Overview of IEEE 802.1 TSN and IETF DetNet

Date: 2018-11-14

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Outline

Deterministic service

Potential markets

IEEE 802.1 Time-Sensitive Networking (TSN) overview http://ieee802.org/1/tsn

- TSN scope
- TSN standards and projects
- Example TSN tools

IETF Deterministic Networking (DetNet) overview https://datatracker.ietf.org/wg/detnet/

- DetNet scope
- DetNet deliverables
- DetNet building blocks

Summary

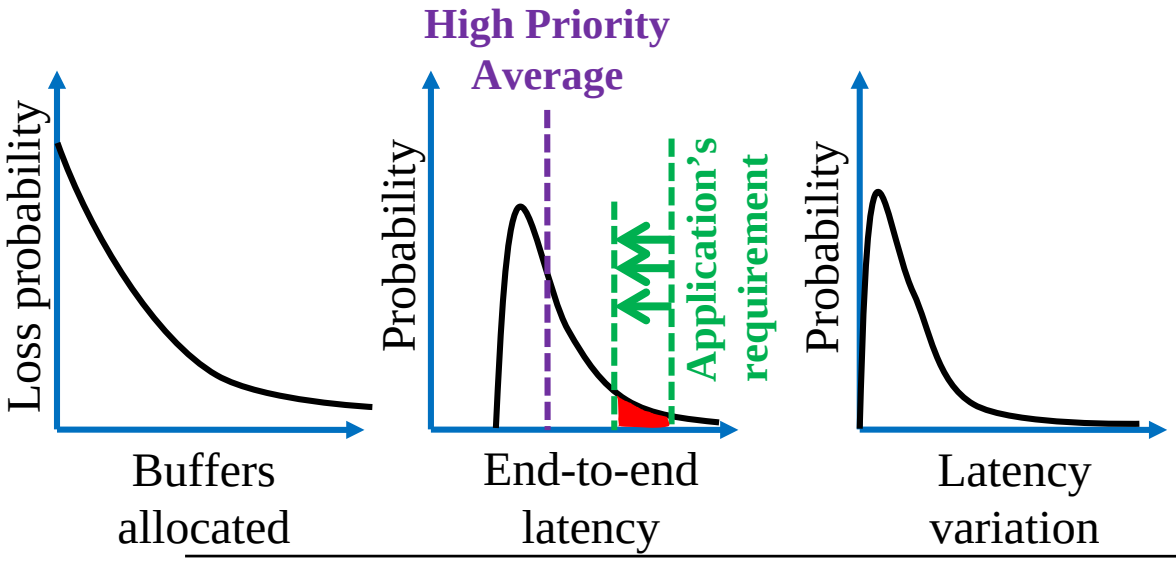
We Are Interested in Deterministic Service

Traditional Service

Curves have long tail

Average latency is good

Lowering the latency means
losing packets (or overprovisioning)

