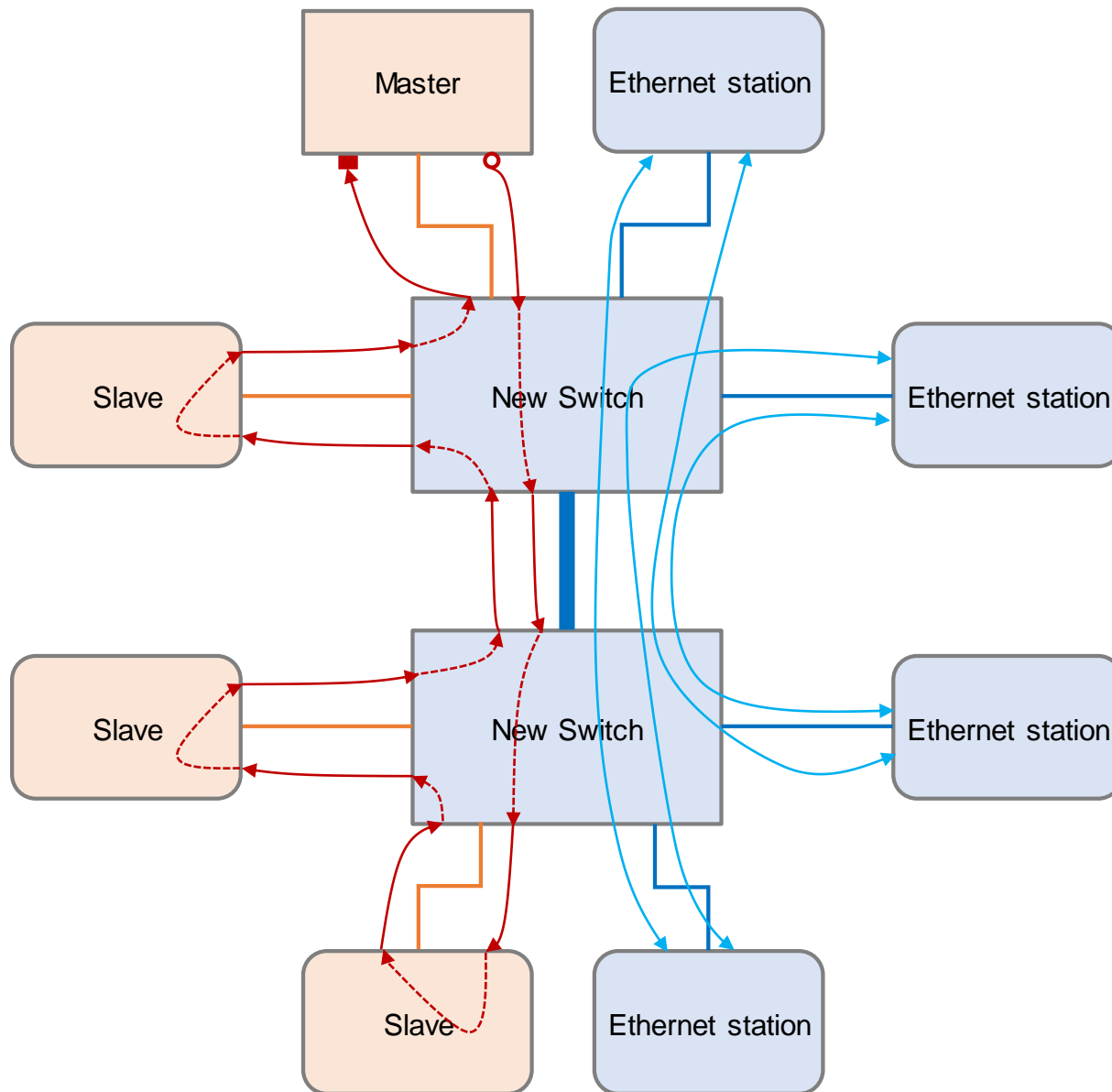
- EtherCAT Junction operates something like a switch
- Forwarding port is statically determined based on ingress port alone
 - ▣ Frames are cut-through forwarded to next port
- EtherCAT Junction is not a bridge
- Is it feasible to consider a “new switch” that would serve as both an EtherCAT Junction and an Ethernet bridge?

