Latency Scenarios of Bridged Networks

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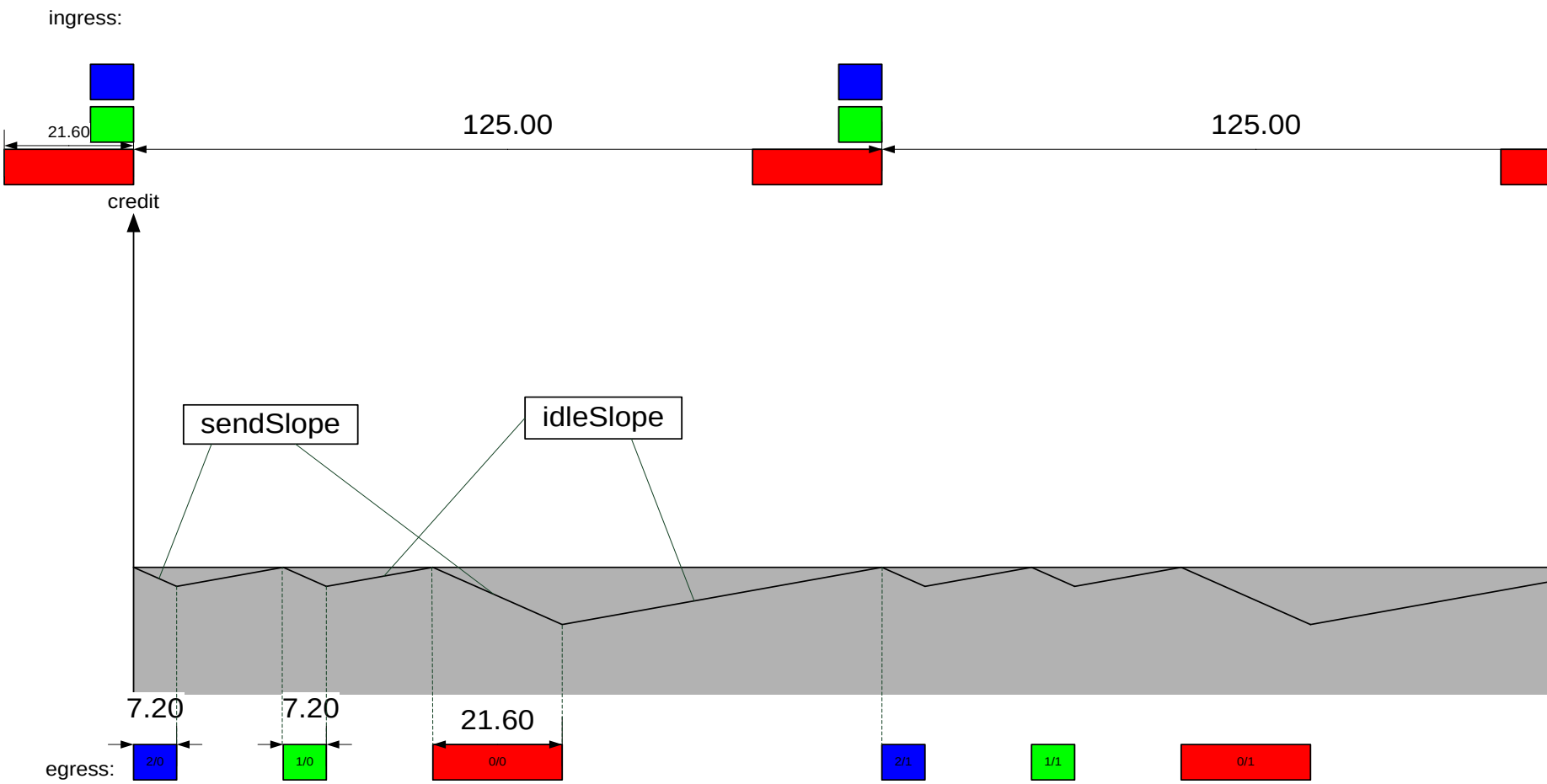
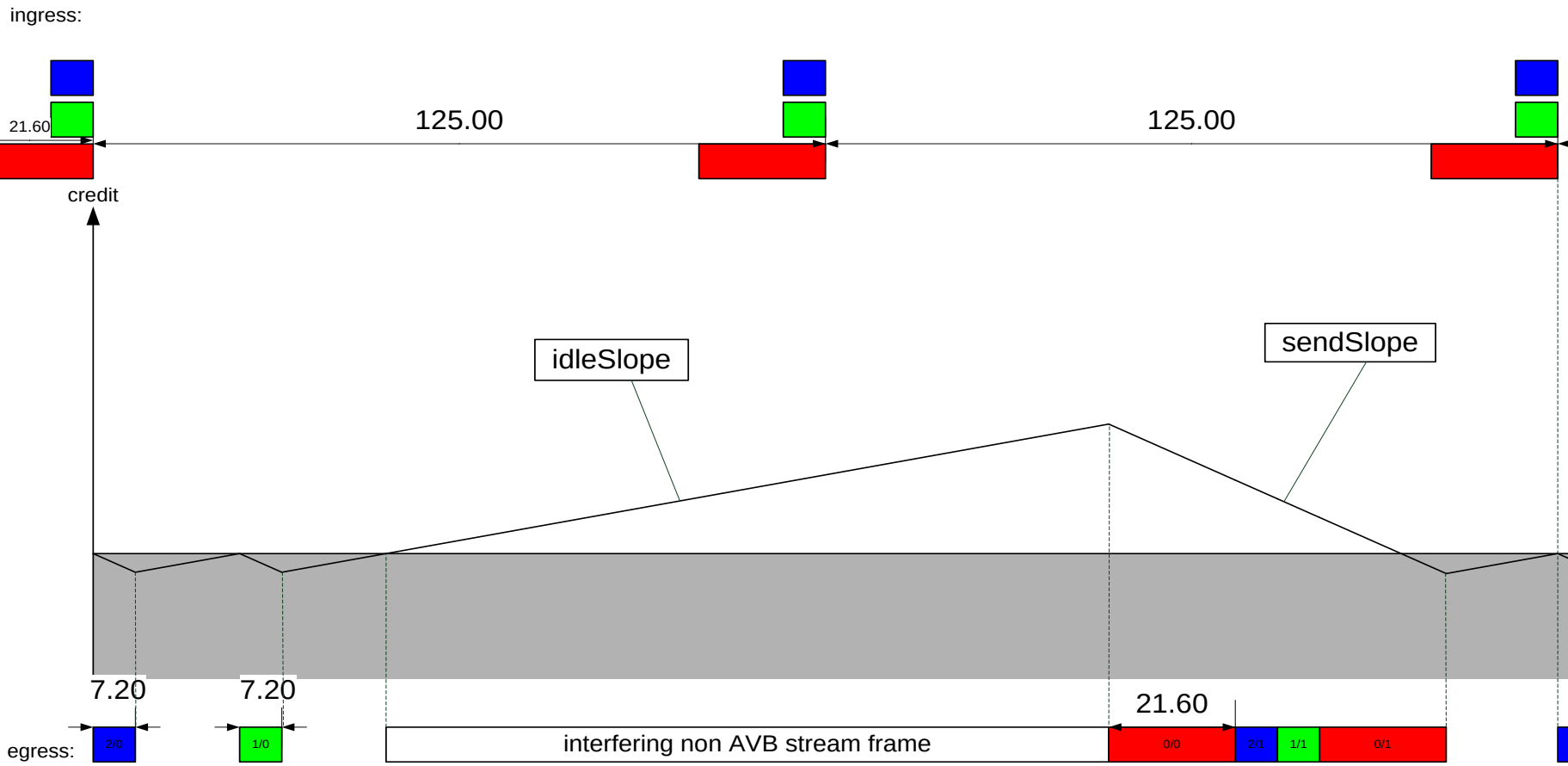
AVB Gen1 Mechanisms

