Configuration for Scheduling of Time-sensitive and Bursty Traffic (STSBT) in TSN

October14, 2019

Name	Company	email
Hasegawa, Akio	Advanced Telecommunications Research Institute International (ATR)	ahase@atr.jp
Nishikawa, Takurou	Fujitsu Limited	nisikawa.taku@jp.fujitsu.com
Sato, Shinichi	Fujitsu Limited	sato_shinichi@jp.fujitsu.com
Itaya, Satoko	National Institute of Information and Communications Technology (NICT)	itaya@nict.go.jp
Kojima, Fumihide	National Institute of Information and Communications Technology (NICT)	f-kojima@nict.go.jp
Koto, Hajime	National Institute of Information and Communications Technology (NICT)	h-koto@nict.go.jp
Murata, Syuuichi	National Institute of Information and Communications Technology (NICT)	murata.syuuichi@nict.go.jp
Ohsawa, Tomoki	National Institute of Information and Communications Technology (NICT)	tohsawa@nict.go.jp
Osuga, Toru	National Institute of Information and Communications Technology (NICT)	osuga@nict.go.jp
Nakajima, Taketoshi	NEC Corporation	nakajima@cp.jp.nec.com
Maruhashi, Kenichi	NEC Corporation	k-maruhashi@bl.jp.nec.com
Onishi, Takeo	NEC Corporation	t-onishi@cj.jp.nec.com
Zein, Nader	NEC Europe Ltd.(NLE GmbH)	Nader.Zein@emea.nec.com
Nakano, Hiroki	NETREQS Co., Ltd	nakano@netreqs.co.jp
Nosaka, Tetusya	Omron Corporation	tetsuya.nosaka@omron.com
Ohue, Hiroshi	Panasonic Corporation	ohue.hiroshi@jp.panasonic.com

Introduction

- This document addresses the need for configuration mechanism for the scheduling of sporadic and bursty* traffic in time-sensitive network.
- The first target is Flexible Factory[1], however, applicable use cases are extended in warehouses, hospitals, airports/stations, etc.
- Technical basis has been explained at interim session in Edinburgh [2]. Modifications have been made considering received feedback.

* All mentions of bursty traffic in this presentation imply bursty and sporadic traffic.

[1] https://mentor.ieee.org/802.1/dcn/19/1-19-0026-03-ICne-flexible-factory-iot-use-cases-and-communication-requirements-for-wired-and-wireless-bridged-networks.pdf

[2] http://www.ieee802.org/1/files/public/docs2019/new-NakanoZein-Scheduling-of-Time-sensitive-and-Bursty-Traffic-in-Reduced-Available-Bandwidth-0919-v02.pdf

Flexible Factory [1]

- The Flexible Factory represents an evolved site for flexible on-demand manufacturing of variable product types with variable production volumes.
- Flexibility in the factory environment emphasizes mobility and configurability of manufacturing facilities.
- In support of the flexibility, human operators are engaged with the production process in order to oversee the on-demand production.

[1] https://mentor.ieee.org/802.1/dcn/19/1-19-0026-03-ICne-flexible-factory-iot-use-cases-and-communication-requirements-for-wired-and-wireless-bridged-networks.pdf

Network Environment - Brownfield [3] -

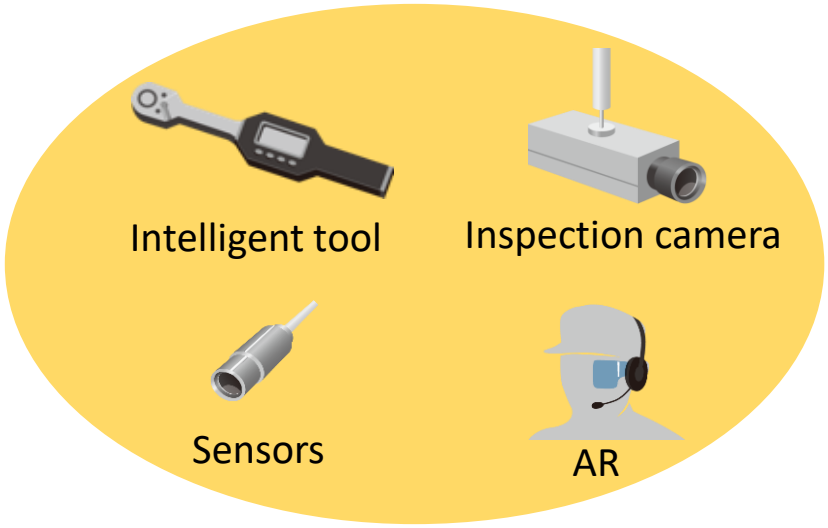
- Network usage is changing from the time when it was designed and commissioned because new devices are added on demand to the network based on step-by-step approach.
- Replacing all devices is difficult and new functions can not be implemented in all existing devices.

