What is TSN – Time Sensitive Networking?
Motivation of TSN

- Ethernet with switches
  - **best effort** approach
  - Use case: work stations, PCs

- **Use cases** with real-time requirements
  - Audio/Video, Mobile Base Stations, Automotive, Automation, …

- New approach for **switching**: TSN – **Time Sensitive Networking** allows combination with best effort traffic (if bandwidth is high enough)
Many different standards

1. 802.1Qbu
2. 802.1Qbv
3. 802.1Qca
4. 802.1CB
5. 802.1Qcc
6. 802.1AS-REV
7. 802.1Qch
8. 802.1Qci
9. 802.1Qcj
10. 802.1CM
11. 802.1Qcp
12. 802.1Qcr
13. 802.1CS
14ff. .....
## Overview and Status

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Several parts released:  

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IEEE 802.1 Paradigm Shift: TSN

- TSN is a paradigm shift in the IEEE 802 world
  - Addresses real time needs of various industries
  - Moving away from the best effort approach
  - Forward frames as fast as possible in the IEEE802.1 context
  - Without losses due to congestion (reservation calculates buffers)

- Part of the bandwidth is reserved for time sensitive streams
- Other part of bandwidth remains for legacy traffic (higher frame drop rate, possibly higher delays)

→ TSN intends to reserve a fraction of the bandwidth for time sensitive traffic
Real time streams within TSN network – non-TSN devices can be connected outside.
TSN communication is done by so called streams

IEEE 802.1 standard terms

- **“Talker”** = the sender of a stream
- **“Listener”** = the receiver of a stream

A stream is an **unidirectional** flow of data from a talker to one or more listeners

A stream transmits a **number of frames** with a **number of data bytes** within a given **interval**
**TSN: set of standards relevant for Streaming with EtherCAT**

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Relevant TSN Technologies

- IEEE 802.1AS-REV **Time Synchronization**
  - Profile of 1588

- IEEE 802.1Qbv: **Scheduled Traffic Windows**
  - “Time Aware Shaper” TAS
  - Interfering frames before start of time-sensitive time period → guard band

- IEEE 802.1Qbu: **Frame Pre-emption**
  - Reduces guard band
EtherCAT and TSN
Application Scenarios for EtherCAT and TSN

- EtherCAT master and EtherCAT segment connected via heterogeneous switch-based network

- Improve real-time capabilities of EAP in switched-based networks
TSN network between master and EtherCAT segment

Bridged Network
(802.1 based incl. TSN)

Any PLC

TSN - EtherCAT adaptation

EtherCAT slave segment

MASTER

EAP

TSN

MASTER

EAP

TSN

MASTER

OPC/UA

MES

printer

TSN Switch

February 2018

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Adaptation of **TSN stream** to EtherCAT segment in **first EtherCAT slave**

- **Bridged Network** (802.1 based incl. TSN)
- **TSN Stream**
- **EtherCAT slave segment**
- **Open Mode Device**
- **TSN Switch**
- **TSN**
- **Any PLC**
- **MES**
- **OPC/UA**
- **EAP**
- **MASTER**
- **ETG**
- **SPS/IPC/Drives 2017**
Adaptation of **TSN stream** to EtherCAT segment in **Switch**

**Bridged Network**
(802.1 based incl. TSN)

**TSN Switch**

**Open Mode Device**

**EtherCAT slave segment**

**Standard EtherCAT Slave**

© EtherCAT Technology Group
TSN network between EtherCAT Masters

Bridged Network
(802.1 based incl. TSN)

Any PLC

EtherCAT slave segment

TSN Switch

TSN

TSN

printer

MES

OPC/UA

EAP

EAP

MASTER

MASTER

MASTER
EAP transferred on TSN-enhanced 802.1 network

Bridged Network
(802.1 based incl. TSN)

EAP

MASTER

EAP

MASTER

EAP

MASTER

OPC/UA

MES

Any PLC

TSN

TSN Switch

Open Mode Device

EtherCAT slave segment

Standard EtherCAT slave
EtherCAT Approach: Profile for usage of TSN

- ETG defines **profile specification** for usage of EtherCAT with TSN with focus on
  - Time based sending
  - Synchronization

- Adaptation of TSN streams to EtherCAT segment

- Includes
  - Handling of MAC addresses
  - **Synchronizing** AS and DC time
  - Set (VLAN) Identifier as base for unique **Stream addresses**
  - Can be either feature of **switch** or of EtherCAT **device** (1st device)
Profile means…

- References
  - EtherCAT standard
  - TSN standard

- Compatibility with other TSN Profiles

- Specifies adaptation
- Defines how to use standards – but not a new protocol
- Specifies a generic interface to TSN “tool box” (not a specific protocol)
Not a new protocol: Separate protocol fields

IEEE 802.1 protocol relevant frame parts
- Destination MAC
- Source MAC
- VLAN tag
- VID
- Priority

EtherCAT protocol relevant frame parts
- EtherCAT Ethertype
- EtherCAT Frame

EtherCAT OUI
- res.
- e.g. VID Value
- Stream Selector

EtherCAT Traffic identification
- EtherCAT Stream Selector within Segment

EtherCAT Segment identification
Stream Adaptation: 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)
Adaptation provides virtual Ethernet channel

- Adaptation maps TSN stream to EtherCAT frame
- Adaptation is hardware independent
- Adaptation on
  - Master
  - Switch or first EtherCAT slave
Effect on master, slave, switches

- **Slave**
  - No change to EtherCAT implementations required

- **Master**
  - **Lean** stream adaptation
  - Only TSN synchronization and stream announcement required
  - Optional: Multiplexing Layer to connect multiple (TSN) functions or segments → multiple applications connected to one (GBit/s) port

EtherCAT TSN Adaptation can be done on either:
- **Switch**
  - incl. TSN features: IEEE802.1.AS/.Qbu/.Qbv/…

- specific component between TSN network and EtherCAT segment
ETG: first hand TSN Know-How

ETG is actively participating in the TSN Working Groups:
Dr. Karl Weber is an active member of IEEE 802.1
Close cooperation of ETG and IEEE 802.1 working group for technical coordination

Grants access to IEEE 802.1 documents working documents even if those are not yet released

Ensures that TSN standards can be referenced within the ETG Profile specification in the right manner and as an early adaptation.

Ensures access for all ETG members to related TSN documents for ETG profile review
ETG.1700 EtherCAT-TSN Communication Profile

Profile

Document: ETG.1700 S (D) V0.0.9

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available

www.ethercat.org/ETG1700
EtherCAT and TSN – connecting the best

- EtherCAT matches perfectly well with TSN Streams – EtherCAT segments can be updated with one single EtherCAT frame
- TSN offers real-time for heterogeneous networks
- EtherCAT offers fieldbus benefits
  - Highest performance
  - Complete semantic concept
  - Device profiles
  - Easy network configuration
  - Diagnosis

No replacement of each other - combine mutual benefits
If you have the choice, take both!

Stream adaptation uses TSN without modification!

+ Stream adaptation uses EtherCAT without modification!
Further Info about EtherCAT and TSN

- Whitepaper: EtherCAT and TSN – Best Practices for Industrial Ethernet System Architectures
  [Download](#)

- Presentation: Layering with TSN and EtherCAT
  [Download](#)

- Specification: ETG.1700 EtherCAT TSN Communication Profile
  [Download](#)
Contact

ETG HQ
Germany
+49 911 54056 20
info@ethercat.org
www.ethercat.org