Proposal for Nendica Study Item: Converged Elastic Ethernet Network

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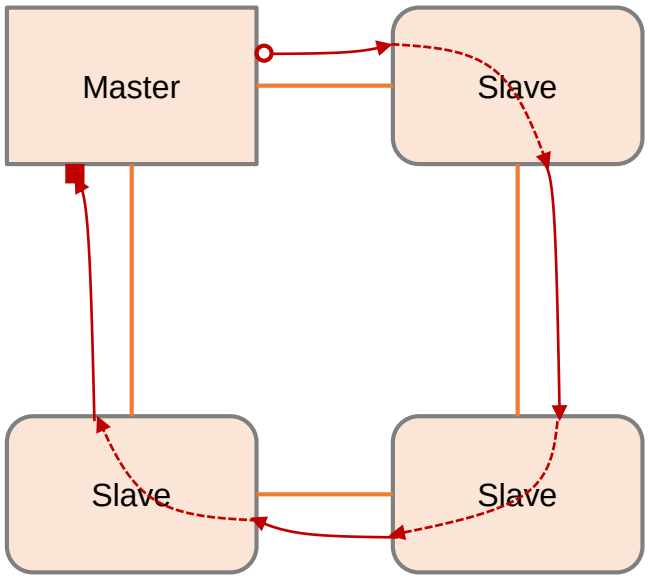
Background

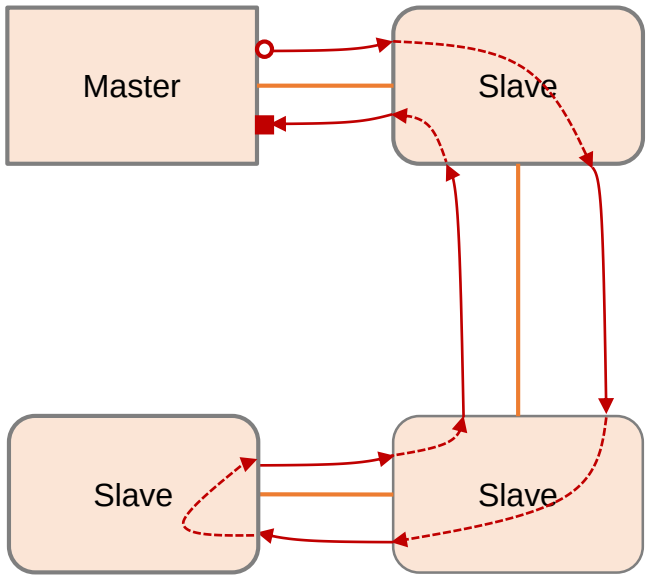
- Regarding Elastic Ethernet, several presentations were discussed:
  - Converged Elastic Ethernet Network (rev 0, presented to Nendica, 2022-06-09)
    - ✓ Highlighted the contrast to IEEE Project P2971 and prospective P2972
    - ✓ Issues of overlap with P60802 were raised.
  - Elastic Ethernet based 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 narrows the scope for contrast to P60802 and proposes to proceed with initiation of the Study Item.

EtherCAT Logical-Ring Forwarding

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.