Brownfield is the name given to extending or expanding automation environments that already exist[3]. Flexible Factory[1] is the same.

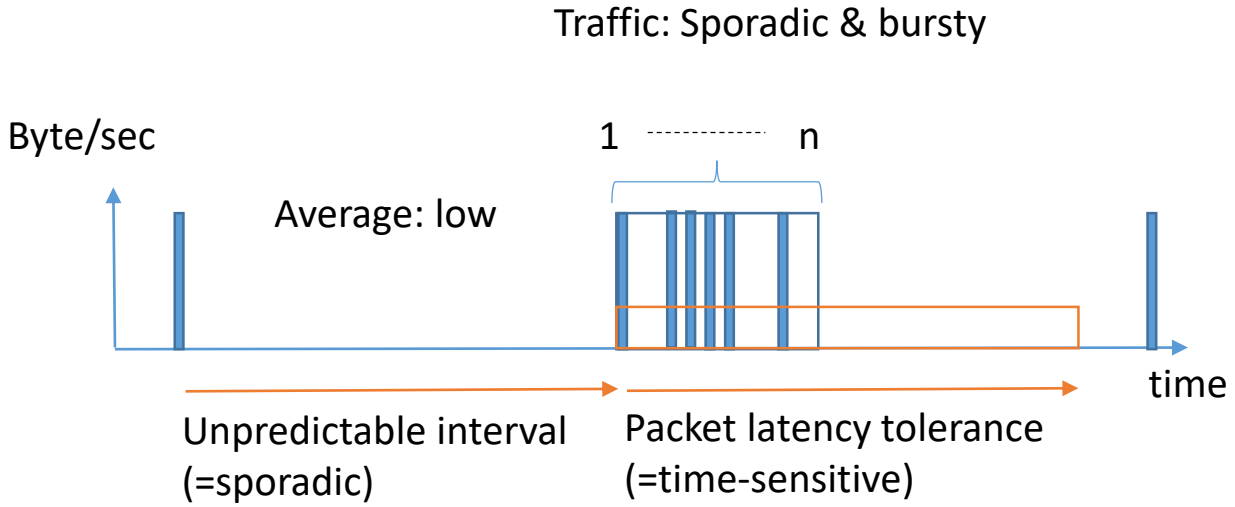
[3] http://www.ieee802.org/3/ad_hoc/ngrates/public/18_03/woods_nea_01_0318.pdf

Risk of Availability due to IoT Devices

- The number of IoT devices which generate busty traffic is increasing in Flexible Factory.
- Large bursts of data have negative impact on the overall performance and will result in risk of service availability at peak traffic condition.



Examples of sources of busty traffic



Traffic pattern of intelligent tool (torque wrench)

Bandwidth Allocation/Stream Reservation

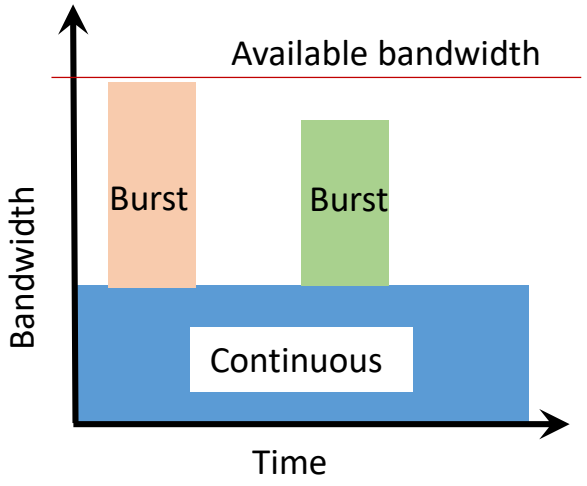
- Over-provisioning is required to allocate bandwidth at peak-rate for a bursty stream.
- SRP supports periodic and bursty traffic but it can't support sporadic and bursty traffic.
- No information how much bandwidth needs to be allocated for sporadic and bursty traffic.