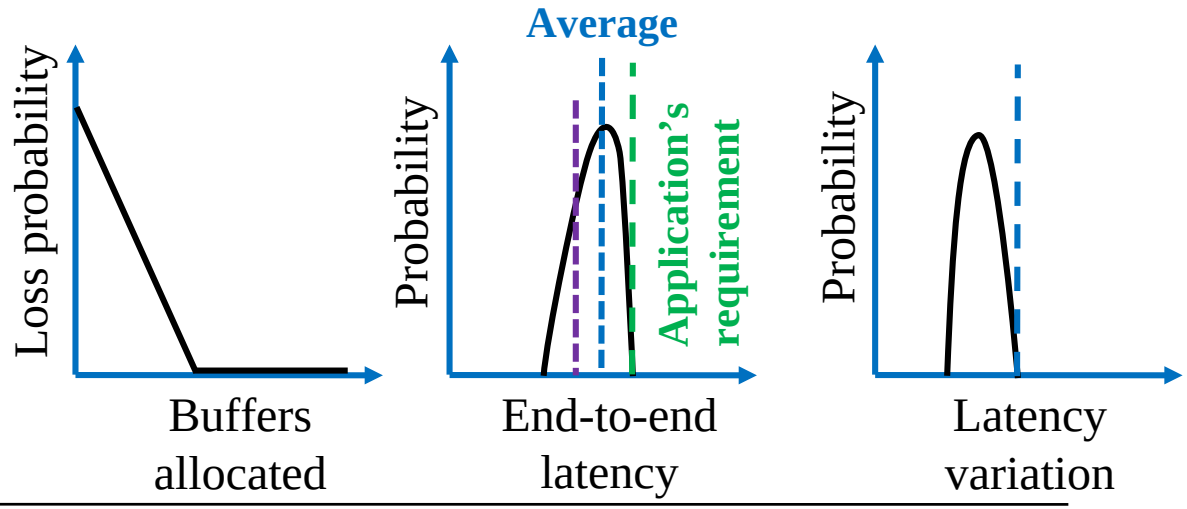


Deterministic Service

Packet loss is at most due to equipment failure (zero congestion loss)

Bounded latency, no tails

The right packet at the right time



Potential Markets (not comprehensive)

TIME-SENSITVE NETWORKING (TSN)

IEEE 802.1 Time-Sensitive Networking (TSN) Task Group

The TSN TG specifies the tools of the TSN toolbox, as well as the use of the tools for a particular purpose

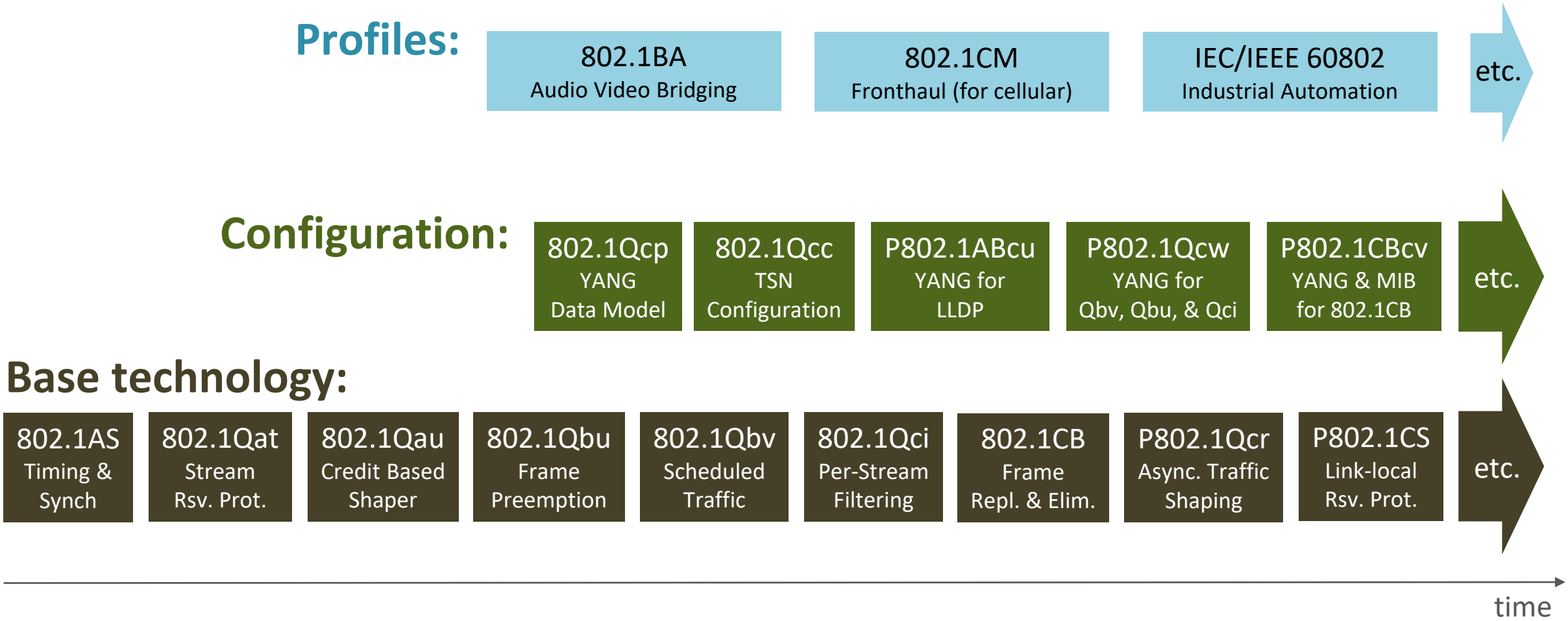
TSN TG is chartered to provide deterministic services through IEEE 802 networks

