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Some sources of Latency and Jitter

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Structure of this Presentation

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Short Recap of Shapers

Overview of names for different Traffic

Sources of Latency and Jitter

What TSN considers / optimized

Ways in AVB and TSN to influence latency

Jitter and the effects for the different Shapers

Conclusion

Short Recap of Shapers

- **CBS (Credit based Shaper)**

- **TAS (Time aware shaper)**

  - optimal/shortest latency
    (under optimal conditions)

  - Calculation effort
    (huge in complex topologies)

- **BLS (Burst limiting shaper)**

  - with scheduled Talker ~same performance
    (with Preemption, Scheduling optional)

  - Good performance for "legacy" traffic

- **BLS with forced Delay**
  http://www.ieee802.org/1/files/public/docs2013/new-tsn-specht-talker-scheduled-traffic-support-20130318.pdf

  - Preemption Jitter-free optimization

- **PS (Peristaltic Shaper)**

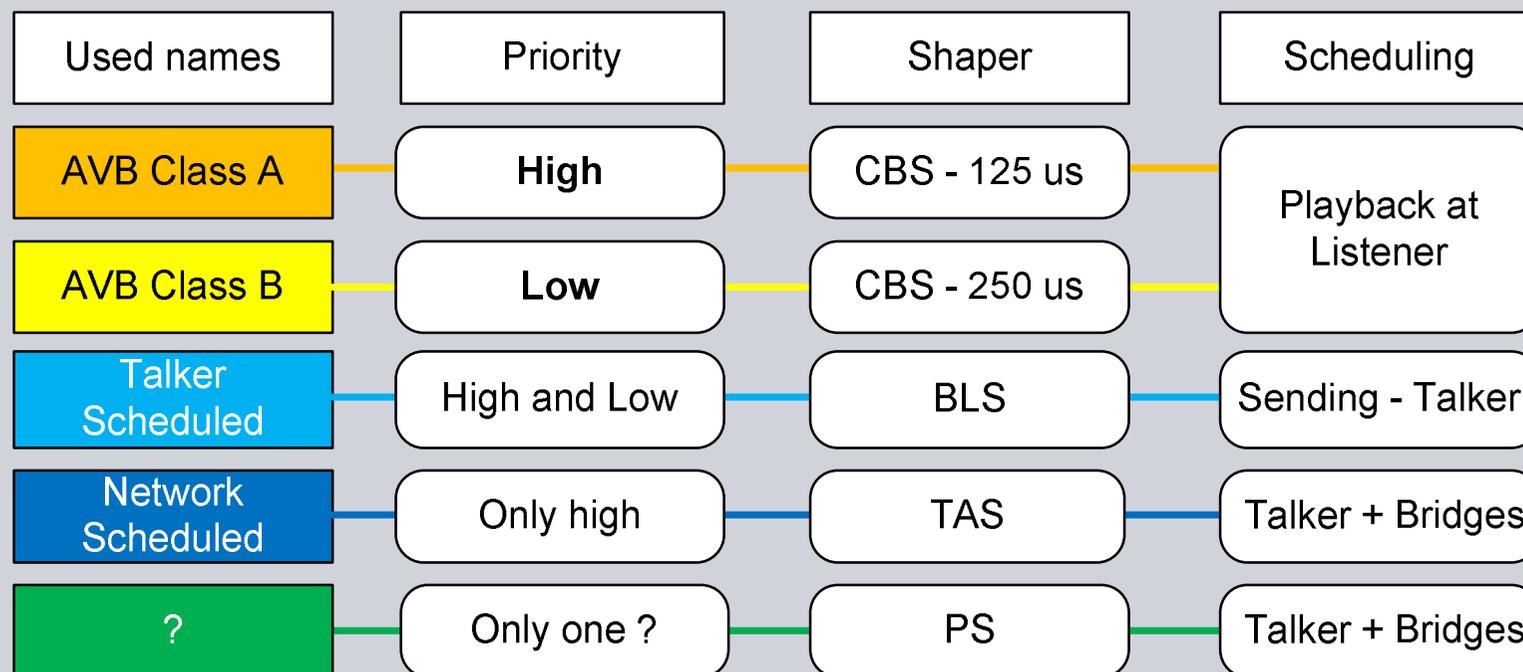 - Proven **guaranteed** maximum latency

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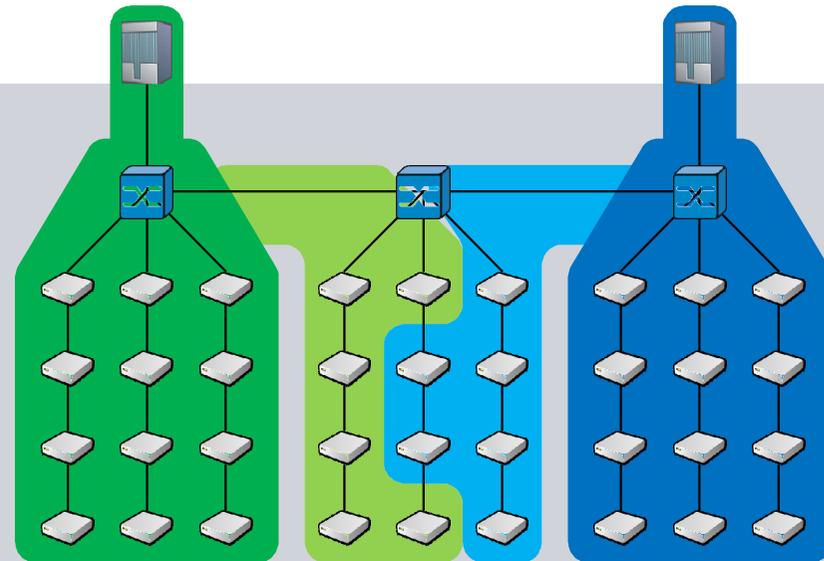
Overview of names for different Traffic

AVB Gen 1 with CBS and **two different traffic classes**

▪ Class A for high Priority - Class B for lower Priority

TSN with more Shapers and with more Scheduling options

Used names	Priority	Shaper	Scheduling
AVB Class A	**High**	CBS - 125 us	Playback at Listener
AVB Class B	**Low**	CBS - 250 us	
Talker Scheduled	High and Low	BLS	Sending - Talker
Network Scheduled	Only high	TAS	Talker + Bridges
?	Only one ?	PS	Talker + Bridges

