# Meeting the AVB Gen2 Latency Requirements

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November 2011
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# Automotive and Industrial Latency Requirements

Copied from the assumptions document [1]:

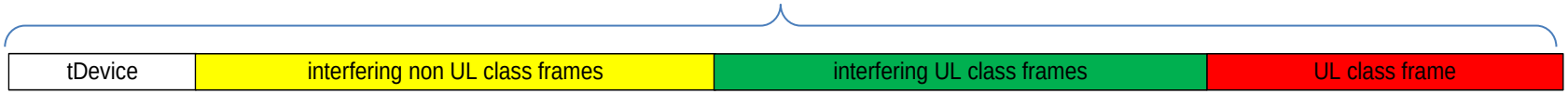
- Automotive:
  - 100 µs w/5 FE hops
  - 128 bytes payload
  - max 7 hops

- Industrial:
  - < 3 µs / hop (Interfering Frames (includes other same PCP frames) + Bridge Latency (not including Store Forward Latency))
  - max 64 hops (daisy chain)

[1] http://www.ieee802.org/1/files/public/docs2011/avb-dolsen-gen2-assumptions-0911-v6.pdf

# Implications of the Industrial Latency Requirements (1)

Latency = tDevice + tInterferingNonUl + tInterferingUl + tUl




Industrial Goal:

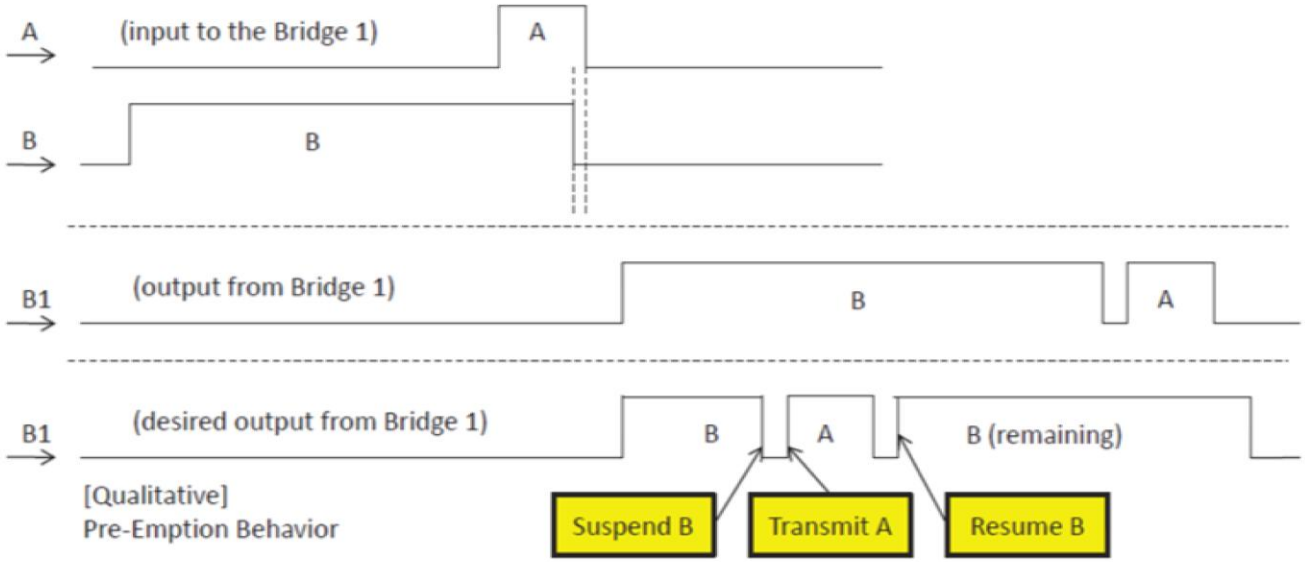
tDevice + tInterferingNonUl + tInterferingUl < 3 µs


tDevice = 1.024 µs

⇒ tInferferingNonUl + tInterferingUl < 1.976 µs

⇒ InterferingNonUl + InterferingUl < 247 bytes

# A Generic Preemption Solution




- There are few other solution to "head of line blocking" delay behind a max frame length packet.
- A generic solution is to suspend the max frame length ("B" in this example) packet, transmit urgent frame, and resume previous. Note: Other completion options besides resume-previous is retransmit B entirely, or always fragment B (regardless of existence of A) are not desirable).