- AVB Gen1 supports 2 traffic classes (Class A and Class B)
- Class A stream traffic has the highest priority (above Class B and strict priority traffic)
- Max 75% of the bandwidth can be allocated for AVB streams
- The packets (Class A) are transmitted with a rate of 8000 packets/s (i.e. one packet every 125µs)
- The packets are shaped by the "Credit Based Shaper" (CBS) in order to prevent bursts (and allow non AVB stream traffic)

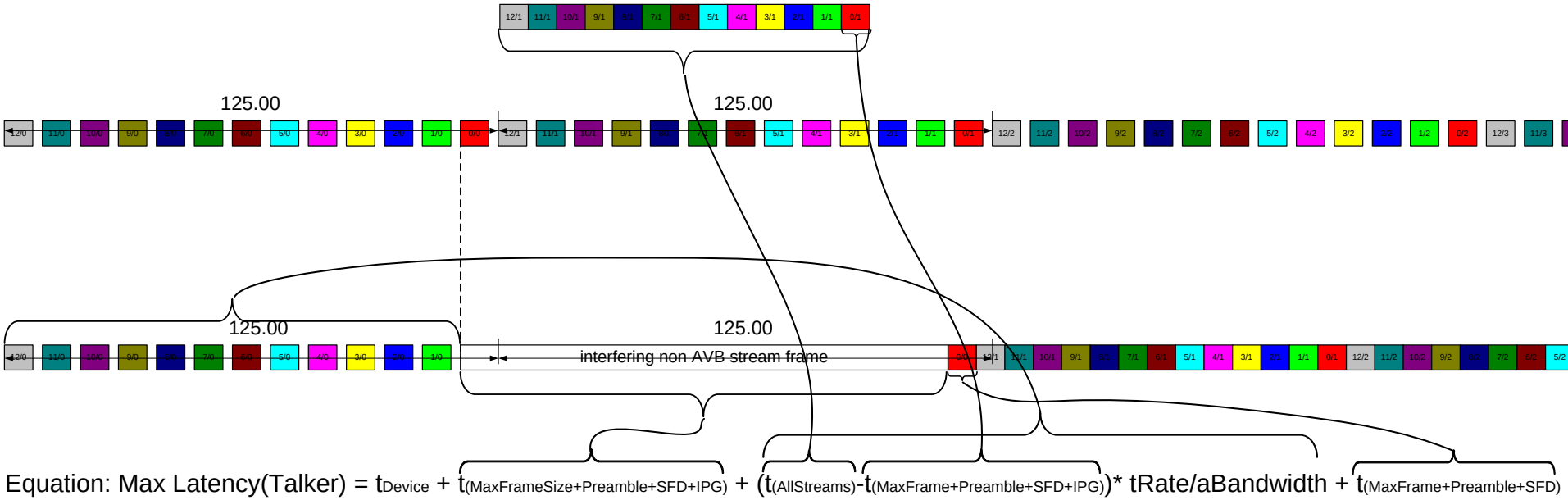
AVB Gen1 Class A – Credit Based Shaper (CBS)



AVB Gen1 Class A – Credit Based Shaper (CBS)



AVB Gen1 Latency



Equation: Max Latency(Talker) = t_{Device} + $t_{(MaxFrameSize+Preamble+SFD+IPG)}$ + ($t_{(AllStreams)}$-$t_{(MaxFrame+Preamble+SFD+IPG)}$)* tRate/aBandwidth + $t_{(MaxFrame+Preamble+SFD)}$