Peak-shaving (burst streams conflict)

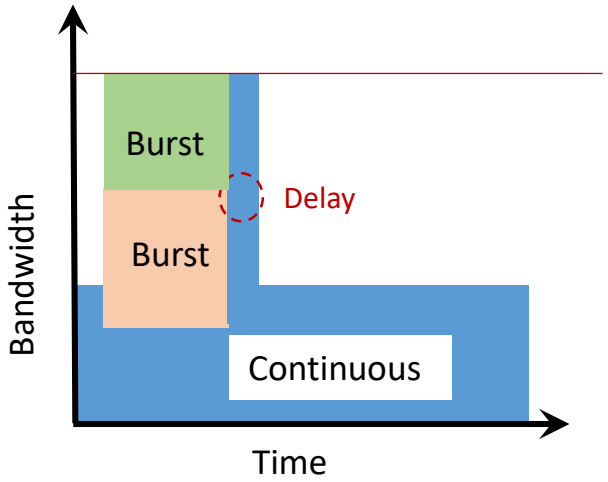
- The process of peak-shaving is used to mitigate the effect of burst streams conflict by minimizing bandwidth occupation while keeping E2E QoS.

$$minimum\ bandwidth = \frac{data\ size}{tolerable\ latency} \times \alpha,\ where\ \alpha = \frac{tolerable\ latency}{tolerable\ latency - Accumlated\ Latency*}$$

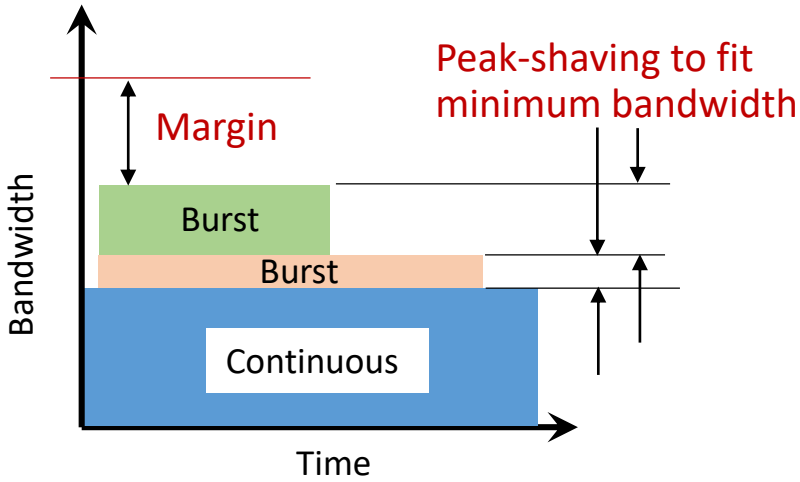
*Accumulated Latency is defined in its path from the Talker to a given Listener (Std. 802.1Q, Clause 35.2.2.8.6)