- Guaranteed packet transport
- Low packet loss
- Bounded low latency
- Low packet delay variation

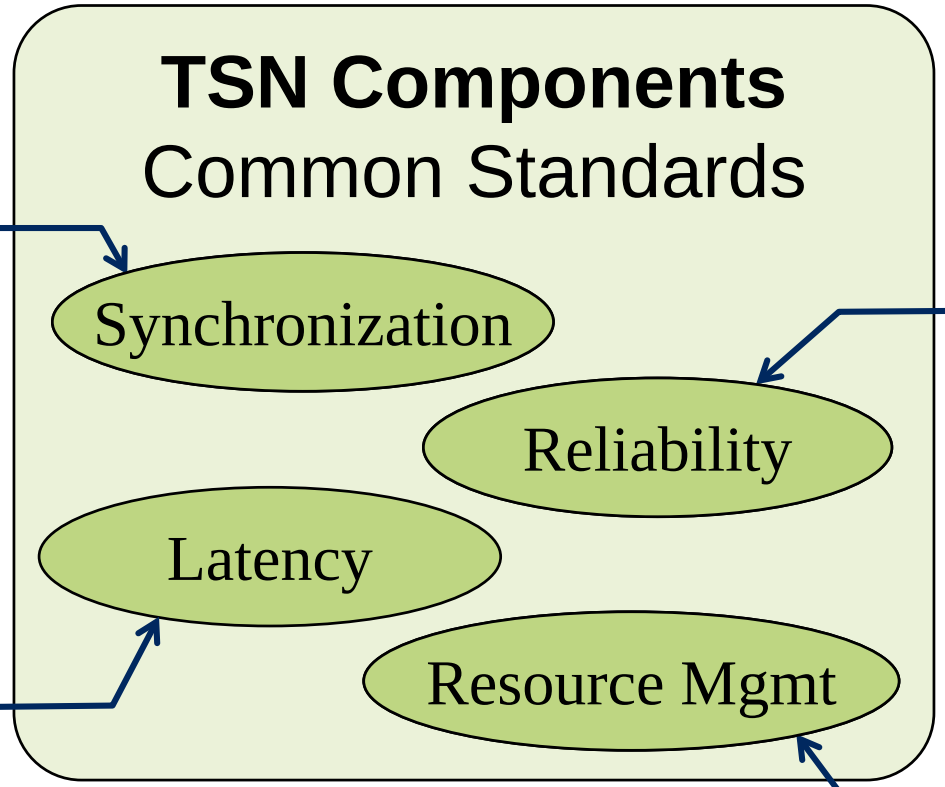
The TSN TG has been evolved from the Audio Video Bridging (AVB) TG

The TSN TG includes the former Interworking TG

Grouping of TSN Standards & Projects



IEEE 802.1 TSN Tools and Configuration



Time synchronization:

Timing and Synchronization (802.1AS)
includes a profile of IEEE 1588
(revision ongoing: P802.1AS-Rev)

Ultra reliability:

Frame Replication and Elimination (802.1CB)
Path Control and Reservation (802.1Qca)
Per-Stream Filtering and Policing (802.1Qci)
Reliability for time sync (P802.1AS-Rev)