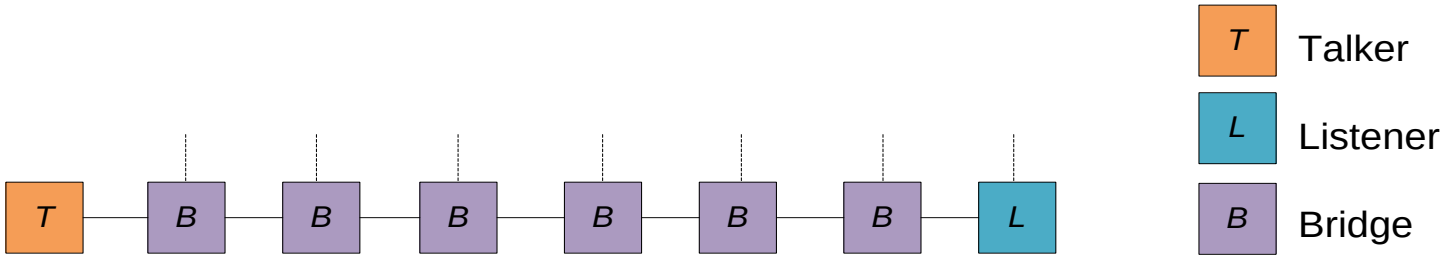
Worst case talker latency:

Fast Ethernet: 250.28 µs

Gigabit Ethernet: 137.528 µs

AVB Gen1 Network Latency

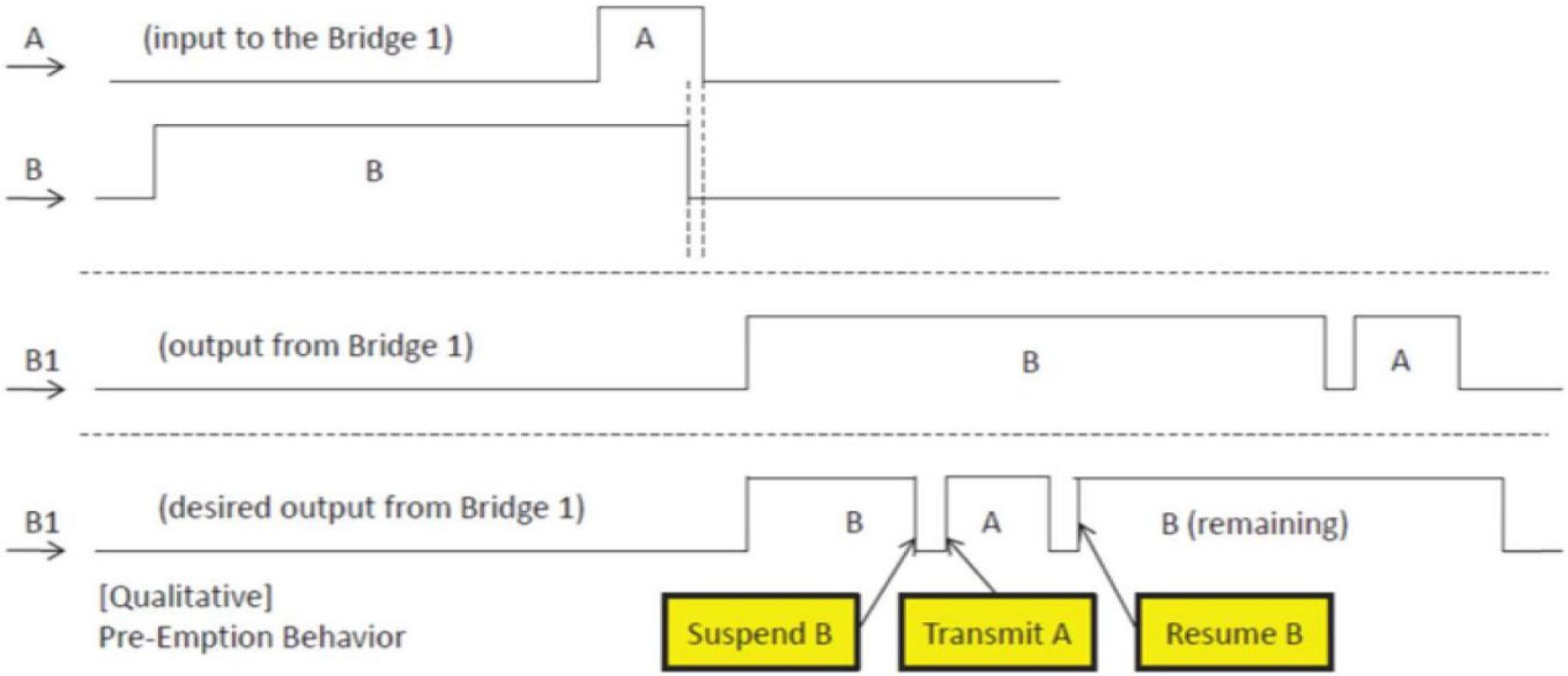
- Class A latency goal: 2ms / 7 hop



- The general assumption is that the average bridge latency equals the worst case talker latency
- But many crossing streams in big networks can increase the latency beyond 2ms / 7 hop
- The CBS guarantees a deterministic latency
- Jitter can be in the same order than the latency
- Class B supports 50ms / 7 hops