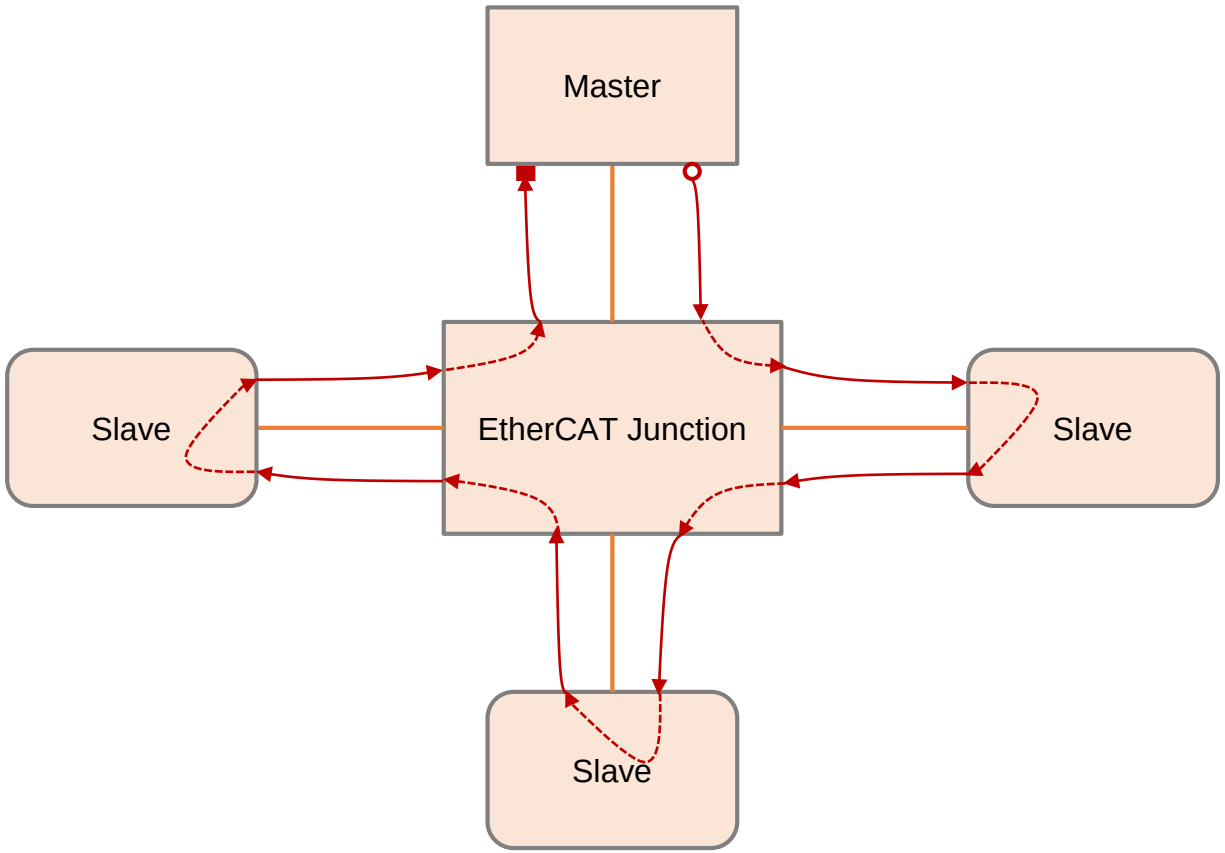
(a)



(b)

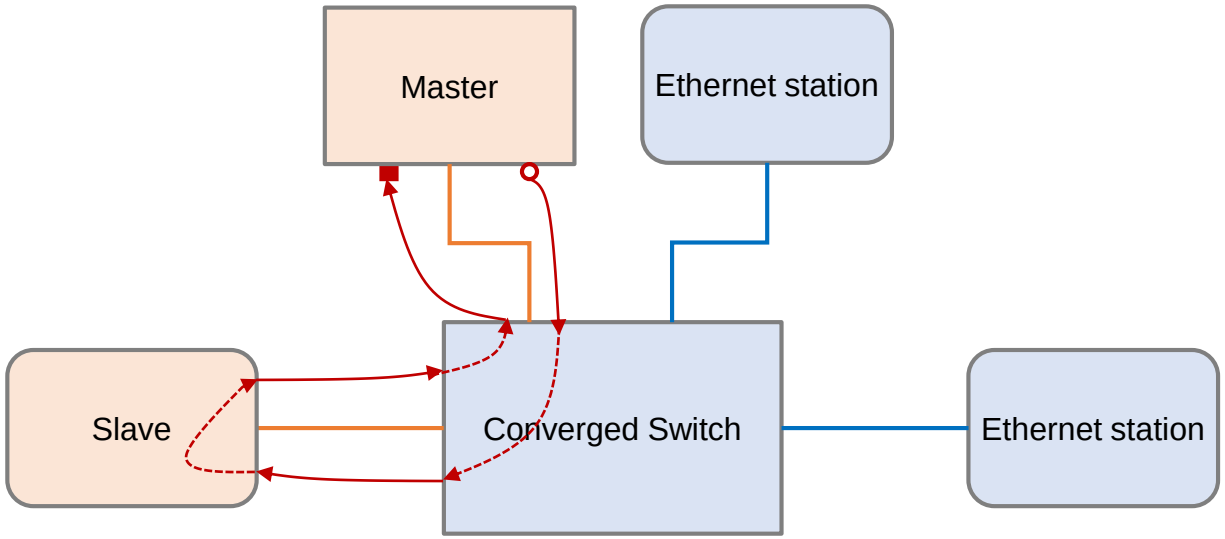
- EtherCAT frame MAC & PHY follow Ethernet specs
  - with distinct Ethertype
- Frame originates at master, passes each slave (which may modify it) and is returned to master
- Logical topology is a ring
  a) physical ring topology
  b) physical line topology
     ✓ Single-port slave forwards frame back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

