Use cases and Requirements IEC/IEEE 60802

Abstract

This document describes requirements for industrial automation based on TSN. The requirements are extracted and derived from

- industrial use cases - http://www.ieee802.org/1/files/public/docs2018/60802-industrial-use-cases-0418-v06.pdf
- TSN-IA preCD Draft - http://www.ieee802.org/1/files/private/liaisons/65c-60802-Ed1-IS-preCD-OE_20180430_rev6p0.pdf

1 Recap - 60802 preCD Draft Requirements

See [2] clause 6.2

Table 1 – preCD purposes

The following properties are expected from an IEC/IEEE 60802 TSN network	
1	Streams can be established and removed at any time in ad-hoc manner without effect on other established streams in the network, i.e. particularly without reboot of the network.
2	Network effectivity and efficiency is independent from the order in which streams were established and/or removed (in a non-overloaded situation)
3	Applications in end nodes need not depend on how the network is organized (trees, etc.).
4	In case of stream failure, sufficient diagnostics information is provided, so that the error cause and potential recovery measures can be identified.
5	The network can be expanded dynamically at any time by attaching an additional TSN bridge – without effect on established streams in the network.
6	Removal of a bridge which is in use will only affect streams which are using that bridge.
7	TSN domain boundaries are enforced by TSN bridges and can optionally be controlled by network management to not interfere with TSN traffic and to support non-TSN traffic in a deterministic manner.
8	The requirements of the various industrial traffic types are met.
9	Applications manage access to the TSN network via a standardized Interface.
10	Several independent applications (e.g. multiple CPx systems, OPC UA@TSN…) are supported at the same time.
11	Interoperability of TSN bridges and the TSN function of end nodes from different vendors need to be assured.
12	Network can be partitioned according to the user's wishes into individual functional domains between bridges – optionally within a bridge so that streams of one functional domain do not cross into another functional domain
13	A default set of parameters shall be provided. [not yet decided]
14	All industrial topologies (IEC 61918: linear, ring, star) – including topologies with redundant links as defined in IEC 62439-1 – shall be supported.
15	The addition of TSN functionality to an Ethernet network shall not impact proper operation of upper functional safety layers used on top of Ethernet based fieldbuses or networks (see IEC 61784-3).
16	The TSN–IA profile shall support redundancy for streams. TSN Network management should support reporting of independent physical paths and control of stream setup to allow management of redundancy.
17	The TSN network should also allow redundancy recovery time to be calculated. The TSN-IA profile defines an upper limit for the redundancy recovery time. The TSN-IA profile shall provide means for calculating the recovery time for given topologies.
18	The TSN-IA profile shall support the extension of brownfield installations.
19	The TSN-IA profile shall support connection of existing or non-TSN devices to TSN networks with as little as possible disturbance of existing modes of operation.
20	The TSN-IA profile shall consider protecting functional domains against traffic from outside the domain – examples shall be provided. [not yet decided]

2 60802 Use Cases

See [1] for the detailed description of the use cases.

Table 2 – use cases overview

	Synchronization
1	Sequence of events
	Industrial automation mode of operation
2	Control Loops with guaranteed low latency
3	Control Loops with bounded latency
4	Reduction ratio of network cycle
5	Drives without common application cycle
6	Drives without common application cycle but common network cycle
	Industrial automation networks
7	Redundant networks
8	High Availability
9	Wireless
10	IEEE 802.3cg APL support (Ethernet Sensors)
11	Fieldbus gateway
12	New machine with brownfield devices
13	Mixed link speeds
14	Multiple isochronous domains
15	Auto domain protection
16	Vast number of connected stations
	Industrial automation machines, production cells, production lines
17	Machine-to-machine communication
18	Pass-through traffic
19	Modular machine assembly
20	Tool changer
21	Dynamic plugging and unplugging of machines (subnets)
22	Energy saving
23	Add machine, production cell or production line
24	Multiple applications in a station using TSN
25	Functional safety
26	DCS device level reconfiguration
27	DCS system level reconfiguration
	Further Industrial automation use cases
28	Network monitoring and diagnostics
29	Security
30	Firmware update
31	Virtualization
32	Digital twin

3 Requirements vs. Use cases Cross reference

In the following sub-clauses for each requirement of the pre-CD Draft the affected use cases of [1] are listed:

3.1 Streams can be established and removed at any time in ad-hoc manner without effect on other established streams in the network, i.e. particularly without reboot of the network

Needed by all use cases, in particular:

Dynamic reconfiguration use cases:

19	Modular machine assembly
20	Tool changer
21	Dynamic plugging and unplugging of machines (subnets)
22	Energy saving
23	Add machine, production cell or production line
26	DCS device level reconfiguration
27	DCS system level reconfiguration

(see 3.21)

3.2 Network effectivity and efficiency is independent from the order in which streams were established and/or removed (in a non-overloaded situation)

Needed by all use cases, in particular:

Dynamic reconfiguration use cases:

19	Modular machine assembly
20	Tool changer
21	Dynamic plugging and unplugging of machines (subnets)
22	Energy saving
23	Add machine, production cell or production line
26	DCS device level reconfiguration
27	DCS system level reconfiguration

(see 3.21)

3.3 Applications in end nodes need not depend on how the network is organized (trees, etc.).

This is a requirement to applications. Therefore out of scope for the profile.

Rephrase proposal: The network needs to be organized to fulfill the applications' needs.

Needed by all use cases.

3.4 In case of stream failure, sufficient diagnostics information is provided, so that the error cause and potential recovery measures can be identified.