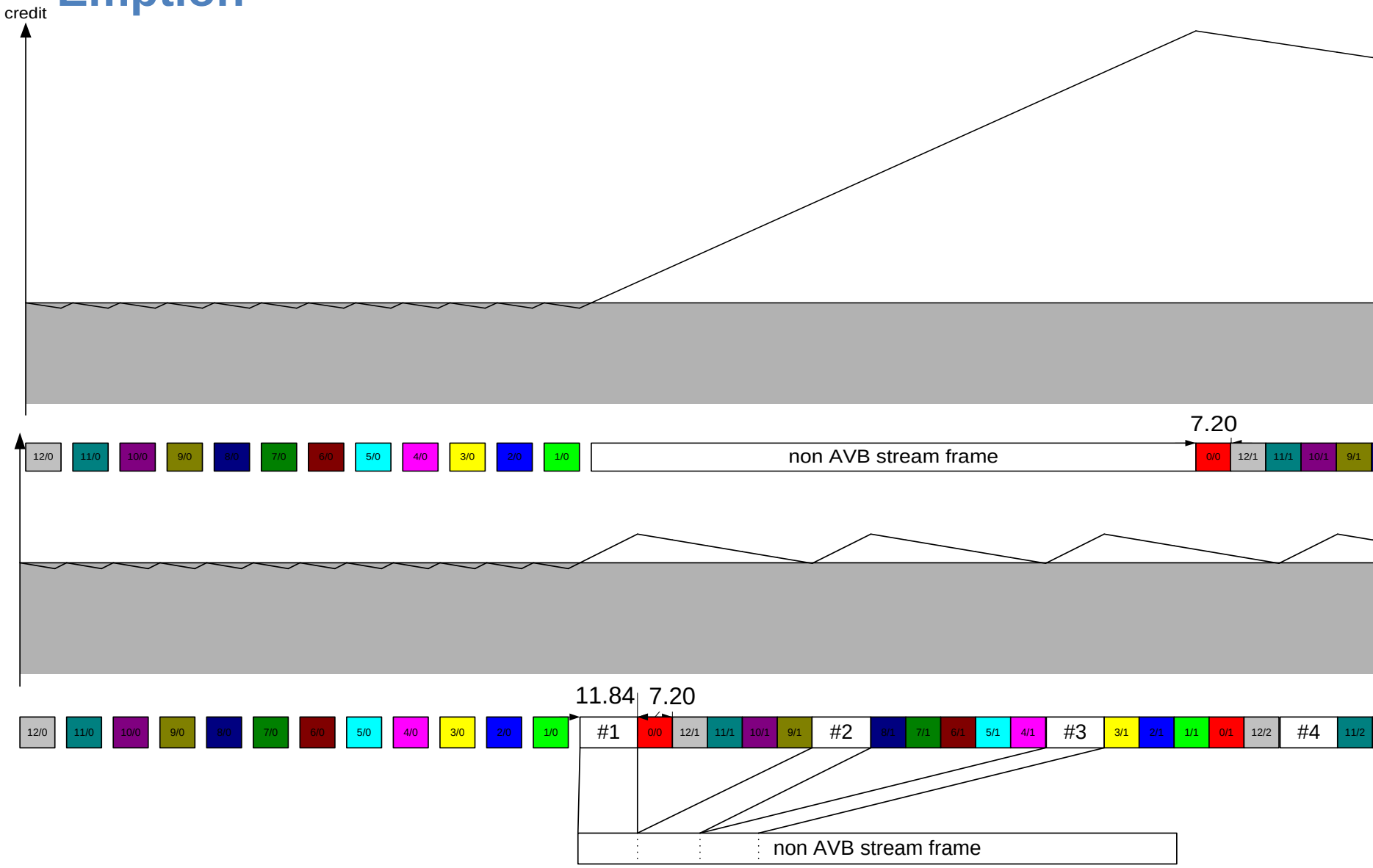
Possible Latency Improvements

AVB Gen2 Proposals – Pre-Emption



http://www.ieee802.org/1/files/public/docs2011/new-avb-kim-very