Sources of Latency

Latency can be caused by

- the cable

- the bridge

- the path (combination of cables and bridges)
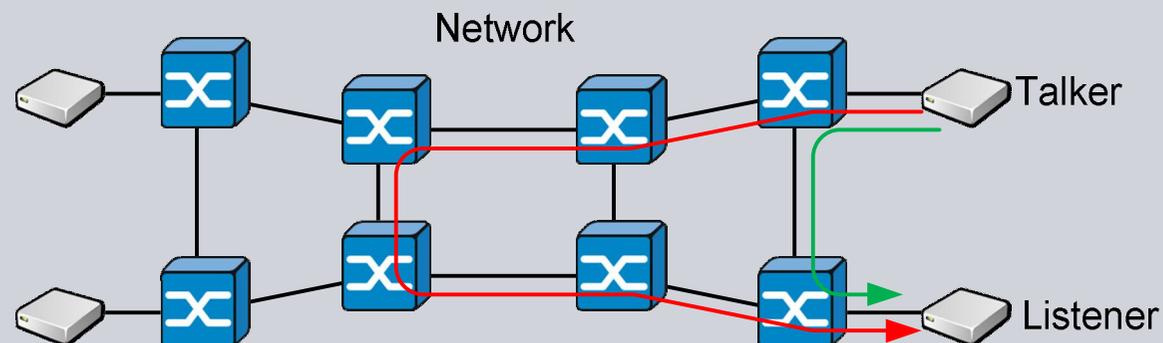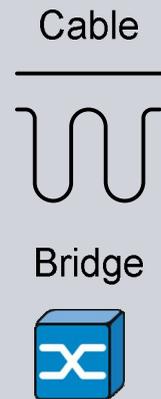
Bridge Latency

Latency inside a bridge can be caused by:

- PHY

- MAC

- Internal Forwarding (Ingres -> Egress Port)

- Transmission status (Port is currently used)

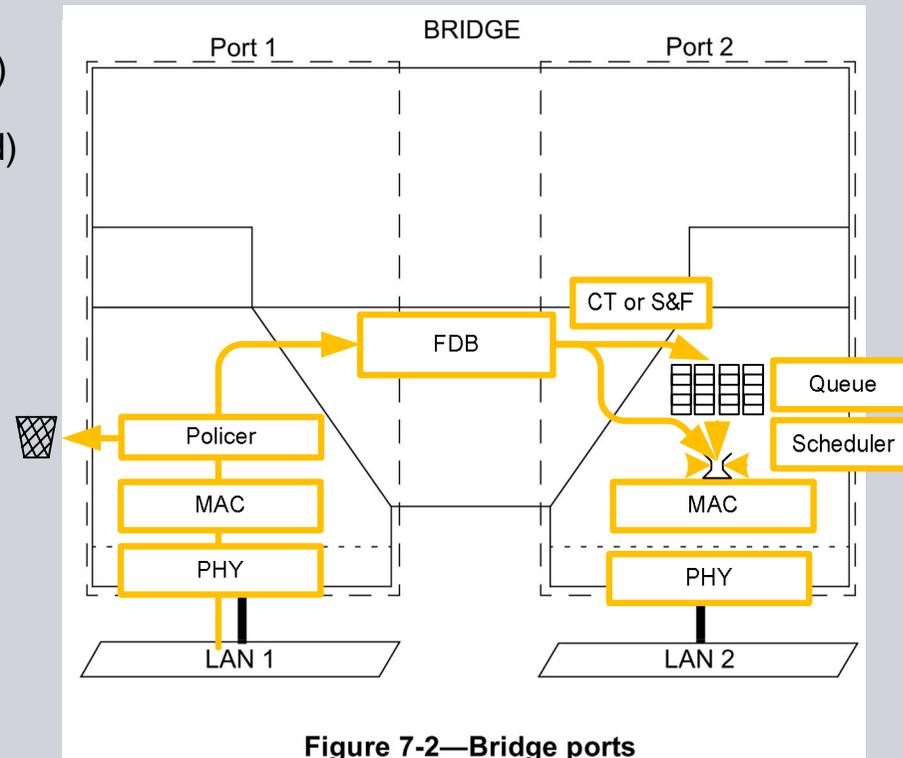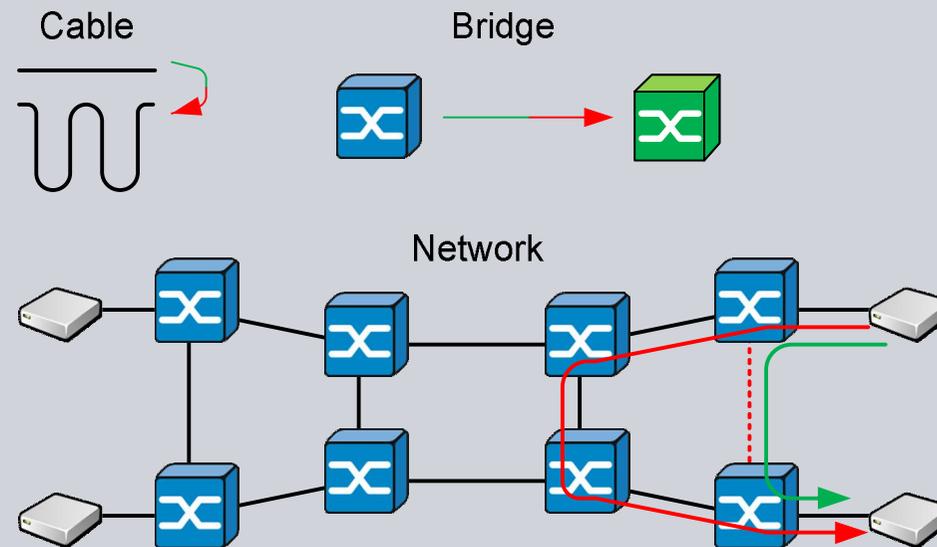- Data in Queues (same or higher priority)

- Shaper / Scheduler

- ...

Bridge

Figure 7-2—Bridge ports

Source: IEEE 802.1D Media Access Control (MAC) Bridges – Figure 7-2 – Bridge ports

Variation of the Delay

Failure / Repair:

- changed cable length

- changed HW / topology

- changed forwarding path

- ...

Cable

Bridge

Network

Jitter (1)

Jitter is the variation of latency
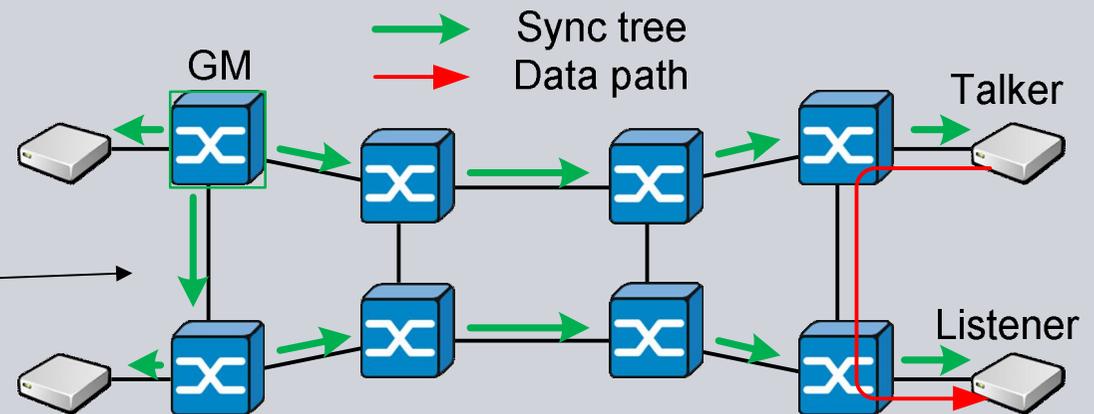
Normal operation:

- PHY <-> MAC (two HW parts)

- Shaper / Scheduler

- **influence of other traffic**

  - Same Queue (Inter-class)

  - Other Queue (different class)

- Usage of CT or S&F

- **…**

Jitter (2)

Jitter is the variation of latency

Caused by "non-ideal" reality

- Synchronization accuracy
  - Resolution of timestamps
  - Sync tree not data path
- Shaper
  - CBS -> history dependent
  - TAS -> scheduling must consider jitter
  - PS -> guaranteed maximum latency - 1 phase jitter
  - BLS -> preemption causes jitter
  - BLS + forced delay ($t_{MaxPreemption}$) -> "no" jitter (delay > max. Jitter)
    http://www.ieee802.org/1/files/public/docs2013/new-tsn-specht-talker-scheduled-traffic-support-20130318.pdf
- …

Sync tree
Data path

GM
Talker
Listener

TSN ways to guarantee low Latency

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TSN mechanism

- separated TSN Queues
  - Internal Queue reordering vs. multiple queues
- resource reservation
- different shapers
- Fragmentation
  - shorter blocking from "legacy" frames
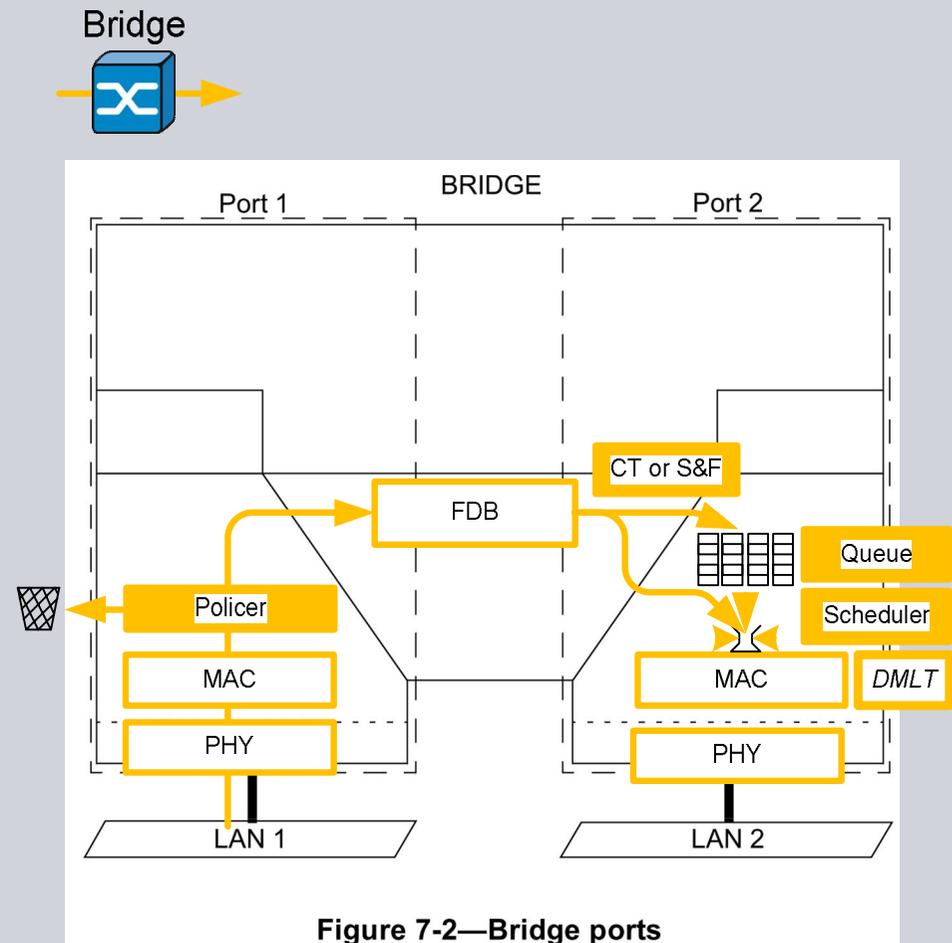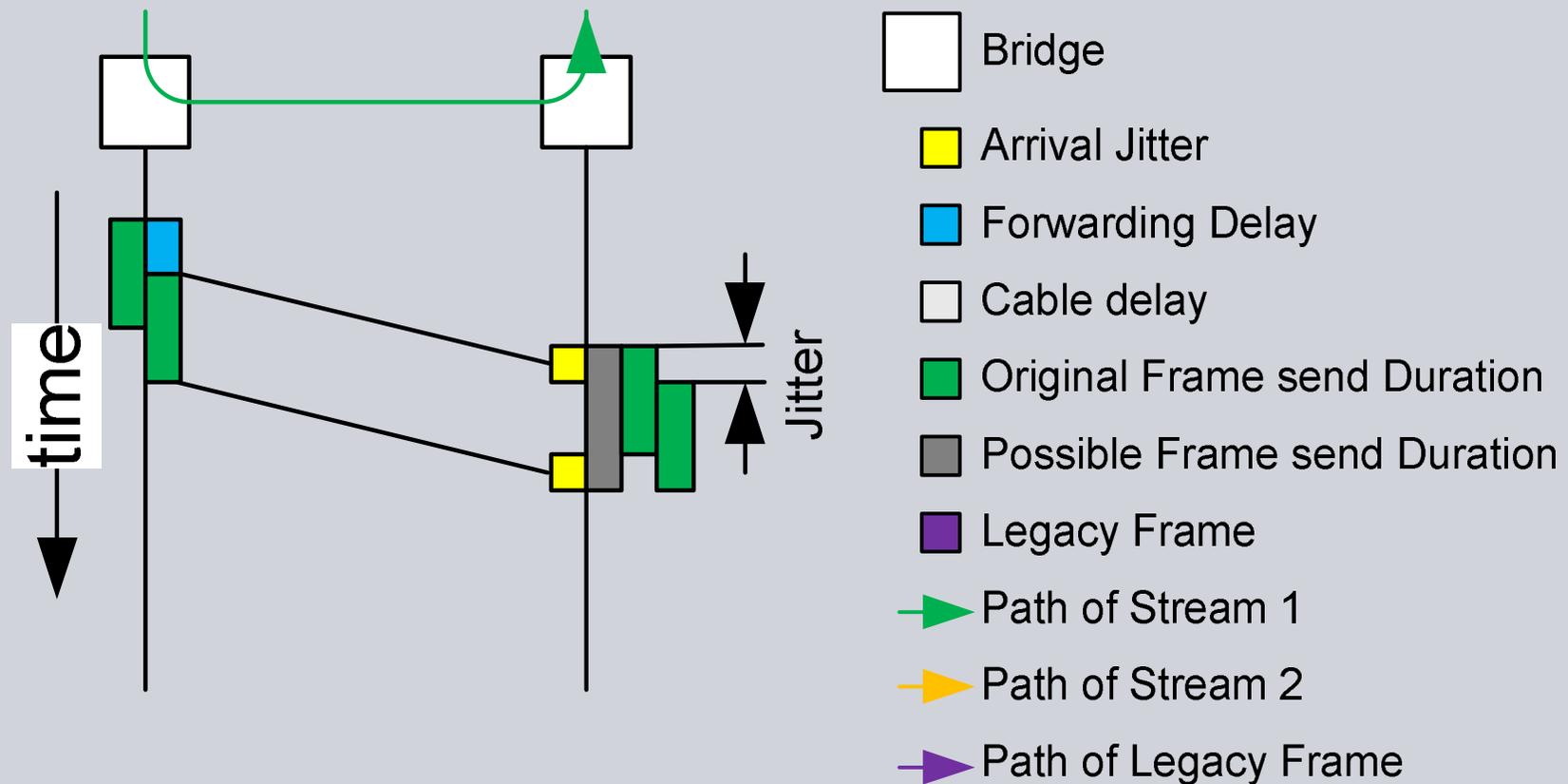- Routing
  - Shortest paths for low latency
- ...