Dedicated resources & API

Stream Reservation Protocol (802.1Qat)
TSN configuration (802.1Qcc)
Basic YANG (802.1Qcp)
Link-local Registration Protocol (P802.1CS)
Resource Allocation Protocol (P802.1Qdd)
YANG for CFM (P802.1Qcx)
YANG for LLDP (P802.1ABcu)
YANG for Qbv, Qbu, and Qci (P802.1Qcw)
YANG & MIB for FRER (P802.1CBcv)
Extended Stream Identification (P802.1CBdb)

Bounded low latency:

Credit Based Shaper (802.1Qav)
Frame preemption (802.3br & 802.1Qbu)
Scheduled Traffic (802.1Qbv)
Cyclic Queuing and Forwarding (802.1Qch)
Asynchronous Traffic Shaping (P802.1Qcr)
QoS Provisions (P802.1DC)

Zero congestion loss

Note: P upfront of an ID indicates ongoing Project

TSN Profiles

Wide breadth of choices in IEEE 802 standards

A TSN Profile

- Narrows the focus ➔ ease interoperability and deployment
- Selects features, options, defaults, protocols, and procedures
- Describes how to build a network for a particular use
- Provides configuration guideline if needed

TSN Profiles so far

- Published TSN Profiles:
  - IEEE Std 802.1BA for Audio-Video Bridging (AVB) networks
  - IEEE Std 802.1CM TSN for Fronthaul (for cellular networks)
- Ongoing: IEC/IEEE 60802 TSN Profile for Industrial Automation
- On the horizon:
  - P802.1DF TSN Profile for Service Provider Networks
  - P802.1DG TSN Profile for Automotive In-Vehicle Ethernet Communications