-low-latency-packet-delivery-problem-statements-1111-v01.pdf

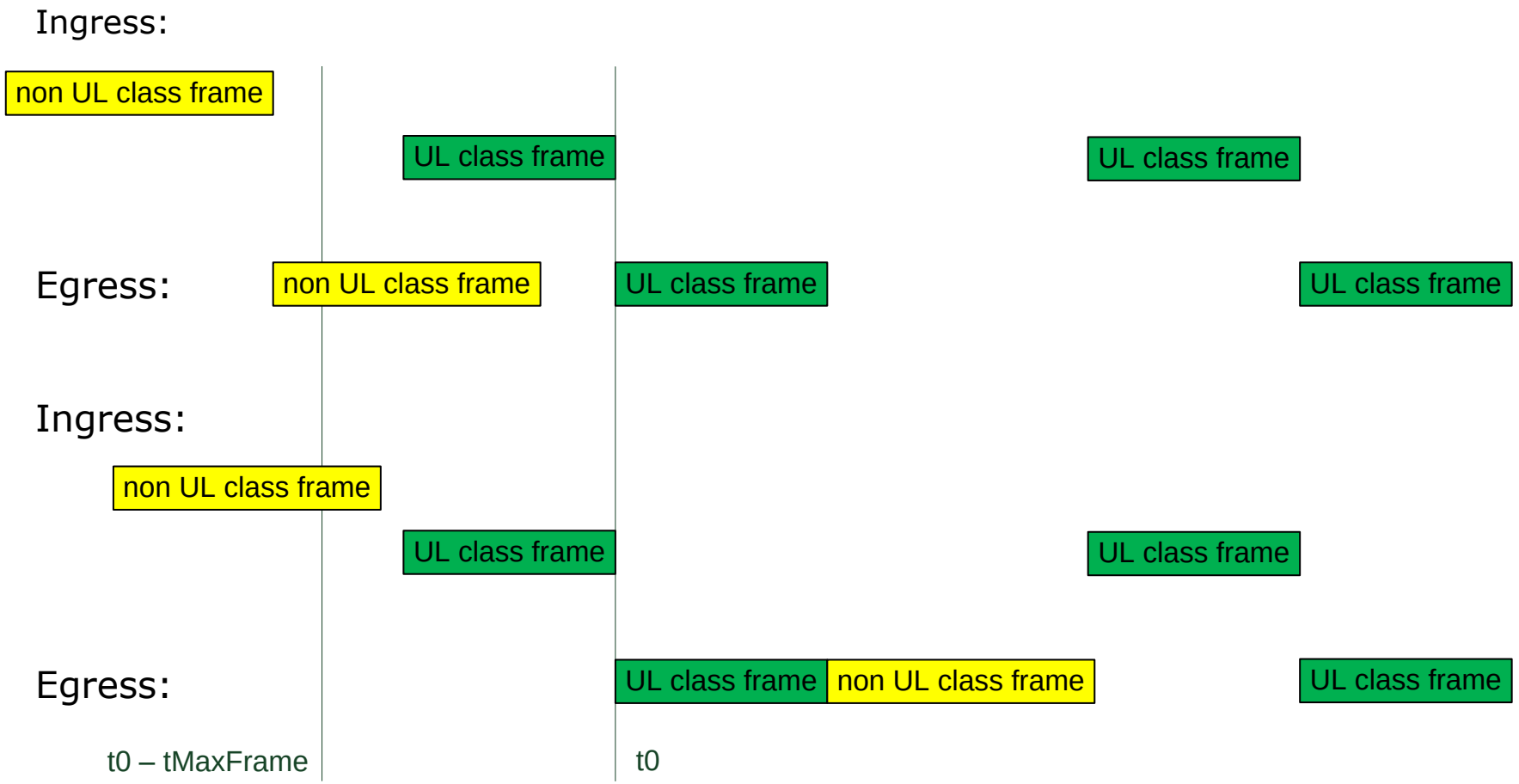
AVB Gen2 Proposals – Credit Based Shaper with Pre-Emption