(a) Normal operation



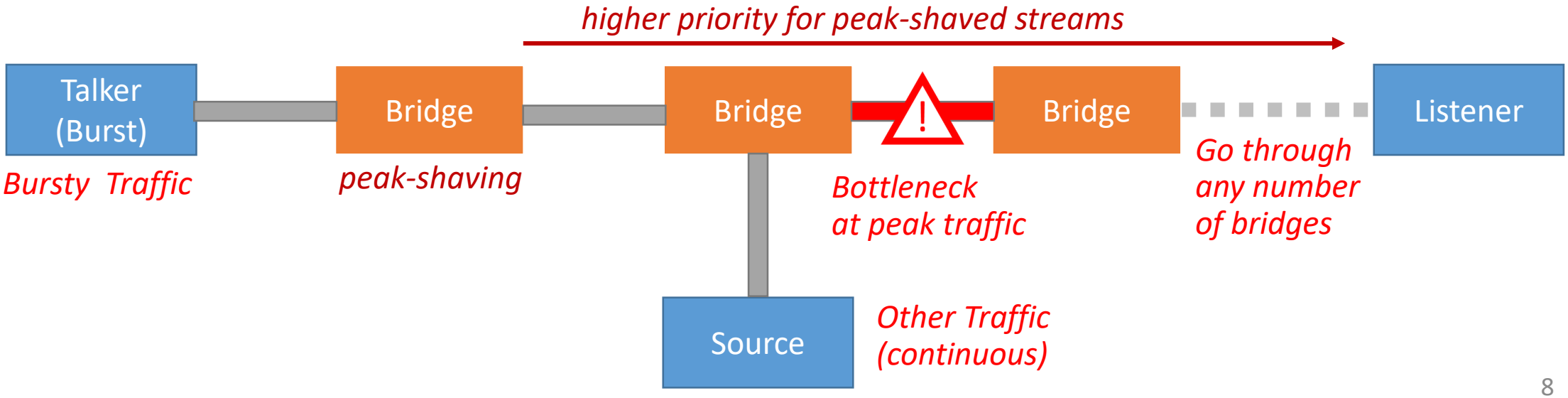
(b) Burst streams conflict



(c) Peak-shaving for bursty traffic

STSBT Operation

- Mitigating traffic load at bottleneck segment of a link for whatever reason that is causing it.
  - ✓ Shaping for peak shaving.
  - ✓ Higher priority assignment (i.e. either with priority forwarding or by bandwidth reservation) for the shaped stream to avoid additional delay.
- Simulation results have been shown in [2].



Ideas of Amendments for STSBT

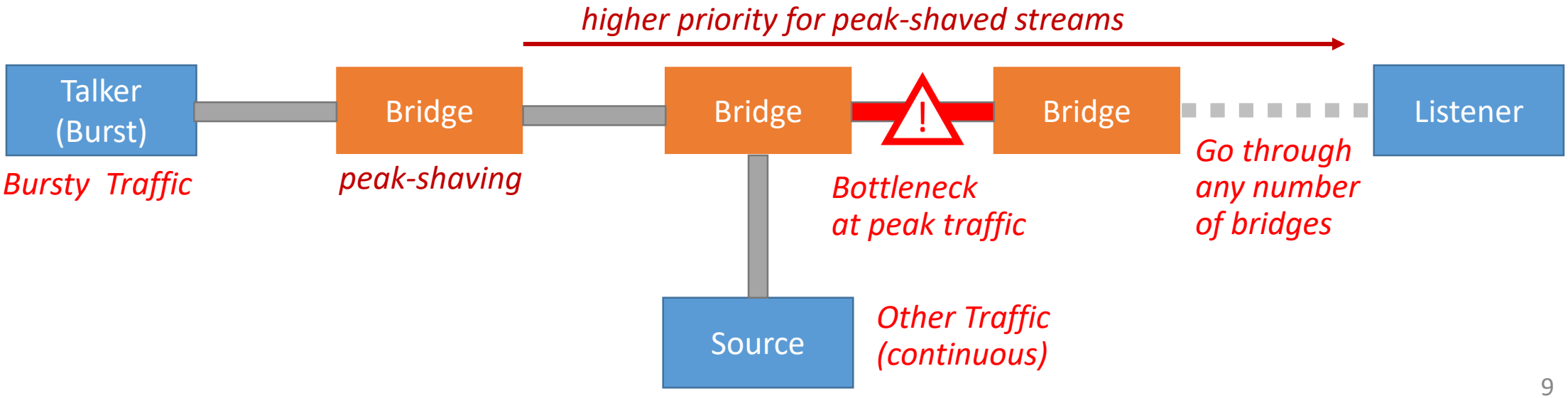
Control Plane

- Distribute information of targeted bursty traffics with ”minimum bandwidth.”
  → Amend .1Q with new information.