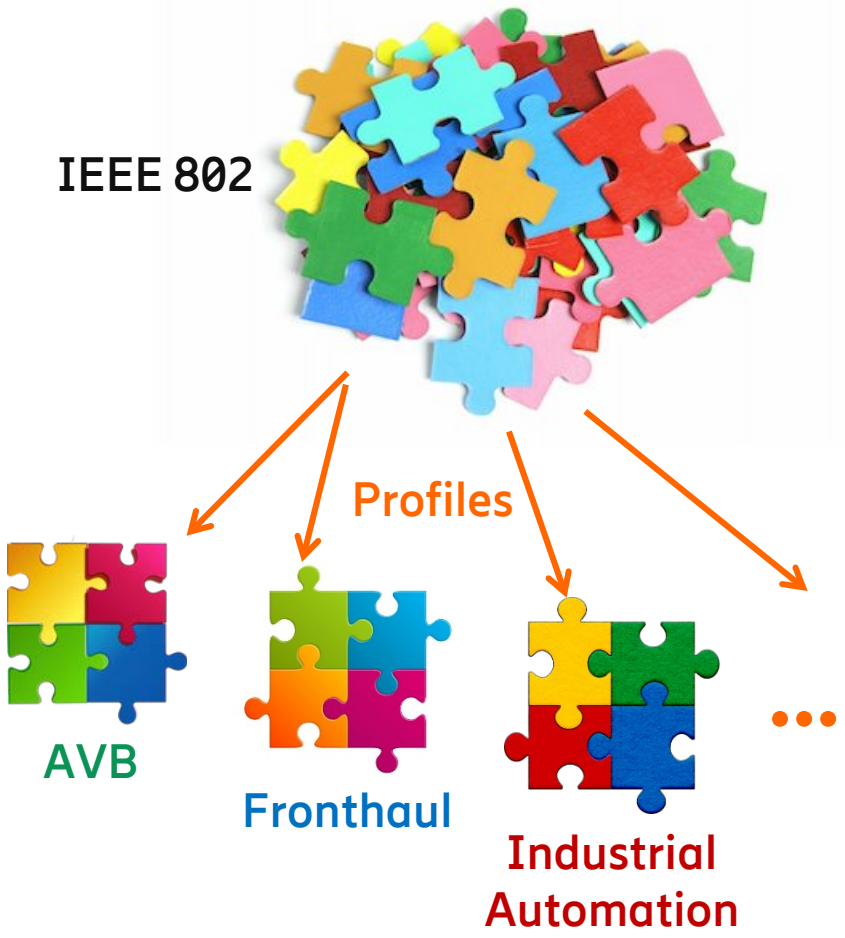
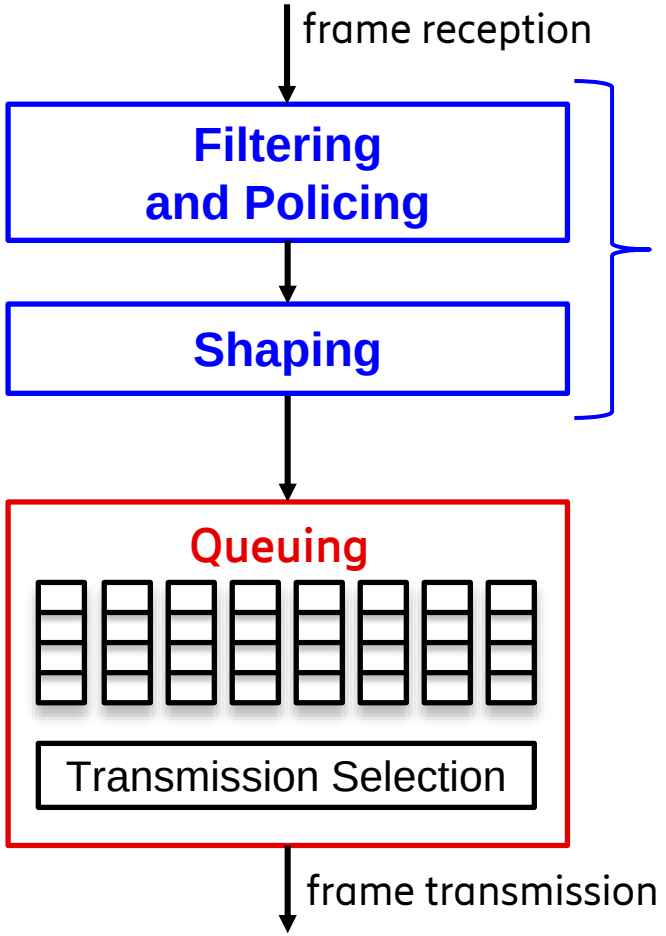


Illustration of QoS Functions



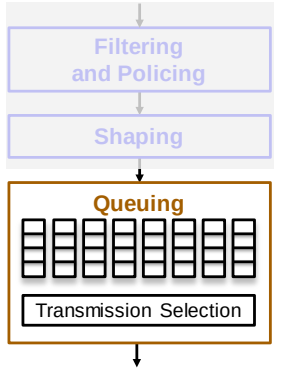
can be
Per Stream,
Per Class, etc.

Per Class

can be viewed as a hierarchical approach

note: other functions are not shown in this figure, e.g., relay, reliability

Scheduled Traffic (802.1Qbv)



Reduces latency variation for frames with known timing

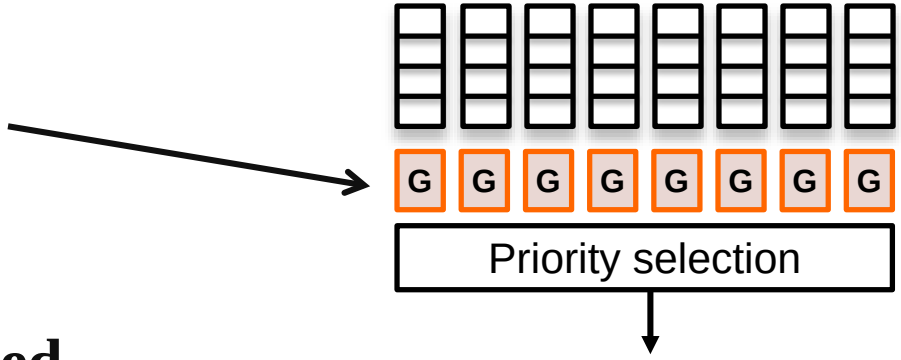
Time-based control and programming of the bridge queues