EtherCAT Junction



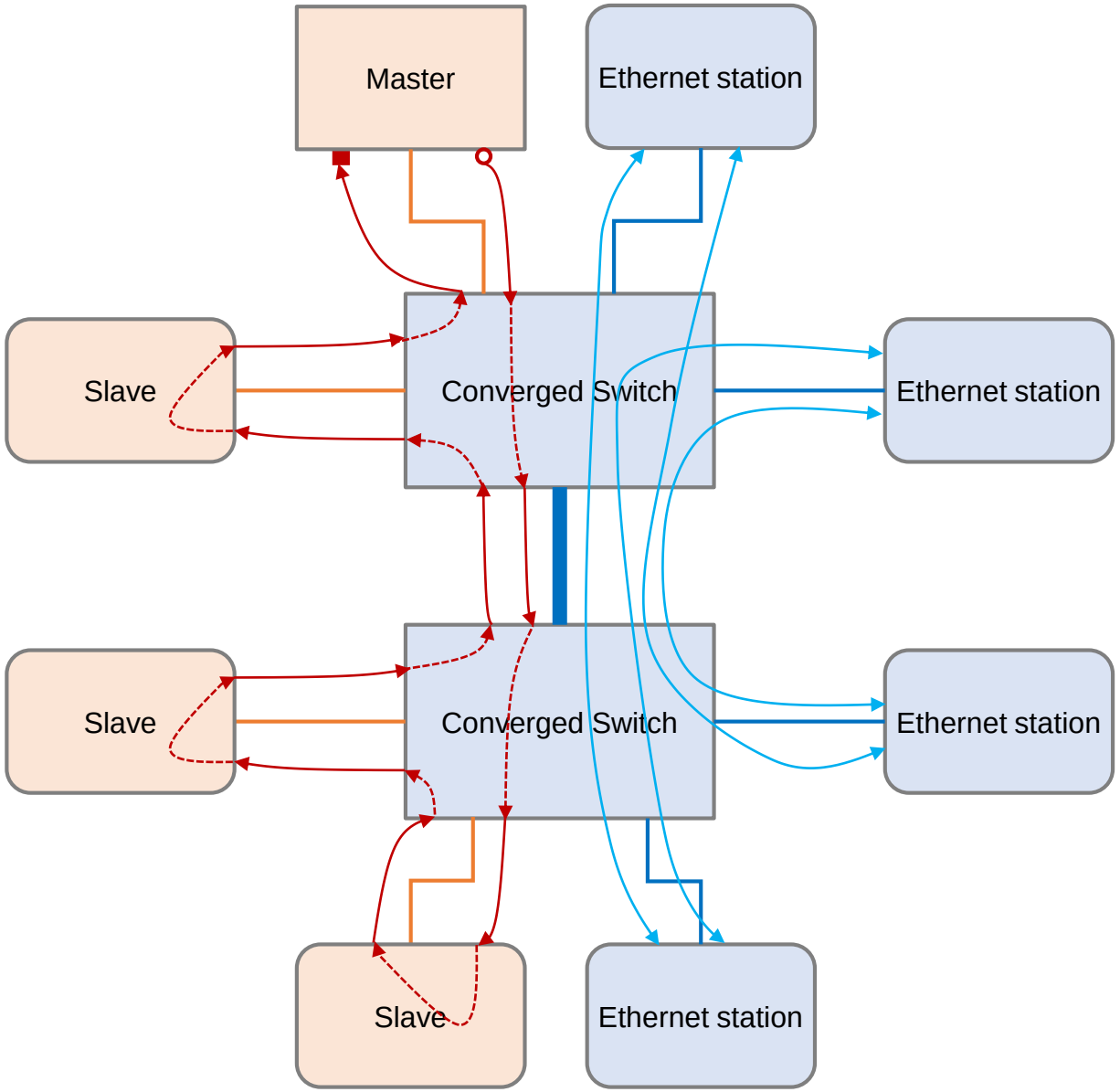
- EtherCAT Junction operates something like a switch
- Forwarding port is statically determined based on ingress port alone
  - Frames are cut-through forwarded to next port
- EtherCAT Junction is not a bridge
- Is it feasible to consider a “converged switch” that would serve as both an EtherCAT Junction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