Bridge

BRIDGE

Port 1 — Port 2

CT or S&F

FDB

Queue

Policer

Scheduler

MAC

MAC

DMLT

PHY

PHY

LAN 1

LAN 2

Figure 7-2—Bridge ports

Explanation for the following Drawings

Example for frame transmission

time

Jitter

Bridge

Arrival Jitter

Forwarding Delay

Cable delay

Original Frame send Duration

Possible Frame send Duration

Legacy Frame

Path of Stream 1

Path of Stream 2

Path of Legacy Frame
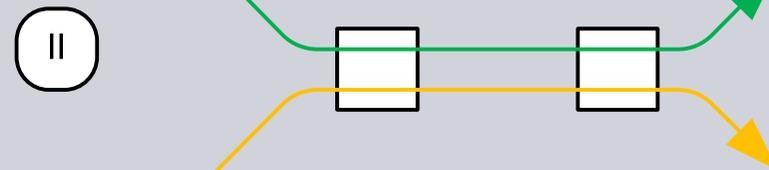
Use-Cases covered in the following Drawings

Normal Operation

- No interference

Ⅰ

Inter-Class Interference

- two streams with same priority
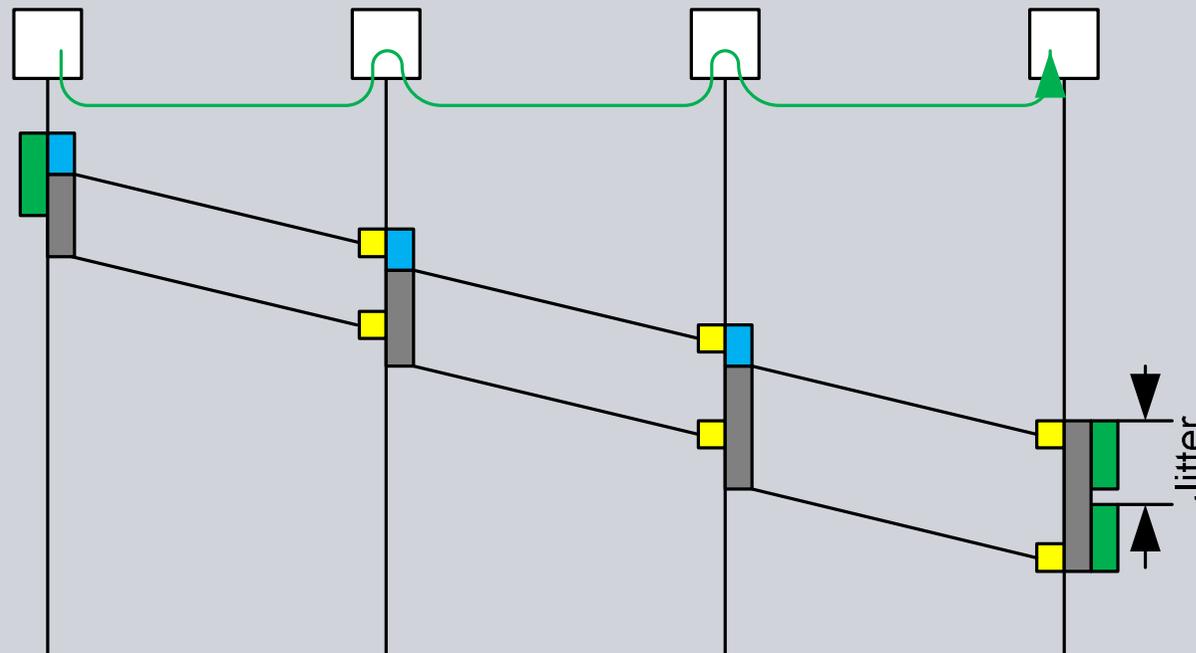
Ⅱ

Legacy Interference

Ⅲ
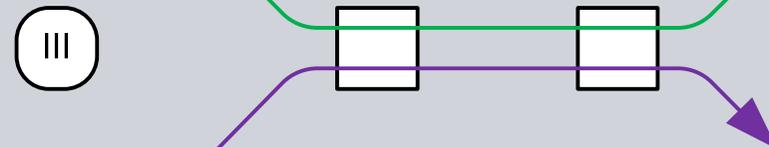
Legacy and Inter-Class Interference

Ⅳ
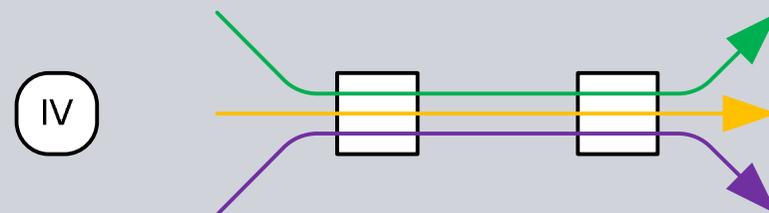
Jitter and the effects for TAS (I)

Normal Operation: All Jitter must be consider in the scheduling

Assumption: Cut through

- Reserved TAS traffic window can't be used from other traffic
  - Highest priority for TAS + only one class / priority possible
    no interfering from lower priority

Jitter and the effects for TAS (II,III, IV)

Inter-class interference: Both Streams have the same priority (**1** and **2**)