Time-Gated queues

Gate (G): Open or Closed

Periodically repeated time schedule

Time synchronization is needed

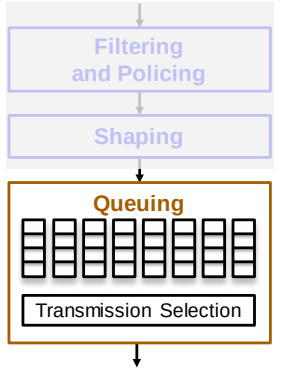


frame transmitted: critical / non-critical

gate(s) for non-critical traffic

Note: gate of non-critical data can be closed in advance to protect critical data

Frame Preemption (802.3br and 802.1Qbu)

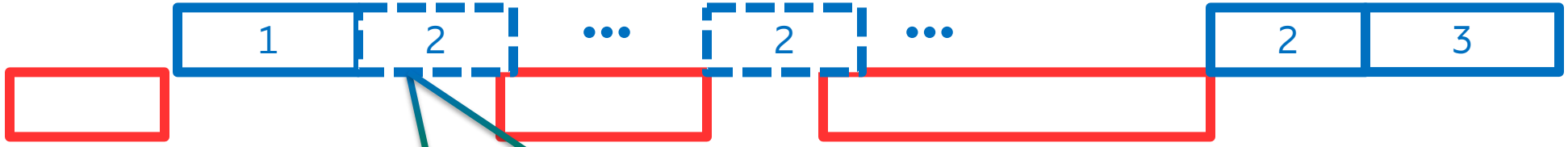


Express frames suspend the transmission of preemptable frames

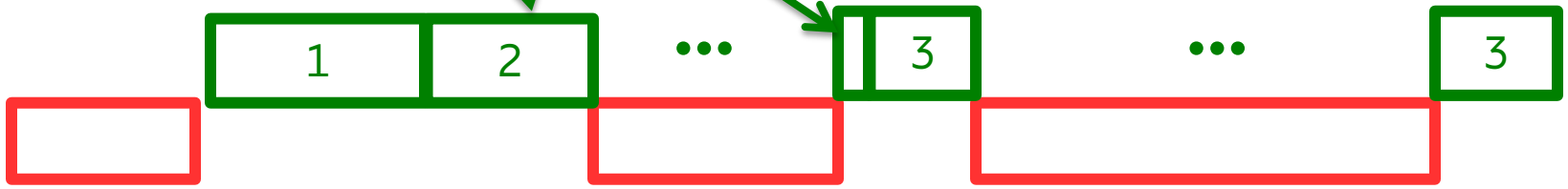
- Decrease delay variation for express, increase bandwidth for preemptable
- It is link local per hop, i.e., it is not IP fragmentation

Scheduled rocks of critical packets in each cycle:

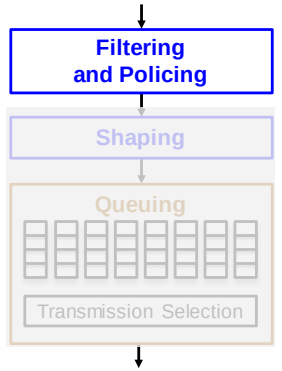
Conflict excessively with non-guaranteed packet rocks:



Problem solved by preemptable sand between the rocks:



Per-Stream Filtering and Policing (802.1Qci)



Protection against bandwidth violation, malfunctioning, attacks, etc.

Decisions on per-stream, per-priority, etc.