802.1 Nov 2011 Plenary | IEEE 802.1 Low Latency Packet Delivery Requirements | Page 12

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

# Pre-emption as Defined for Automotive

- **Lower Priority Frames can be Pre-empted but each Framelet down the wire must be a good Frame**
  - Pre-emption to occur on a Link-by-Link basis
  - Re-constructed Frame must be 100% as it was before pre-emption
  - Each Framelet will have a good CRC
  - Each Framelet must be at least 64 bytes in size
  - Pre-empt on Modulo boundaries (easier for the receiver) – assume 64 bytes for now – is that 64 bytes on the wire or 64 bytes of the re-constructed Frame (which would be more on the wire due to the 'Tag')?
  - Pre-emptable Frames will need extra Tag bytes added



http://www.ieee802.org/1/files/public/docs2011/new-avb-pannell-latency-options-1111-v2.pdf

# Implications of the Industrial Latency Requirements (2)

InterferingNonUl + InterferingUl < 247 bytes

Assuming preemption with a minimum framelet length of 128 bytes

⇒ InterferingNonUl = 128 byte (payload incl. pre-emption overhead)

⇒ 150 bytes frame

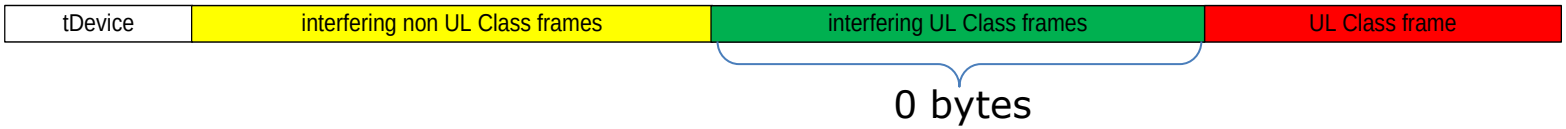
⇒ 158 bytes packet

⇒ 170 bytes packet and IPG

⇒ InterferingUl = 77 bytes

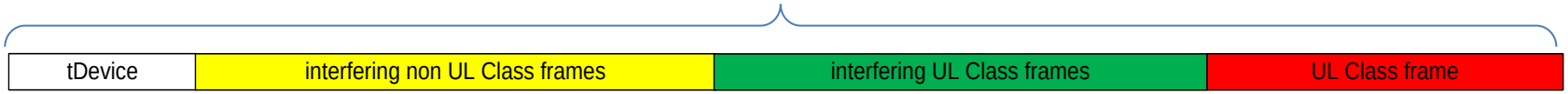
(minimum size packet + IPG = 84 bytes)

⇒ **It has to be guaranteed that UL class frames do not interfere with other UL class frames**



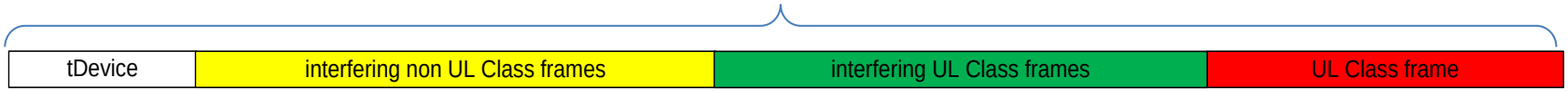
# Implications of the Automotive Latency Requirements

Latency = tDevice + tInterferingNonUl + tInterferingUl + tUl




Automotive Goal:

tDevice + tInterferingNonUl + tInterferingUl + tUl < 20 µs (5 FE Hops)




tDevice = 5.12 µs

tUl = 12.64µs (158 bytes)