A New Switch with Limited Functionality: Pure Ports



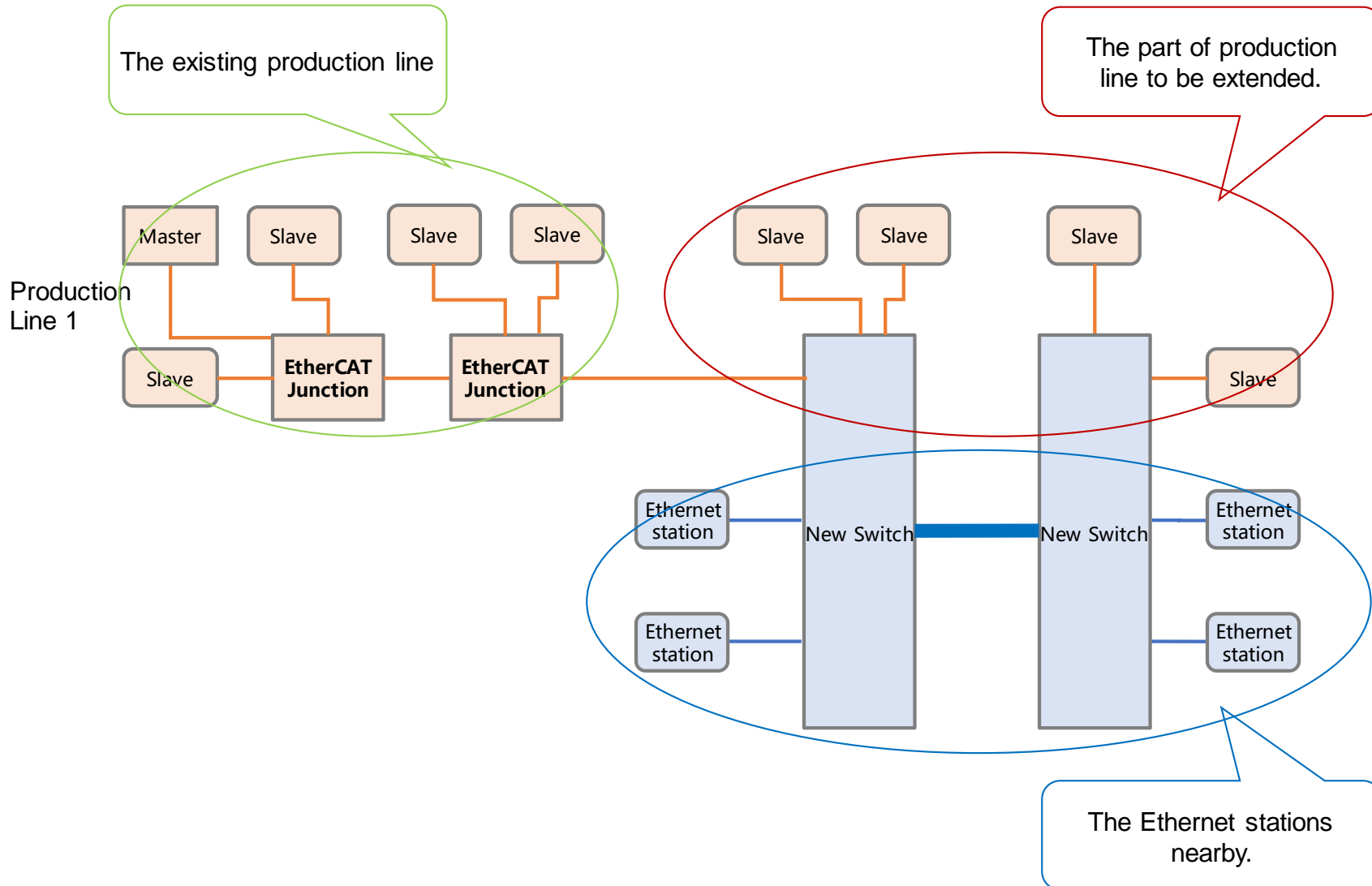
- The most elementary functionality of new switch is statically configured for pure EtherCAT-only ports and pure Ethernet-only ports
- No new protocol required
 - ❑ Could add management tools to configure ports
 - ❑ Not very interesting for networking technology

A New Switch with New Functionality: Mixed Ports



- New functionality is required to support ports with mixed EtherCAT and Ethernet frames
- Some ports are pure EtherCAT or pure Ethernet
 - ❑ Forwarding can be statically configured
- Other ports are mixed
 - ❑ e.g. blue and bold link
 - ❑ new procedure is required
- New procedures
 - ❑ Identify EtherCAT frame; then
 - Cut-through to egress port, based on ingress port
 - ❑ otherwise forward as bridge