Converged Switch with Limited Functionality: Pure Ports



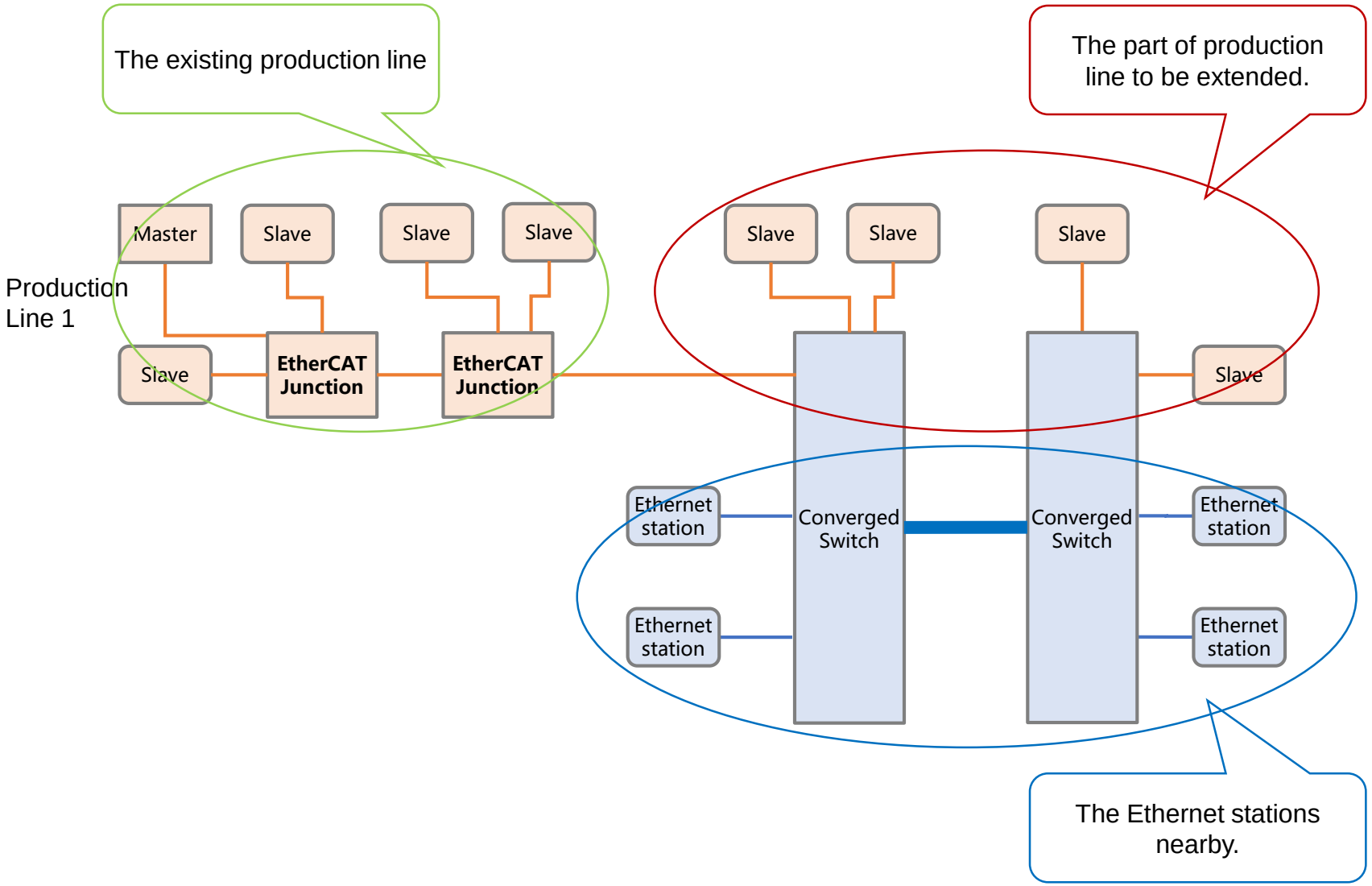
- The most elementary converged switch functionality is statically configured for pure EtherCAT-only ports and pure Ethernet-only ports
- No new protocol required
  - Could add management tools to configure ports
  - Not very interesting for networking technology