Filter

Filters, Counters

Time-gate

Time scheduled gate

Open or Closed

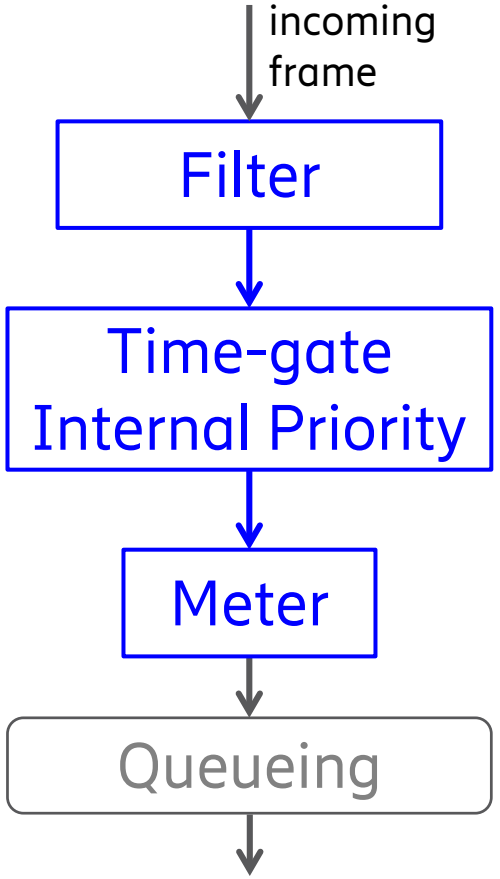
Internal Priority Value (IPV)

Bridge internal traffic class of the frame

Meter

Bandwidth Profile of MEF 10.3

Red/Yellow/Green Marking



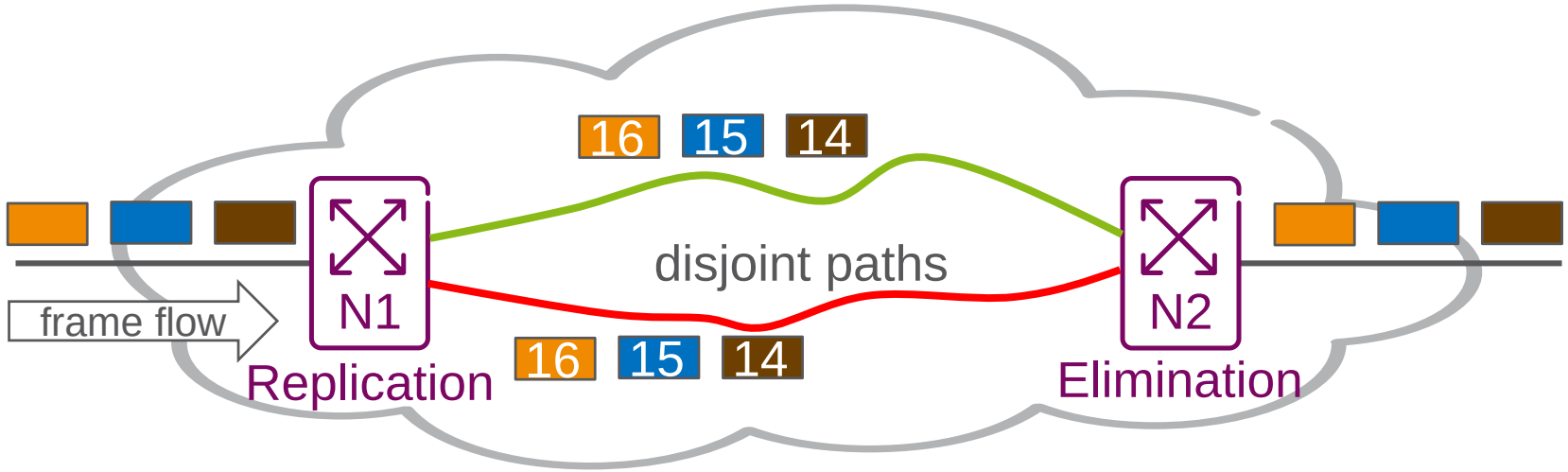
Frame Replication and Elimination for Reliability (FRER) (802.1CB)