⇒ tInferferingNonUl + tInterferingUlFrames = 2.24 µs

⇒ InterferingNonUl + InterferingUl = 28 bytes

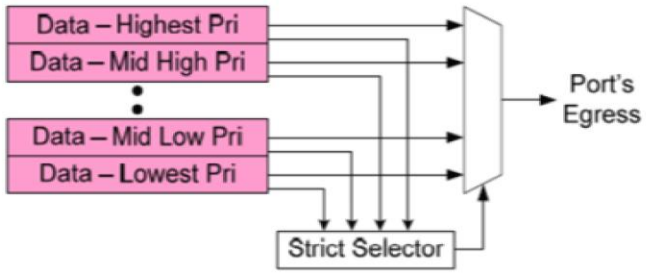
⇒ 28 bytes are not enough to send a minimum size frame

⇒ **Pre-emption alone is not enough to achieve this goal**

Marvell. Moving Forward Faster

# Typical Egress Queues

- **IEEE Standards before AVB Standardized two Possible Shapers**
  - Strict (as shown)
    - –Transmit all Highest Pri frames until the queue is empty
    - –Then transmit the next highest priority queue until it is empty, etc.
  - Or, Proprietary
- **Strict gets a Signal that a Queue has Data or not and the highest Queue with Data is selected**

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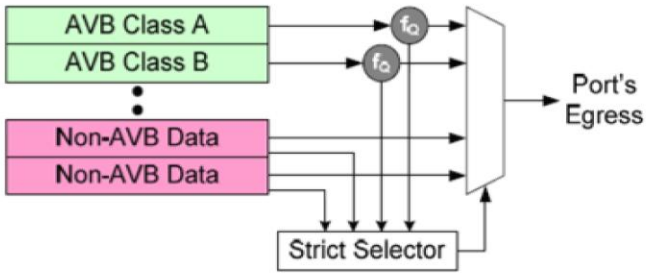
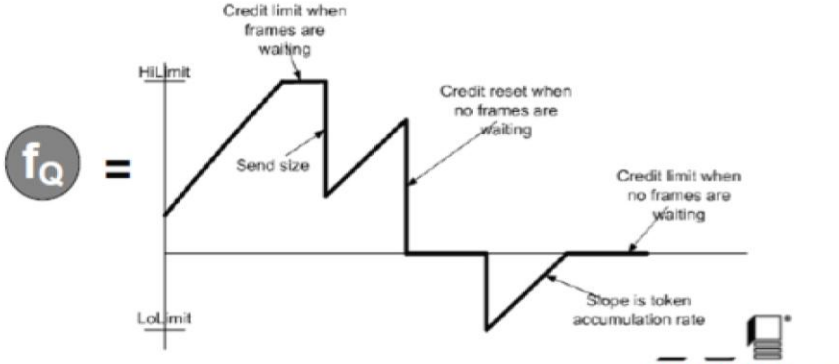
http://www.ieee802.org/1/files/public/docs2011/new-avb-pannell-latency-options-1111-v2.pdf

# What AVB's Qav Added

- IEEE 802.1 Qav added a 3rd Standardized Shaper
- The AVB Queues are Typically the top two Queues with a Strict Scheduler
- The AVB Queues add Qav Shapers that Selectively prevents the Strict Selector from 'seeing' Frames that are in the AVB queues.
- This spreads out Bursts of AVB data most of the time