Configuration of Data Plane

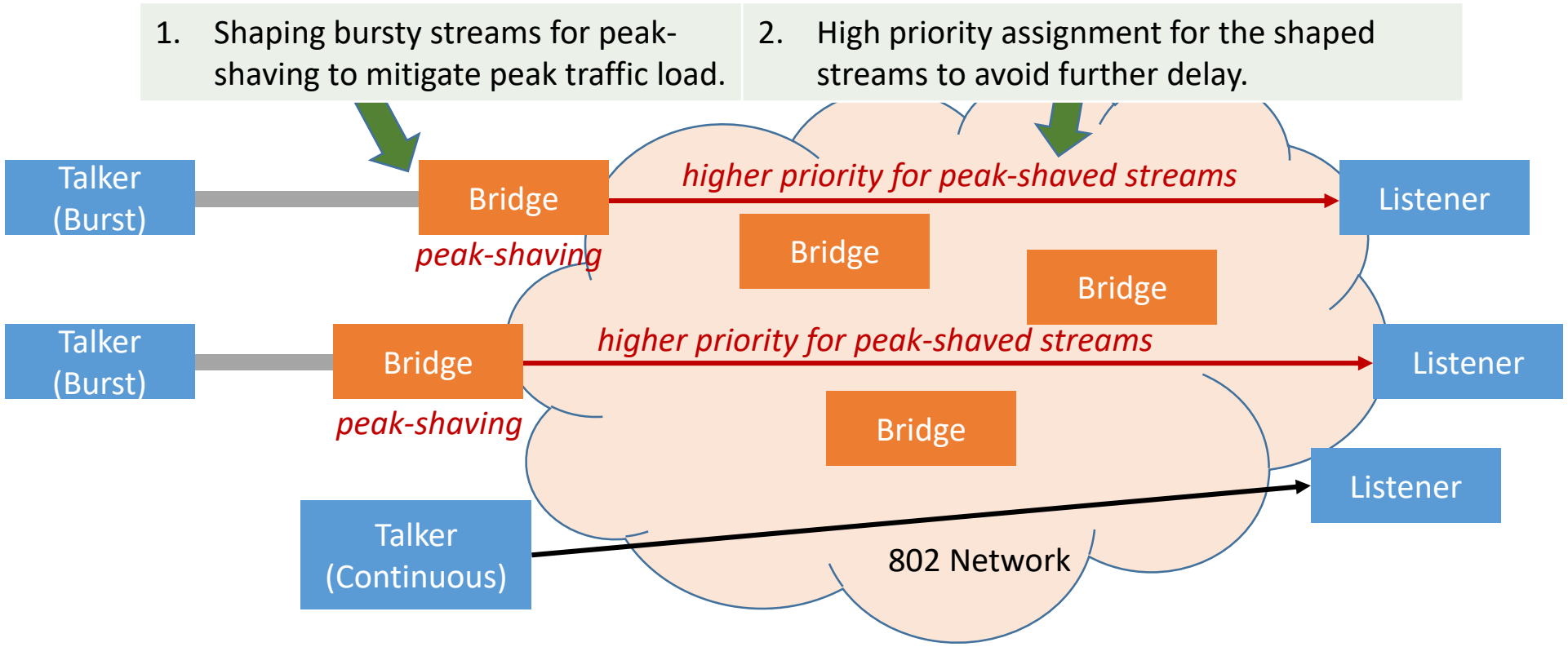
- Configure bridges next to source nodes to peak-shave the traffics.
  → Use CBS, ATS or any other shapers
- Configure bridges across the path towards the listeners to protect the STSBT streams to guarantee E2E bounded latency.
  → Use a queue with higher priority
- Identify streams to be controlled with this mechanism → Use .1CB/CBdb.

- In addition to the above modifications, description of the STSBT operation mechanism is needed in an Annex in 1Q.



Concept of General STSBT

- Proposal: Configuration mechanism to be added in 1Q for scheduling of sporadic and bursty traffic in time-sensitive network. Details are open to discuss.



Draft for Main parts of PAR and CSD

Main Part of PAR

- 2.1 – Project Title

Standard for Local and metropolitan area networks--Bridges and Bridged Networks
Amendment: Scheduler for Time-Sensitive and Bursty Traffic

- 4.2 and 4.3 Project dates

4.2 Expected Date of submission of draft to the IEEE-SA for Initial Sponsor Ballot:
03/2021

- 4.3 Projected Completion Date for Submittal to RevCom

01/2022

Main Part of PAR –cont'd

- 5.2A – Standard scope

This standard specifies Bridges that interconnect individual LANs, each supporting the IEEE 802 MAC Service using a different or identical media access control method, to provide Bridged Networks and VLANs.

- 5.2B – Project scope

This project specifies procedures and managed objects for bridges and end stations to configure and perform shapers over reduced available bandwidth links for sporadic bursty traffic type.

Main Part of PAR –cont'd

- 5.3 – Project contingency

5.3 Is the completion of this standard dependent upon the completion of another standard:

No

- 5.4 – Project purpose

Bridges, as specified by this standard, allow the compatible interconnection of information technology equipment attached to separate individual LANs.

Main Part of PAR –cont'd

- 5.5 – Project need

Industrial networks serve a variety of traffic types including irregular bursty traffics which requires to be conveyed across reduced available bandwidth links with deterministic latency. Shaping is needed in order to mitigate the impact of reduced bandwidth while maintaining QoS for multiple traffic. Current bridging standards do not address configuration mechanism for shaper for reduced available bandwidth for variety of traffic types including Sporadic bursty traffic.

- 5.6 Stakeholders for the Standard:

Developers, providers, and users of networking services and equipment for streaming of time-sensitive data. This includes software developers, networking integrated circuit developers, bridge and network interface controller vendors, and users.