- Transmission order of Streams is important
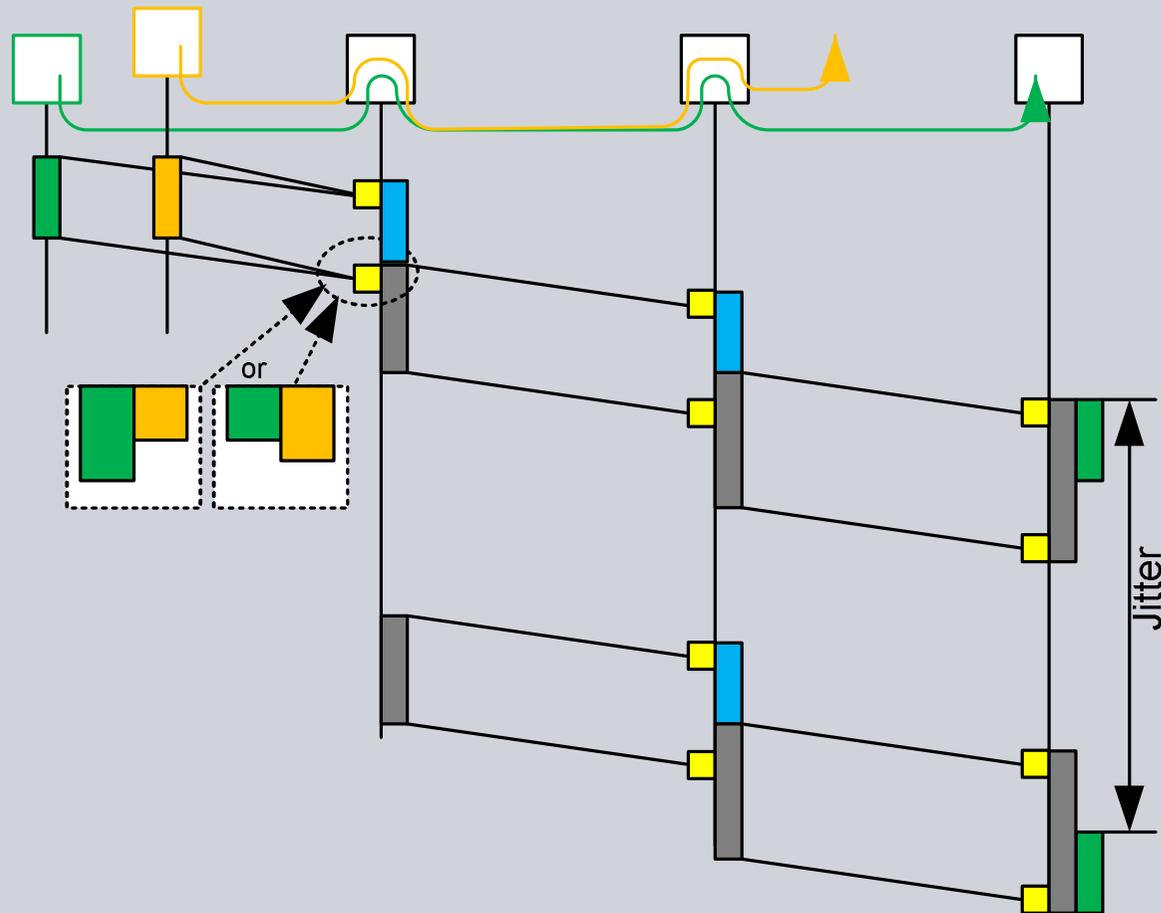- Jitter can lead to miss-ordering and a larger window size
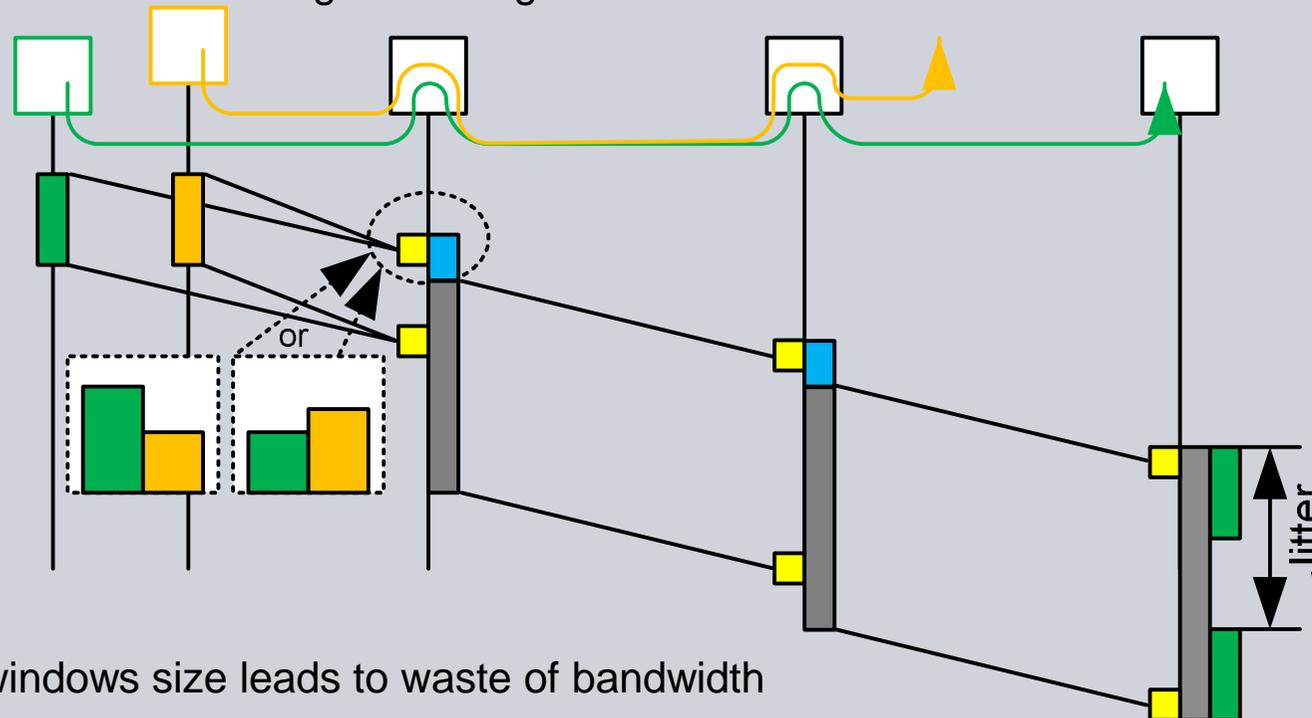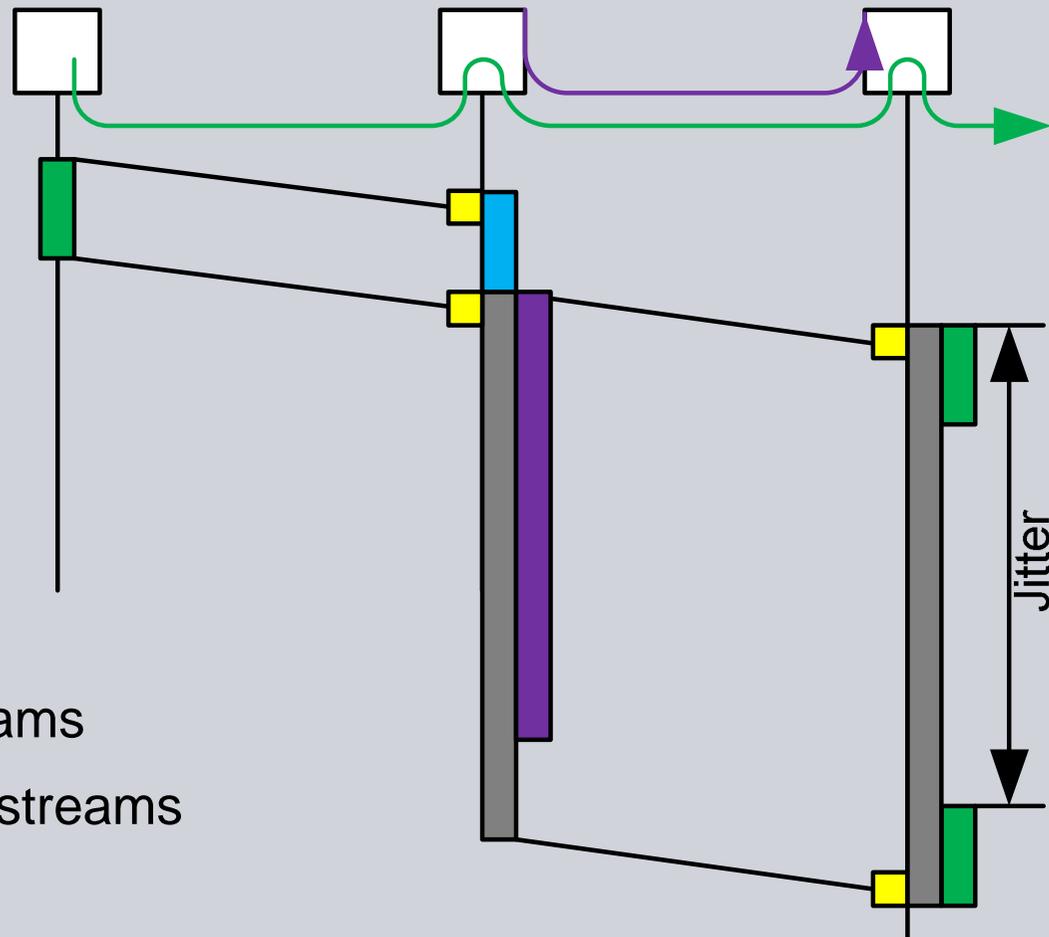
A larger TAS windows size leads to waste of bandwidth