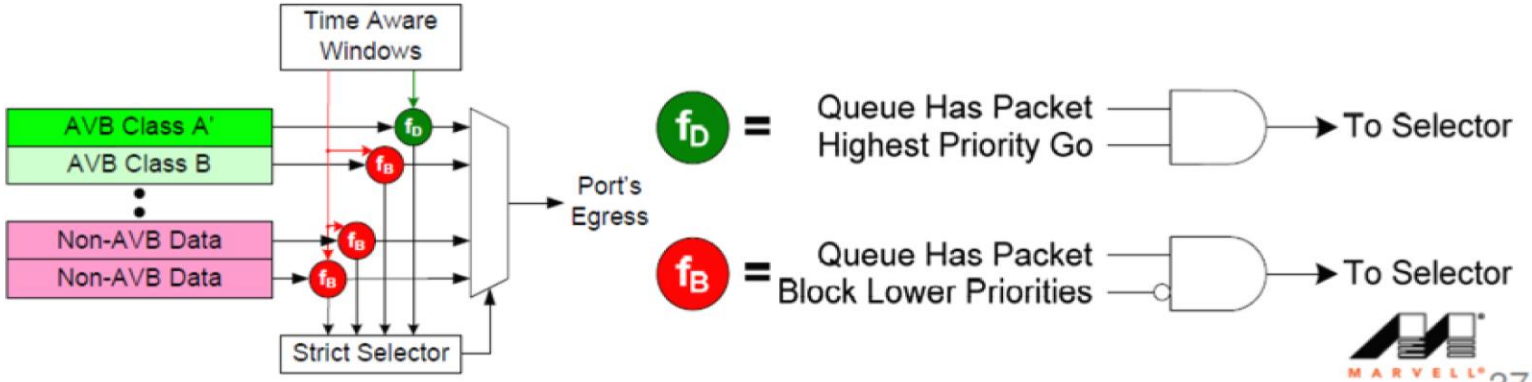






http://www.ieee802.org/1/files/public/docs2011/new-avb-pannell-latency-options-1111-v2.pdf

# Time Aware Blocking Shapers - TABS

- **Time Aware Blocking Shapers are quite simple**
  - Just an AND gate as shown below
- **They Can work in Parallel with the Qav Shapers**
- **Most of the Logic is generating the Time Aware Windows**
  - One signal is the De-Blocking signal or 'Highest Priority Goes'
  - The other is an Inverted Blocking signal or 'Lower Priorities OK'



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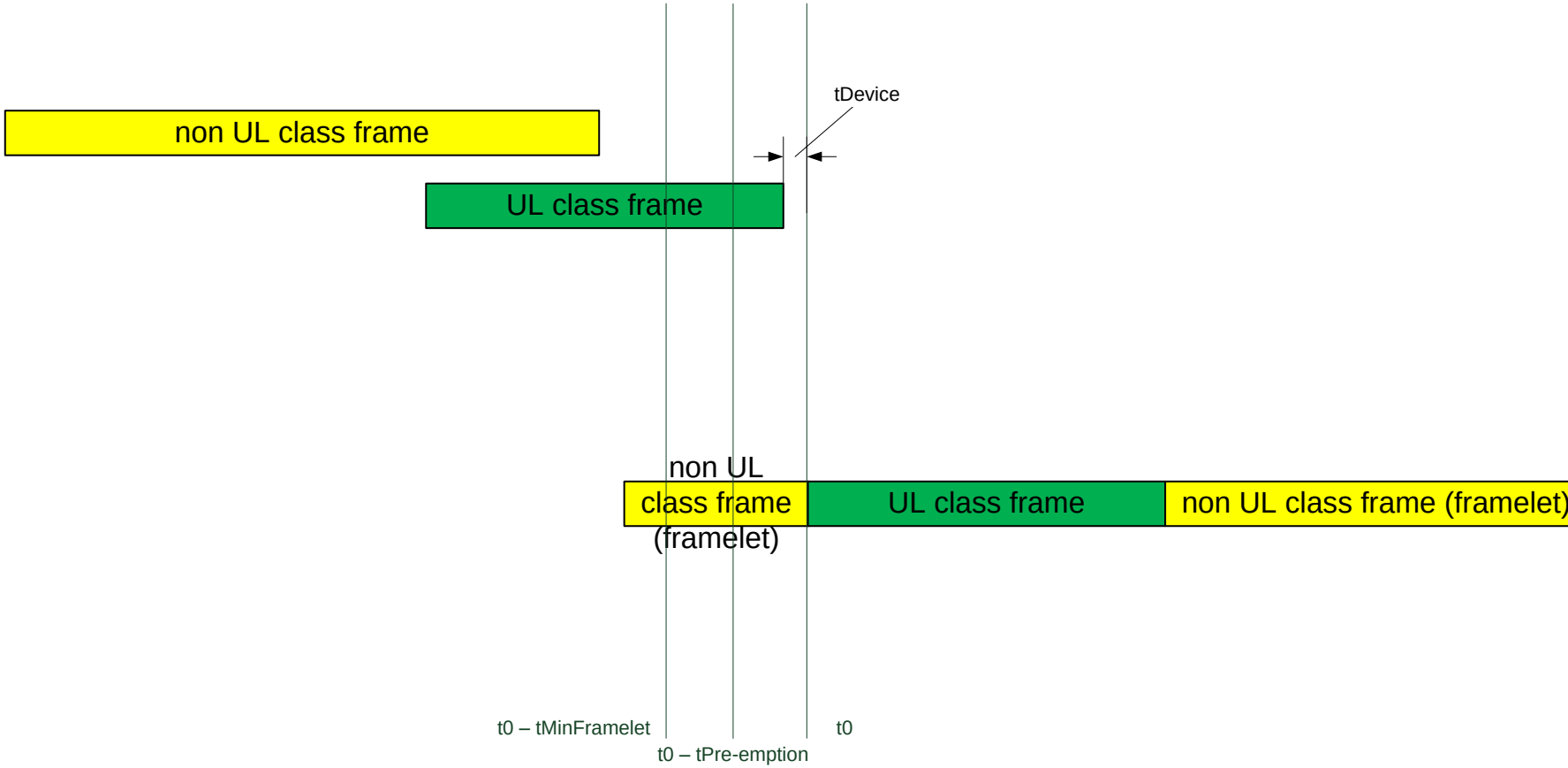
# Combining Pre-emption with TABS