Main Part of CSD - 1.1.1 Managed objects

Describe the plan for developing a definition of managed objects. The plan shall specify one of the following:

a) The definitions will be part of this project.

b) The definitions will be part of a different project and provide the plan for that project or anticipated future project.

c) The definitions will not be developed and explain why such definitions are not needed.

This project will use method a). The managed objects definitions will be part of this project.

Main Part of CSD - Coexistence

A WG proposing a wireless project shall demonstrate coexistence through the preparation of a Coexistence Assurance (CA) document unless it is not applicable.

a) Will the WG create a CA document as part of the WG balloting process as described in Clause 13? (yes/no)

b) If not, explain why the CA document is not applicable.

This project will use method b). This project is not a wireless project.

Main Part of CSD - Broad market potential

Each proposed IEEE 802 LMSC standard shall have broad market potential. At a minimum, address the following areas:

a) Broad sets of applicability.

b) Multiple vendors and numerous users.

The proposed amendment enhances bridges functionality allowing systems to further provision for broad variety services, applications and traffic types in reduced available bandwidth networks.

TSN has been applicable for many applications including industrial automation and other applications. This amendment further extends the application of TSN to include IoT devices broadening TSN applications and use.

Furthermore, the proposed amendment enable efficient utilization of legacy network in support of increased traffic in industrial applications.

This proposal supports network with dense IoT devices that are deployed in factories, warehouses, hospitals, market places, stadiums and etc.

Multiple vendors and users of industrial automation, professional audio-video, automotive, and other systems require complete and comprehensive management of TSN features in bridged LAN networks through common interfaces.

Main Part of CSD - Compatibility

Each proposed IEEE 802 LMSC standard should be in conformance with IEEE Std 802, IEEE 802.1AC, and IEEE 802.1Q. If any variances in conformance emerge, they shall be thoroughly disclosed and reviewed with IEEE 802.1 WG prior to submitting a PAR to the Sponsor.

a) Will the proposed standard comply with IEEE Std 802, IEEE Std 802.1AC and IEEE Std 802.1Q?

b) If the answer to a) is no, supply the response from the IEEE 802.1 WG.

The review and response is not required if the proposed standard is an amendment or revision to an existing standard for which it has been previously determined that compliance with the above IEEE 802 standards is not possible. In this case, the CSD statement shall state that this is the case.

As an amendment to 802.1Q, the proposed standard shall comply with IEEE Std 802, IEEE Std 802.1AC and IEEE 802.1Q.

Main Part of CSD - Distinct Identity

Each proposed IEEE 802 LMSC standard shall provide evidence of a distinct identity. Identify standards and standards projects with similar scopes and for each one describe why the proposed project is substantially different.

This amendment differs from existing IEEE 802.1 standard in that it address scheduling and shaper for variety of traffic types including bursty data rates traffic over links with varying bandwidth operating at reduced available bandwidth.

Main Part of CSD - Technical Feasibility

Each proposed IEEE 802 LMSC standard shall provide evidence that the project is technically feasible within the time frame of the project. At a minimum, address the following items to demonstrate technical feasibility:

a) Demonstrated system feasibility.

The proposed shaper is similar in principle to the ones introduced in IEEE Std 802.1Q-2018 and will build on them to provide additional capabilities.

b) Proven similar technology via testing, modeling, simulation, etc.

The technical feasibility has been demonstrated by analysis. In particular, feasibility has been shown by modeling and simulation (see http://www.ieee802.org/1/files/public/docs2019/New-NakanoZein-Scheduling_of_Time_sensitive_and_Bursty_Traffic_in_Reduced_Available_Bandwidth-0919.ppx).

This project is based on mature virtual LAN bridging and transmit selection and scheduling

Main Part of CSD - Economic Feasibility

Each proposed IEEE 802 LMSC standard shall provide evidence of economic feasibility. Demonstrate, as far as can reasonably be estimated, the economic feasibility of the proposed project for its intended applications. Among the areas that may be addressed in the cost for performance analysis are the following:

a) Balanced costs (infrastructure versus attached stations).

b) Known cost factors.

c) Consideration of installation costs.

d) Consideration of operational costs (e.g., energy consumption).

e) Other areas, as appropriate.

The well-established balance between infrastructure and attached stations will not be changed by this enhancement.

The cost factors, including installation and operational factors, are well known from similar technologies and proportional to the benefits gained.

The proposed amendment does not require additional hardware cost as it proposes STSBT shaper that can be accommodated into the current specifications.