Converged 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 Converged Switch to Forward EtherCAT & Ethernet Frames Simultaneously



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

Contrast with 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

NO.	Category	P60802 Network (of TSN Bridges)	Elastic Ethernet (based on Converged Switch)
1	Network scope	● The P60802 network is composed by industrial network of Ethernet bridges, supporting TSN mechanisms and other features, options and configurations etc. per current IEEE standards.	● Converged switch should forward both EtherCAT datagrams and Ethernet datagrams intermixed. ● Converged switch would ideally support all OT network datagrams. ● QoS would be managed for all frames
2	Mechanisms	● As a TSN profile, the project selects features, options, configurations, defaults, protocols, and procedures, not specifying new ones. ● All of the bridges / switches are managed under TSN mechanisms. ● The domain or subnetwork of specific OT network may run independently and is managed under the OT network mechanism.	● Mechanism to forward and schedule the EtherCAT frames and Ethernet frames may depend on future amendments to functionality specified in standards.

Proposal for Nendica Study Item

- For Nendica to initiate a study item on **Converged Elastic Ethernet Network**

To be studied	• Detail use case and practical requirements for converged switch to support intermixed EtherCAT and Ethernet forwarding • Feasibility of operation • Impact on functionality, including latency, compared to independent networks • Feasibility of scheduling for EtherCAT and Ethernet frames • Feasibility of assuring QoS for EtherCAT and Ethernet • Other related aspects requested by converged switch
Deliverable	An informal report documenting • Summary requirements of converged switch according to industrial scenarios • Potential benefits of converged switch • Summary of feasibility issues • Impact & optimization of evolving technologies from the viewpoint of converged switch • Possible standardization needs • Possible recommendation to initiate a work item
Leader	• Huajie Bao (Huawei), or other volunteers
Timeline	• 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	• Weekly meeting or on-demand meeting • Encourage all contributions

Thank you.

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 Converged Switch)
1	Network site	● The gateway is deployed between industrial networks.	● The converged switch is deployed internally within industrial network.
2	Main functionality	● 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.	● The functionality to be studied is at Layer 2. ● The converged switch supports forwarding among a mix of different industrial network datagrams. ● The converged switch does not alter fields at the application layer. ● Both communication endpoints are devices in a common industrial network.
3	Network scope	● Including network bus (non-Ethernet based), industrial Ethernet, industrial wireless	● Including industrial Ethernet only