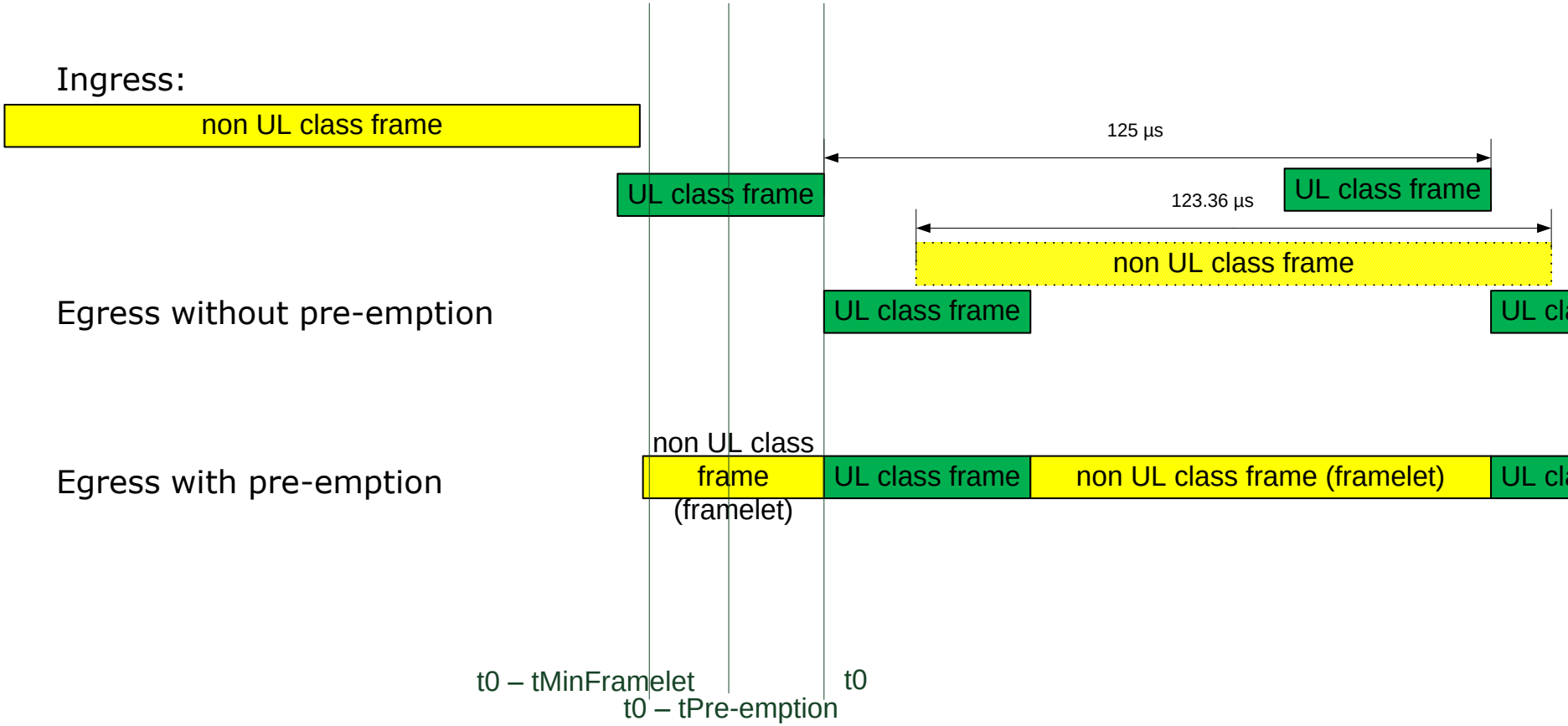
AVB Gen2 Proposals – Credit Based Shaper with Pre-Emption