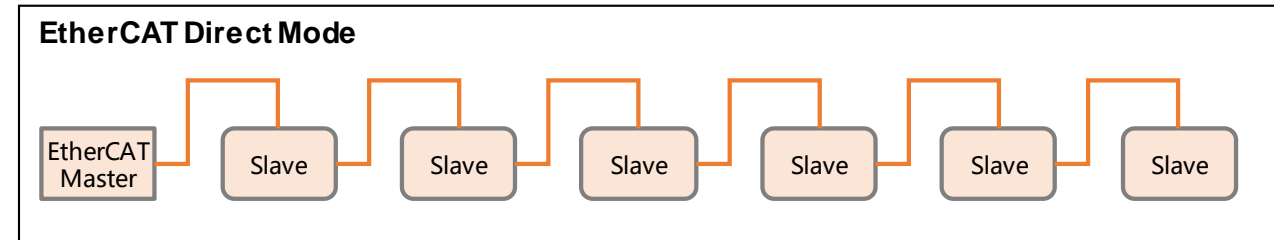
Use Case for A New Switch to Forward EtherCAT & Ethernet Frames Simultaneously



- Production line network requirement: cycle time 4ms, jitter < 10%
- Considering the space and cost, the factory seeks new switches to forward EtherCAT frames and Ethernet frames from the same link.

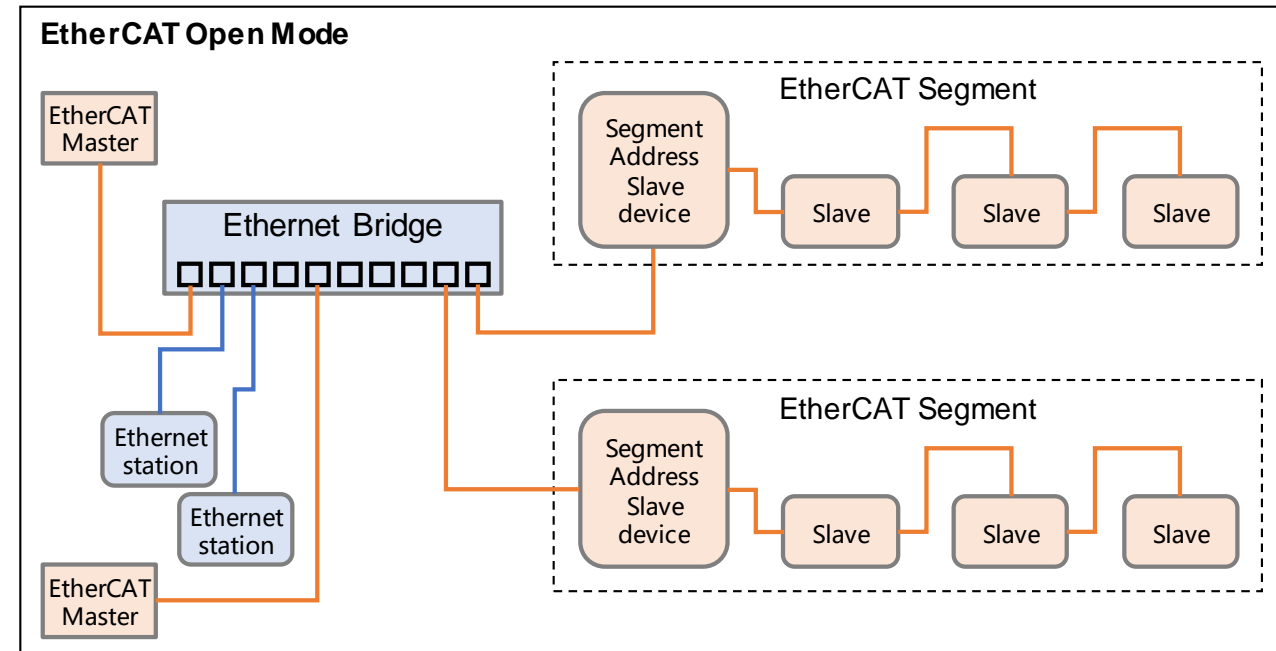
EtherCAT Open Mode & Direct Mode

➤ The previous slides indicated EtherCAT direct mode. In the direct mode, the EtherCAT master and the slave devices are connected one by one, and the frames are forwarded in a logical ring, and the MAC address fields of the EtherCAT frames are not checked (the SA is the EtherCAT master address, and the DA is the broadcast address).