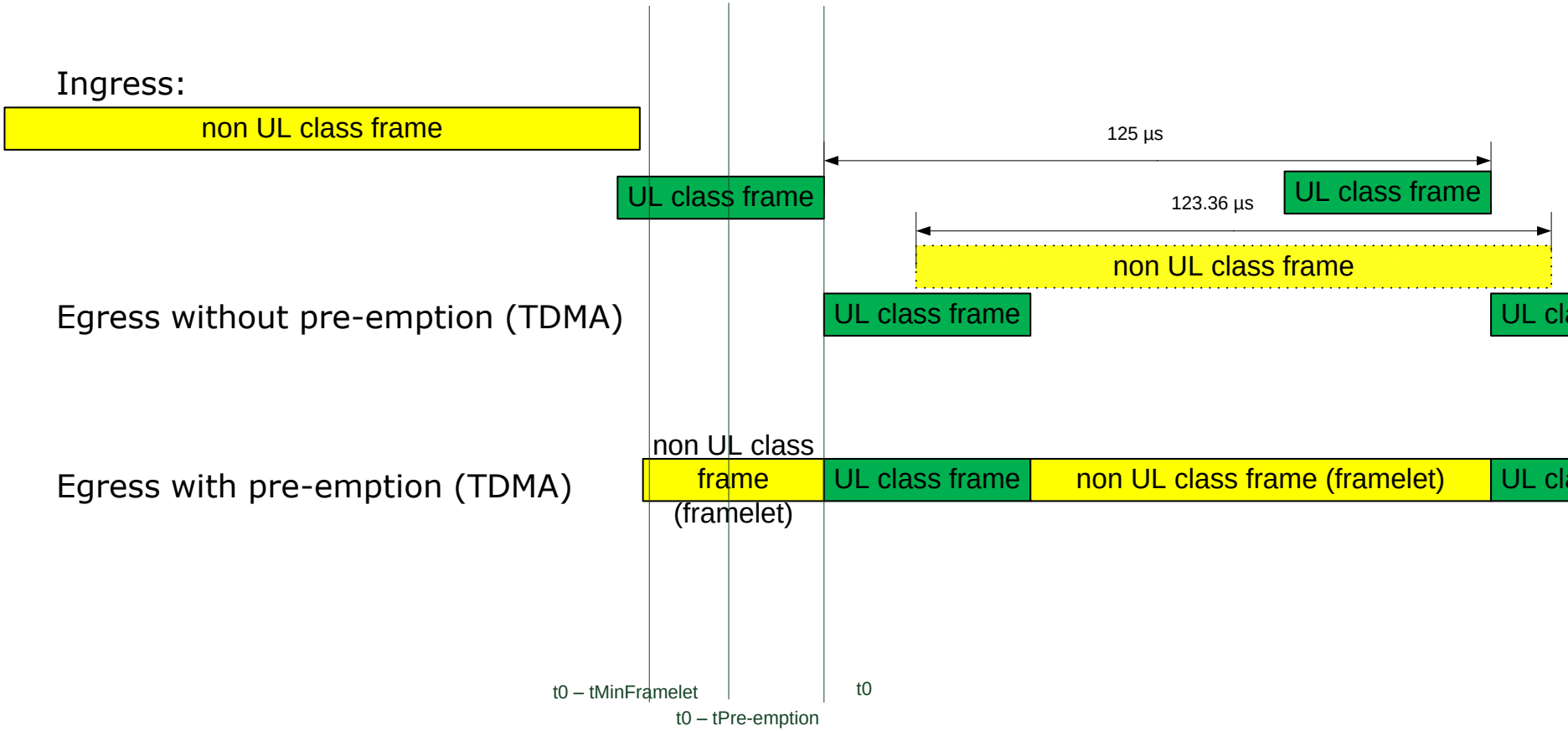

t0: UL class frame is ready to be transmitted and UL class queue is de-blocked

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

t0-tPre-emption: Pre-emption mechanism is activated
(t0-tMinFramelet = t0-tPre-emption ?)