Legacy Frames during the TAS window not possible

Jitter and the effects for CBS (II)

Inter-class interference leads to an additional delay

or

Jitter

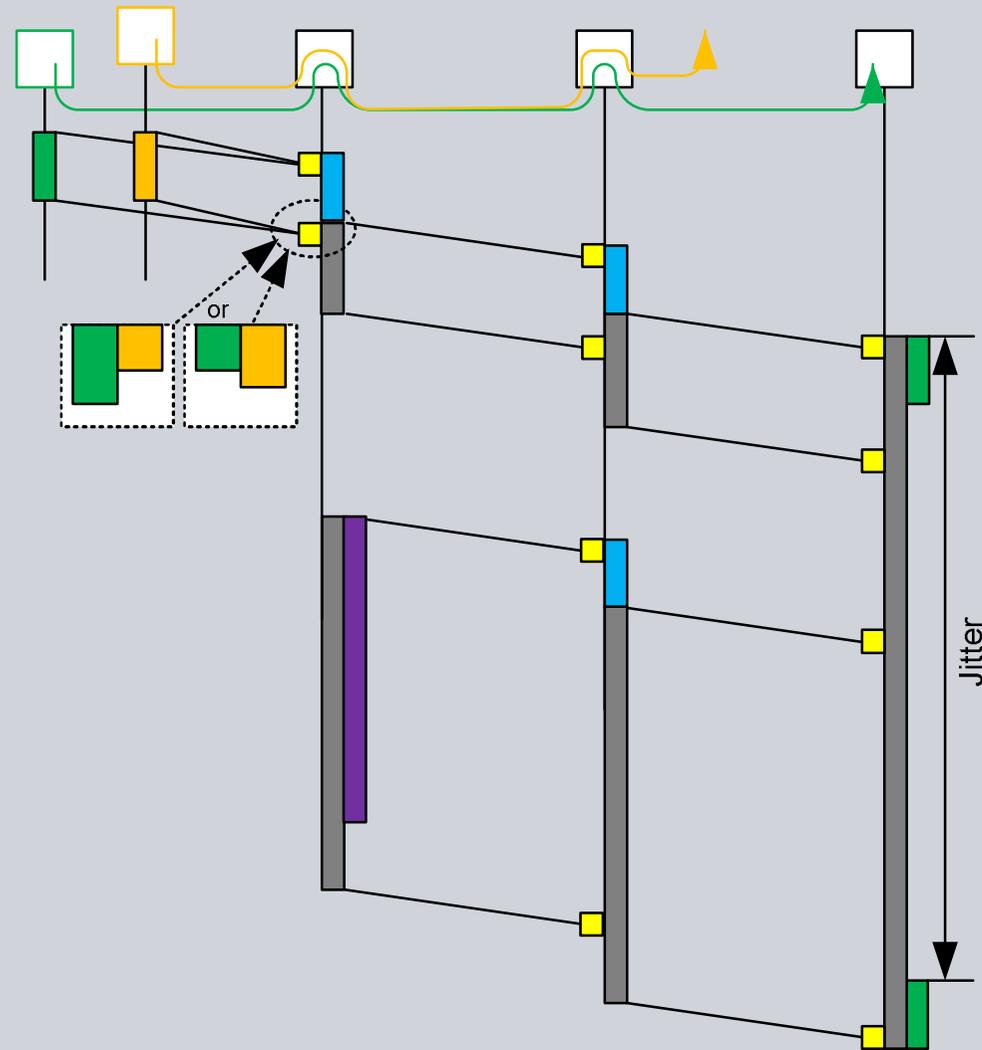# Jitter and the effects for CBS (III)