➤ Using the EtherCAT open mode, one or several EtherCAT segments can be connected via Ethernet bridge with one or more Master devices. Each segment can be addressed using a "Segment Address Slave" device (the head station of the segment).

- ❑ The EtherCAT master sends the EtherCAT frame, and the DA is the MAC address of the Segment Address Slave device.
- ❑ The Ethernet bridge forwards the EtherCAT frame to Segment Address slave device.
- ❑ This Segment Address Slave device replaces the DA with the SA (address of master) and replaces the SA with its own MAC address.
- ❑ The EtherCAT frame loops as the rule of EtherCAT in the segment network.
- ❑ Finally, the EtherCAT frame is forwarded to master by the Ethernet bridge.



Relationship to P60802 “TSN Profile for Industrial Automation”

- Draft 1.3: <http://www.ieee802.org/1/files/private/60802-drafts/d1/60802-d1-3.pdf>
- “Use Cases IEC/IEEE 60802 V1.3” <https://www.ieee802.org/1/files/public/docs2018/60802-industrial-use-cases-0918-v13.pdf>
- See also page 25-27 of https://www.ieee802.org/1/files/public/docs2022/webinar-parsons-WSIS_Forum_2022_TSN-0422.pdf

- P60802 is a profile, supporting TSN mechanisms and other features, options and configurations etc. per current IEEE standards, not specifying new ones.
- The uses cases described here may require new functionality (e.g. cut-through forwarding of EtherCAT frames).
- The intention here is to study the possible application for the use case and identify feasibility issues
 - ▣ not to develop a profile or standard
- The results may be useful to outlining possible future amendments that may allow expansion of P60802 applicability.

Difference between P2971 / P2972 and Elastic Ethernet

IEEE PAR P2971 (“Standard for the Test Requirements of a Gateway Supporting a Time Sensitive Networking in the Field of Industrial Internet”) [authorized 2020-12-03]

<https://standards.ieee.org/ieee/2971/10467/>

See also: “Introduction of IEEE P2971 and P2972”

https://www.ieee802.org/1/files/private/liaisons/liaison-IEEE_P2971+P2972_introduction-0121.pdf.

NO.	Category	P2971 / P2972 (based on Gateway)	Elastic Ethernet (based on New Switch)
1	Network site	<ul style="list-style-type: none"> ● The gateway is deployed between industrial networks. 	<ul style="list-style-type: none"> ● The new switch is deployed internally within industrial network.
2	Main functionality	<ul style="list-style-type: none"> ● The functionality operates at Layers 4-7. ● The gateway implements information exchange and conversion among multiple industrial networks. ● The focus is on protocol conversion among applications. ● The communication endpoints are devices from different industrial networks. 	<ul style="list-style-type: none"> ● The functionality to be studied is at Layer 2. ● The new switch supports forwarding among a mix of different industrial network datagrams. ● The new switch does not alter fields at the application layer. ● Both communication endpoints are devices in a common industrial network.
3	Network scope	<ul style="list-style-type: none"> ● Including network bus (non-Ethernet based), industrial Ethernet, industrial wireless 	<ul style="list-style-type: none"> ● Including industrial Ethernet only

Ethernet Stations Connect to EtherCAT Network via Ethernet over EtherCAT Mailbox Protocol

- Ethernet over EtherCAT (EoE): The EtherCAT master implements the Ethernet over EtherCAT mailbox protocol to enable the tunneling of Ethernet frames to special slave devices which can forward the frames tunneled to Ethernet stations.
 - ❑ Only EtherCAT telegrams can be transmitted in an EtherCAT network, other types of data are encapsulated and transferred within an EtherCAT telegram.
 - ❑ The standard Ethernet stations connect to the EtherCAT network through EtherCAT Gateway devices which are responsible for tunneling Ethernet frames through the EtherCAT network.
 - ❑ Moreover, the Ethernet frame tunneled has to be known on beforehand so that adequate space can be reserved in the EtherCAT frame.
- **EoE is different from the New Switch, the former is to support the connection and interaction between Ethernet devices and Ethernet stations, the latter is to forward the EtherCAT frames and Ethernet frames respectively.**