Avoid frame loss due to equipment failure

It is a per-frame 1+1 (or 1+n) redundancy

NO failure detection / switchover

Send frames on 2 (or more) maximally disjoint paths, then combine and delete extras



DETERMINISTIC NETWORKING (DETNET)

based on

http://www.ieee802.org/1/files/public/docs2018/detnet-tsn-berger-detnet-overview-1118-v03.pdf
http://www.ieee802.org/1/files/public/docs2018/detnet-tsn-varga-detnet-basic-concepts-1118-v01.pdf

DetNet WG Scope

The Deterministic Networking (DetNet) Working Group focuses on deterministic data paths that operate over Layer 2 bridged and Layer 3 routed segments, where such paths can provide bounds on latency, loss, and packet delay variation (jitter), and high reliability.

DetNet addresses Layer 3 aspects in support of applications requiring deterministic networking.

DetNet focuses on solutions for networks that are under a single administrative control or within a closed group of administrative control.

DetNet is NOT for large groups of domains such as the Internet

Note: DetNet leverages existing techniques as much as possible instead of inventing new ones

DetNet Deliverables

Based on WG Charter

https://datatracker.ietf.org/wg/detnet/about

Overall architecture:

encompasses the data plane, OAM, time synchronization, management, control, and security aspects.

Data plane specification:

document how to use IP and/or MPLS to support a data plane of flow identification and packet forwarding over Layer 3.

Data flow information model:

identify the information needed for flow establishment and control and be used by reservation protocols and YANG data models. The work will be independent from the protocol(s) used to control the flows

(e.g. YANG+NETCONF/RESTCONF, PCEP or GMPLS).

YANG models:

This work will document device and link capabilities (feature support) and resources (e.g. buffers, bandwidth) for use in device configuration and status reporting.

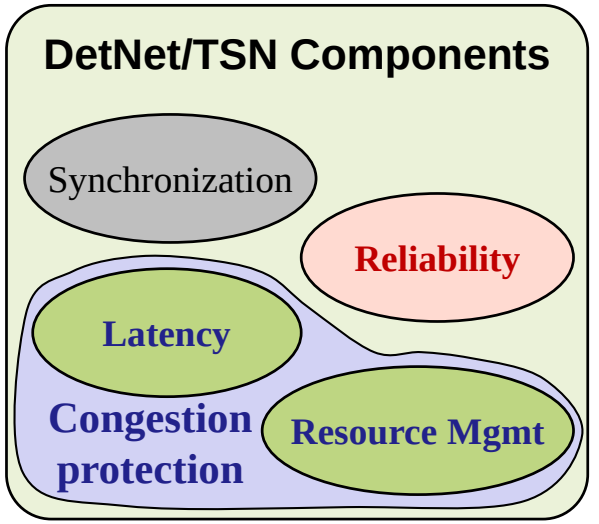
Problem statement (as needed):

This effort will establish the deployment environment and deterministic network requirements.

Vertical requirements (as needed):

This effort will detail the requirements for deterministic networks in various industries, for example, professional audio, electrical utilities, building automation systems, wireless for industrial applications.

DetNet Building Blocks



Congestion protection

Addresses latency and packet loss due to congestion. Provides bounded end-to-end latency and packet delay variation.

Focused on service parameters; not on queuing mechanism, which may be subnetwork specific.

Service Protection

Addresses random media errors and equipment failures. Packet replication, ordering, and elimination functions (PREOF) on disjoint pats.

Explicit routes

Addresses impact of the convergence of routing protocols (i.e., temporary interruptions). DetNet uses already defined explicit routing techniques, does not define new one.

Summary

TSN and DetNet provide guaranteed delivery with bounded low latency, low delay variation, and extremely low loss

Extreme values (µsec, lossless, …) often appear; the main target is guaranteed upper bound