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No reserved time for streams
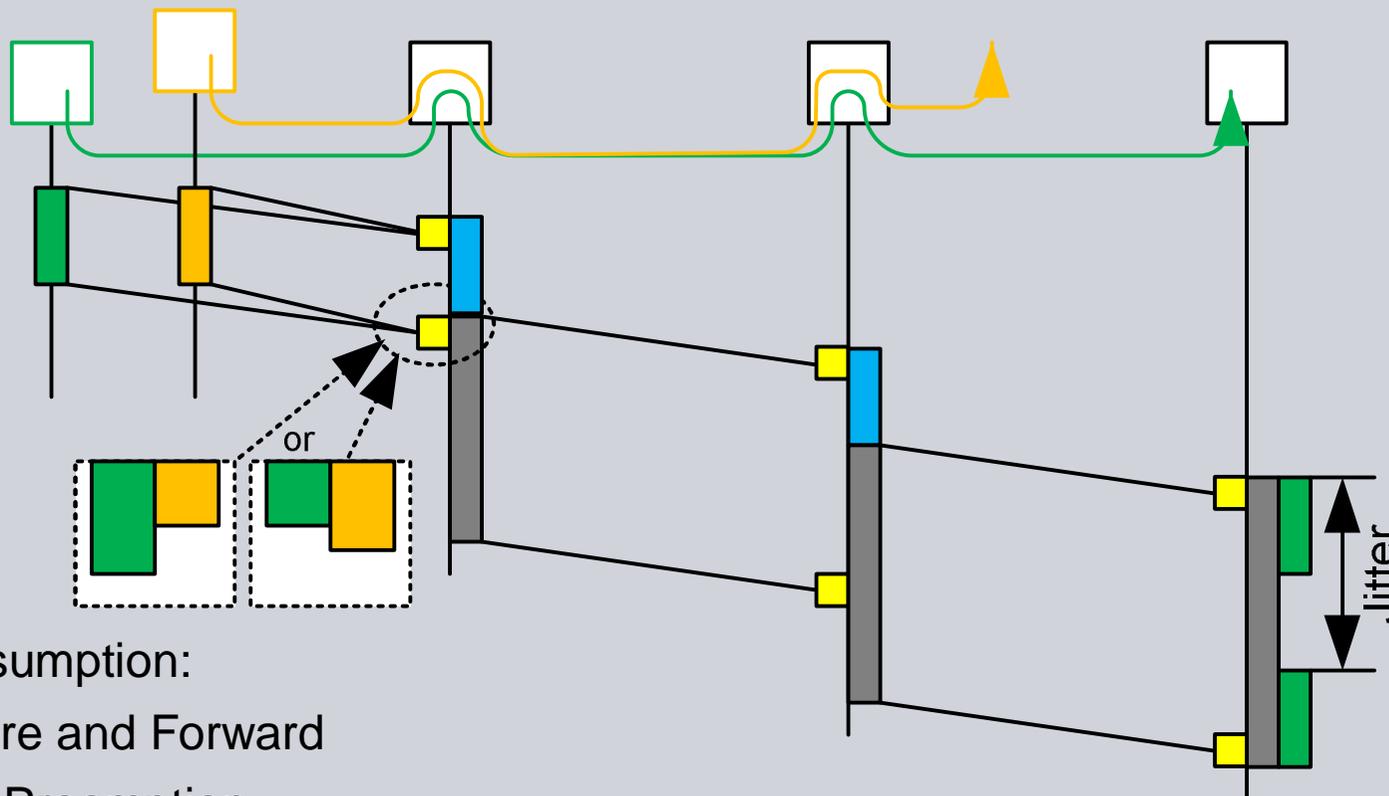
- legacy frames interfere streams

Jitter

Jitter and the effects for CBS (IV)

Interfering legacy frame
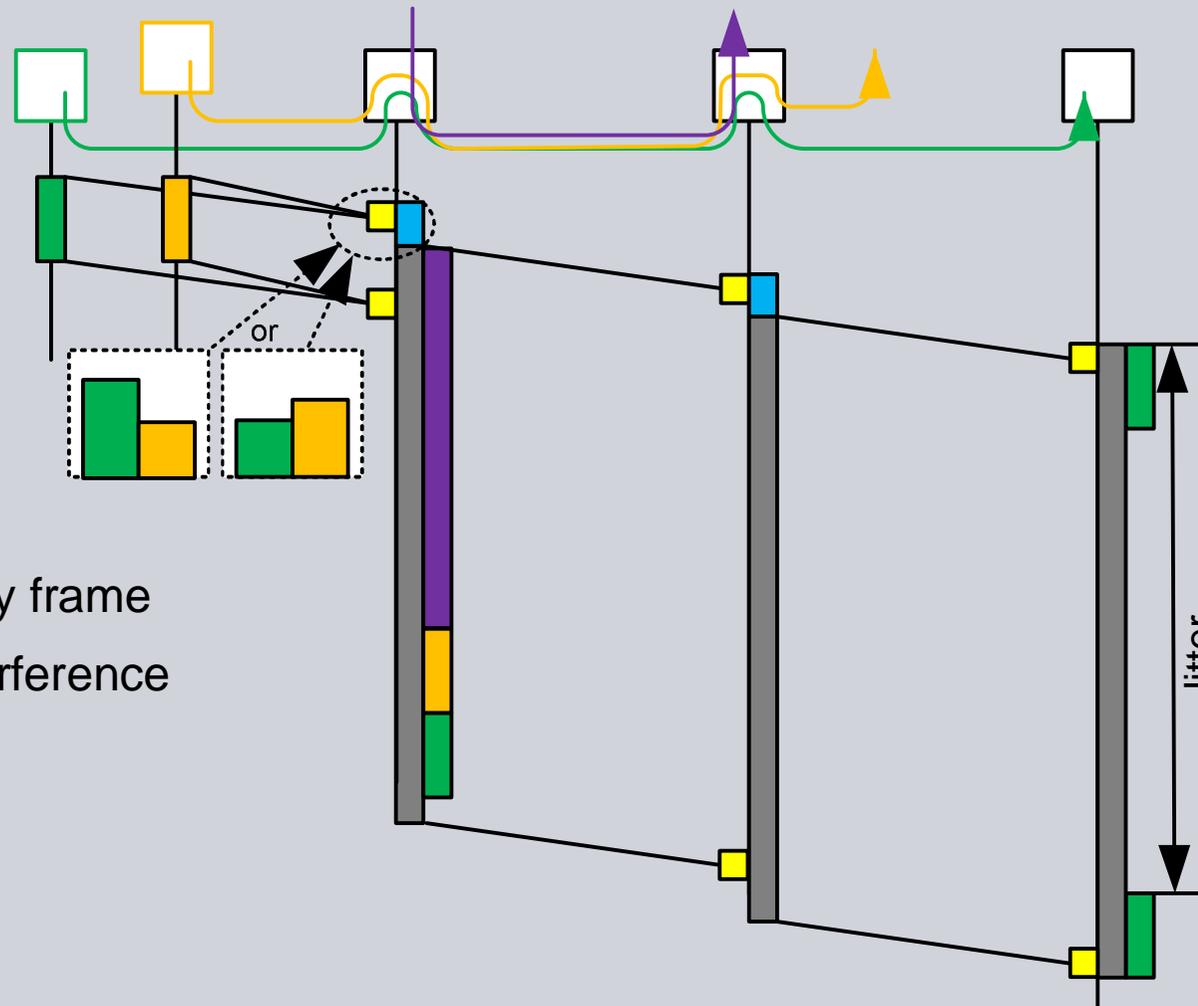and in-class interference

Jitter and the effects for BLS (II)