- Worst case talker latency (Class A):
  - Fast Ethernet: 138.76 µs (AVB Gen 1: 250.28 µs)
  - Gigabit Ethernet: 126.376 µs (AVB Gen 1: 137.528 µs)
- Less problems in bigger networks, especially Fast Ethernet networks
- But still not really Ultra-Low Latency (UL)

AVB Gen2 Proposals – Time Aware Shaper



AVB Gen2 Proposals – Time Aware Shaper



t0: UL class frame is ready to be transmitted and UL class queue is de-blocked

t0-tMinFramelet: Egress port is blocked for non UL class

t0-tPre-emption: Pre-emption mechanism is activated

AVB Gen2 Proposals – Time Aware Shaper

Resulting latency:

Latency = tDevice + tULclassFrame + tJitter

tDevice = device specific latency (e.g. MAC, switching delay)

tULclassFrame = time to transmit the UL class frame

tJitter= time to compensate the time synchronization error

- Lowest latency for store-and-forward
- Lowest delivery variation

Fast Ethernet latency: 19.72µs/hop

Gigabit Ethernet latency: 2.38µs/hop

Even Smaller Latencies with Cut-thourgh

- Cut-through doesn‘t improve the worst case latency in normal networks
- But cut-through improves the latency if the port is idle when the frame is ready to be transmitted

➔Time Aware Shaping guarantees that the port is idle

➔Even lower latencies with cut-through in combination with Time Aware Shaping

  - Fast Ethernet: 10.24µs
  - Gigabit Ethernet: 1.536µs

A Latency Option for Every Application

Fast Ethernet per hop latencies for a 150 byte frame:

- Credit Based Shaper AVB Gen1: 250,28µs
- Credit Based Shaper w/pre-emption: 138.76µs
- Time Aware Shaper in the end-stations but only pre-emption in the bridges: 30.56µs ++
- Time Aware Shaper: 19.72µs (jitter=1µs)
- Time Aware Shaper w/cut-through: 10.24µs

tDevice = 5.12 µs; min framelet = 128 byte; cut-through time = 5.12µs; cable delay not included

A Latency Option for Every Application

Gigabit Ethernet per hop latencies for a 150 byte frame:

- Credit Based Shaper AVB Gen1: 137.04µs
- Credit Based Shaper w/pre-emption: 126.89µs
- Time Aware Shaper in the end-stations but only pre-emption in the bridges : 3.57µs ++
- Time Aware Shaper: 2.38µs (very low jitter)
- Time Aware Shaper w/cut-through: 1.536µs

tDevice = 1.024 µs; min framelet = 128 byte; cut-through time = 0.512µs; cable delay not included

Thank You