# Advantages of Pre-emption with TABS

- For Fast Ethernet Networks




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

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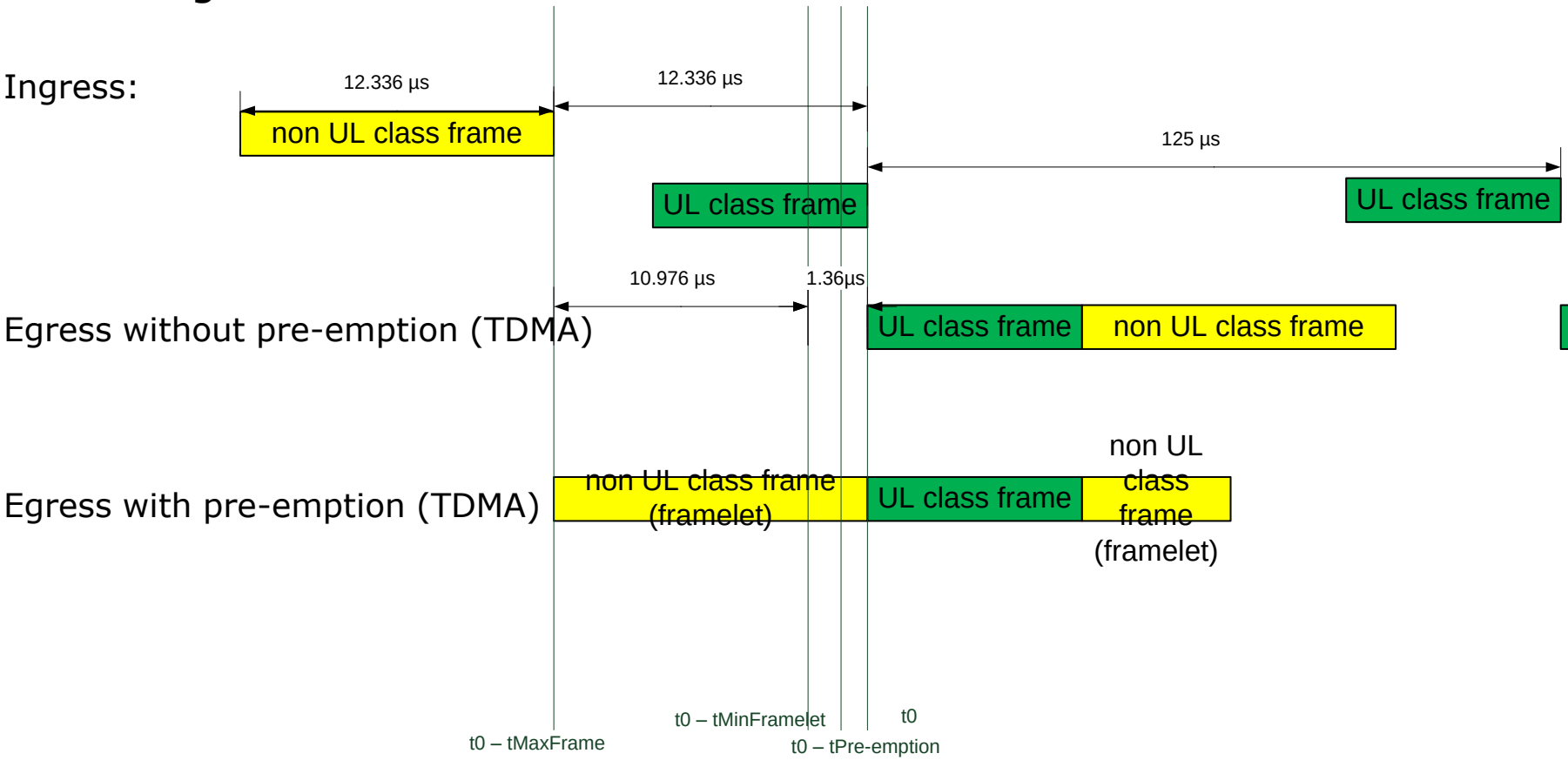
t0-tPre-emption: Pre-emption mechanism is activated