Inter-class interference can lead to an change in the transmission order

or

Assumption:
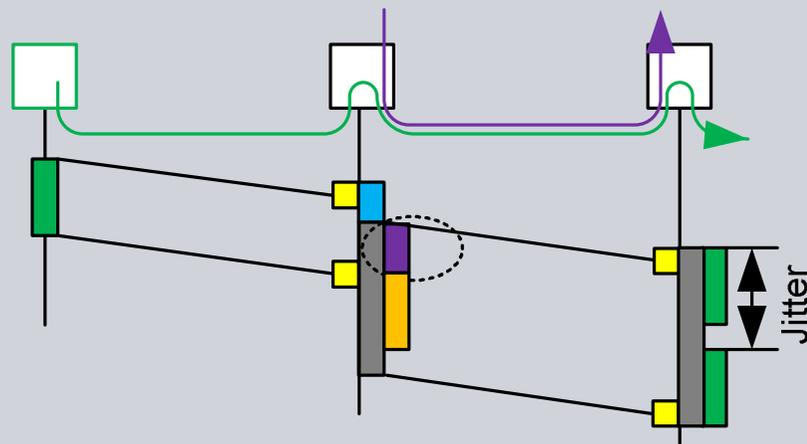
Store and Forward

No Preemption

Jitter

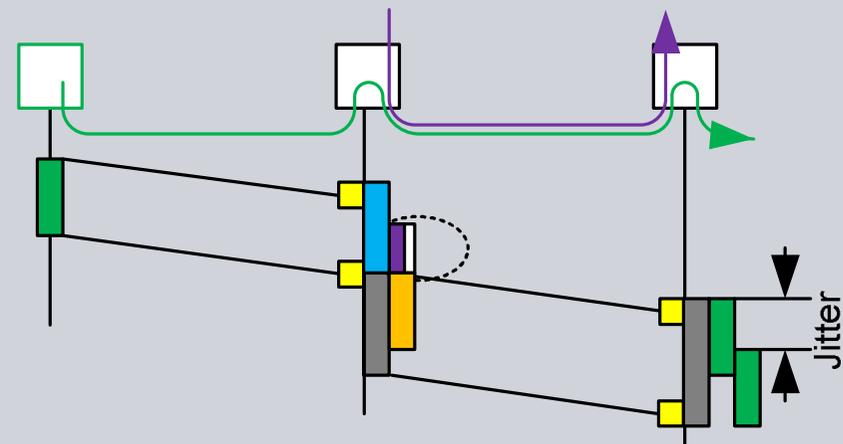# Jitter and the effects for BLS (IV)

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Interfering legacy frame

and in-class interference

or

Jitter

BLS with fragmentation and forced delay (III)

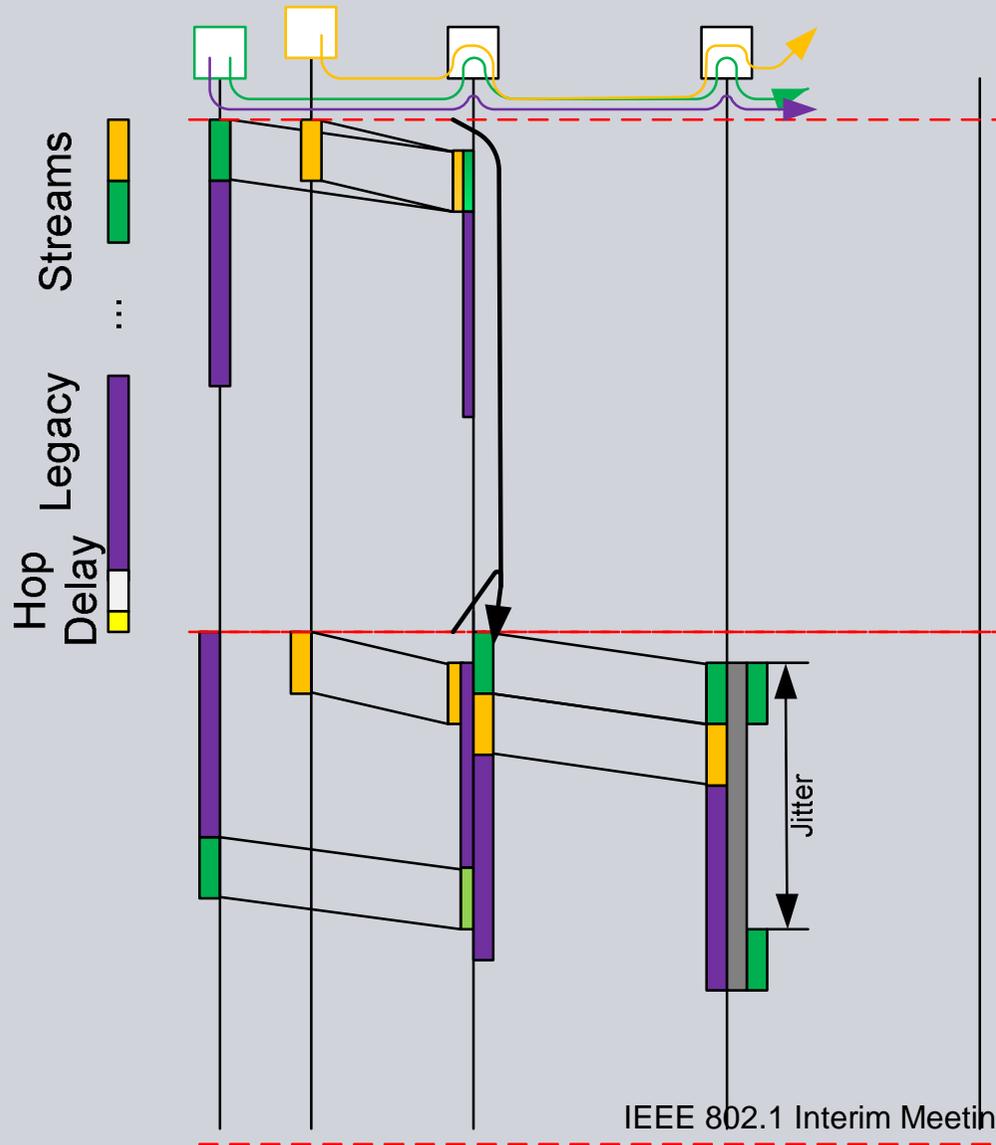Fragmentation to reduce the
jitter effect of legacy frames

Forced delay to eliminate the
jitter effect of fragmentation

Jitter and the effects for PS

Fixed delay for every hop:

- streams
- max. legacy frame
- Jitter

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Conclusion

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Shaper	TAS	BLS	CBS	PS
I Latency	**optimal**	Low	medium	High - **guaranteed maximum**
Jitter	Must be considered from scheduling	Synchronisation	Synchronisation + **Shaper**	Max. 1 phase
Scheduling	**needed**	**Can shorter delay** ~TAS performance	Can ensure transmission order	phase synchronisation
II Legacy interference **IV** In-class interference **III**	Not possible during TAS window / Prevented by scheduling	Increases the delay		Doesn't matter
Fragmentation Improvement	Only for lower priority traffic	Can lower the effect of legacy traffic		x

Latency: **TAS** — BLS+Scheduling — BLS — CBS — **PS**

Thank you for your attention!

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