Needed by all use cases, in particular:

28	Network monitoring and diagnostics

(see 3.21)

3.5 The network can be expanded dynamically at any time by attaching an additional TSN bridge – without effect on established streams in the network.

Needed by all use cases, in particular:

19	Modular machine assembly
20	Tool changer
21	Dynamic plugging and unplugging of machines (subnets)
22	Energy saving
23	Add machine, production cell or production line
26	DCS device level reconfiguration
27	DCS system level reconfiguration

(see 3.21)

3.6 Removal of a bridge, which is in use, will only affect streams, which are using that bridge.

Needed by all use cases, in particular:

19	Modular machine assembly
20	Tool changer
21	Dynamic plugging and unplugging of machines (subnets)
22	Energy saving
23	Add machine, production cell or production line
26	DCS device level reconfiguration
27	DCS system level reconfiguration

(see 3.21)

3.7 TSN domain boundaries are enforced by TSN bridges and can optionally be controlled by network management to not interfere with TSN traffic and to support non-TSN traffic in a deterministic manner.

Needed by all use cases, in particular:

15	Auto domain protection

(see 3.21)

3.8 The requirements of the various industrial traffic types are met.

Only stream based traffic types are covered by the use cases.

In particular:

2	Control Loops with guaranteed low latency
3	Control Loops with bounded latency
4	Reduction ratio of network cycle
5	Drives without common application cycle
6	Drives without common application cycle but common network cycle

(see 3.21)

3.9 Applications manage access to the TSN network via a standardized Interface.

Needed by all use cases.

3.10 Several independent applications (e.g. multiple CPx systems, OPC UA@TSN…) are supported at the same time.

Needed by all use cases, in particular:

17	Machine-to-machine communication
24	Multiple applications in a station using TSN

(see 3.21)

3.11 Interoperability of TSN bridges and the TSN function of end nodes from different vendors need to be assured.

Needed by all use cases, in particular:

17	Machine-to-machine communication

(see 3.21)

3.12 Network can be partitioned according to the user's wishes into individual functional domains between bridges – optionally within a bridge so that streams of one functional domain do not cross into another functional domain.

Needed by all use cases, in particular:

15	Auto domain protection
17	Machine-to-machine communication

(see 3.21)

3.13 A default set of parameters shall be provided [not yet decided].

- network configuration is intentionally postponed -

3.14 All industrial topologies (linear, ring, star [source: IEC 61918]) – including topologies with redundant links as defined in IEC 62439-1 – shall be supported.

Needed by all use cases, in particular:

7	Redundant networks
8	High Availability
9	Wireless

(see 3.21)

3.15 The addition of TSN functionality to an Ethernet network shall not impact proper operation of upper functional safety layers used on top of Ethernet based fieldbuses or networks (see IEC 61784-3).

Needed by all use cases, in particular:

25	Functional safety

(see 3.21)

3.16 The TSN–IA profile shall support redundancy for streams. TSN Network management should support reporting of independent physical paths and control of stream setup to allow management of redundancy.

TSN Network management not defined!

Needed by all use cases, in particular:

7	Redundant networks
8	High Availability
9	Wireless

(see 3.21)

3.17 The TSN network should also allow redundancy recovery time to be calculated. The TSN-IA profile defines an upper limit for the redundancy recovery time. The TSN-IA profile shall provide means for calculating the recovery time for given topologies.

Upper limits and means for calculation are part of IEC 62439.

Needed by all use cases, in particular:

7	Redundant networks
8	High Availability
9	Wireless
32	Digital twin

(see 3.21)

3.18 The TSN-IA profile shall support the extension of brownfield installations.

Needed by all use cases, in particular:

11	Fieldbus gateway
27	DCS system level reconfiguration

3.19 The TSN-IA profile shall support connection of existing or non-TSN devices to TSN networks with as little as possible disturbance of existing modes of operation.

Needed by all use cases, in particular:

12	New machine with brownfield devices
18	Pass-through traffic
26	DCS device level reconfiguration

3.20 The TSN-IA profile shall consider protecting functional domains against traffic from outside the domain – examples shall be provided [not yet decided].

Needed by all use cases, in particular:

15	Auto domain protection
18	Pass-through traffic
29	Security

3.21 Summary

Table 3 – use cases / purposes cross reference

Purposes \ Use Cases	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1																			X	X	X	X	X			X	X					
2																			X	X	X	X	X			X	X					
3																																
4																												X				
5																			X	X	X	X	X			X	X					
6																			X	X	X	X	X			X	X					
7															X																	
8		X	X	X	X	X																										
9																	X														X	
10																	X							X								X
11																	X															
12															X		X															
13																																
14							X	X	X																							
15																									X							
16							X	X	X																							
17							X	X	X																							
18											X																X					
19												X						X								X						
20															X			X											X			

4 Not covered yet

4.1 Synchronization].

Needed by all use cases, in particular:

1	Sequence of events
14	Multiple isochronous domains

4.2 Stream establishment

Needed by all use cases, in particular:

10	IEEE 802.3cg APL support (Ethernet Sensors)
13	Mixed link speeds
16	Vast number of connected stations

4.3 Application behavior

This is a requirement to applications. Therefore out of scope for the profile.

Needed by all use cases, in particular:

30	Firmware update

5 Literature

[1] “Industrial Use Cases”, IEC/IEEE JWG Contributor group;
http://www.ieee802.org/1/files/public/docs2018/60802-industrial-use-cases-0418-v06.pdf.

[2] “IEC preCD 60802”
http://www.ieee802.org/1/files/private/liaisons/65c-60802-Ed1-IS-preCD-OE_20180430_rev6p0.pdf