# Advantages of Pre-emption with TABS

- For Gigabit Ethernet Networks




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 frames

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

# Resulting Latency

- Automotive:
  - Max latency = 100 µ / 5 hops
  - Latency(TDMA + Pre-emption) = tDevice + tUl = 5.12 µs + 12.64 µs
  - Latency(TDMA + Pre-emption) = 17.76 µs
  - => 88.8 µs / 5 hops

- Industrial:
  - < 3 µs / hop (Interfering Frames (includes other same PCP frames) + Bridge Latency (not including Store Forward Latency))
  - Latency(TDMA + Pre-emption) = tDevice = 1.024 µs

# TDMA with Pre-Emption

- TDMA  with pre-emption in bridges and end stations would guarantee the automotive and industrial latency requirements
- TDMA with pre-emption would allow Fast Ethernet networks with small transmission periods
- Pre-emption would increase the bandwidth utilization for Fast Ethernet and Gigabit Ethernet networks with TDMA
- Pre-emption would allow lower latency even in non engineered networks
- Pre-emption in combination with AVB Gen1 would decrease the AVB Gen 1 latency

# 1 Hop Bridge Latency #'s w/300 byte AVB Frame

- AVB FE – Qav shaper w/1522 interfering = 249.640 uSec
- Gen 2 FE – No Shaper w/1522 interfering = 147.360 uSec
- Gen 2 FE – Preemption w/Max Stream @300 = 46.080 uSec
- Gen 2 FE – Time Aware Shaper w/Max Stream @300 = 34.240 uSec
- Gen 2 FE – Time Aware Cut Through w/Max Stream @300 = 15.360 uSec

- AVB GE – Qav shaper w/1522 interfering = 137.460 uSec
- Gen 2 GE – No Shaper w/1522 interfering = 14.736 uSec
- Gen 2 GE – Preemption w/Max Stream @300 = 4.608 uSec
- Gen 2 GE – Time Aware Shaper w/Max Stream @300 = 3.424 uSec
- Gen 2 GE – Time Aware Cut Through w/Max Stream @300 = 1.536 uSec

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# Thank You