MANAGING AUTOMOTIVE ACCUMULATED NETWORK TRAFFIC CONGESTION POINTS – USE CASE

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GENERAL MOTORS

AGENDA

MANAGING AUTOMOTIVE NETWORK ACCUMULATION CONGESTION POINTS – USE CASE

Scope of this presentation:

- Description **of a few** Automotive Constraints
- Use case based on simple common architectural OEM design
- A single specific use case (out of many…), with focus on traffic and accumulated congestion points in the network

Not scope of this presentation:

- Provide a pre-selection of IEEE 802.1 mechanisms “one size fits all” solution representing the whole automotive industry
- Representation of different OEM opinions and additional architecture designs

MANAGING AUTOMOTIVE NETWORK ACCUMULATION CONGESTION POINTS – USE CASE

Automotive Considerations:

Configuration

- Maintain standardization amongst suppliers
- Allow simple configuration for integrators
- Allow distributed network development (i.e., different divisions, different suppliers)

Safety/ISO 26262 (uses Automotive Safety Integrity Level (ASIL) compliance for Hazard Analysis & Risk Accessment)

- Keep data integrity high (e.g., FCS checks)
- Allow E2E protection
- Keep communication network "robust"/avoid unnecessary single points of failure
- Dual Plausible failure requirements
- Allow for network validation and verification

Topologies

- Keep overall wire length low (packaging & cost)
- Designs follow physical and packaging constraints of … vehicle builds and their components
- Designs follow physical and packaging constraints of … protocols and their functional limitations (cmp. System)
- Allow redundant transmission (IEEE 802.1CB FRER, dynamic structural redundancy, partial network replication, time redundancy, etc.), where needed (cost vs. safety)
- Provide a pre-selection of IEEE 802.1 mechanisms "one size fits all" solution representing the whole automotive industry
- Representation of different OEM opinions

MANAGING AUTOMOTIVE NETWORK ACCUMULATION CONGESTION POINTS – USE CASE

Automotive Considerations: (con't)

Bandwidth

- Keep wire speed low (PHY & common chokes costs)
- Keep net bandwidth high/overhead low

Traffic

- Support periodic traffic with different periods and priorities
- Support Event Driven Traffic with different priorities
- Maintain original priority "determinism classification" hop-to-hop
- Support "conventional" streams (e.g., video)
- All types of traffic can occur simultaneously (I.e, without topological separation), for example, in backbone segments

Endpoints

- Integrate with AUTOSAR
- Integrate with automotive grade communication stacks
- Keep performance limitations of µCs into account

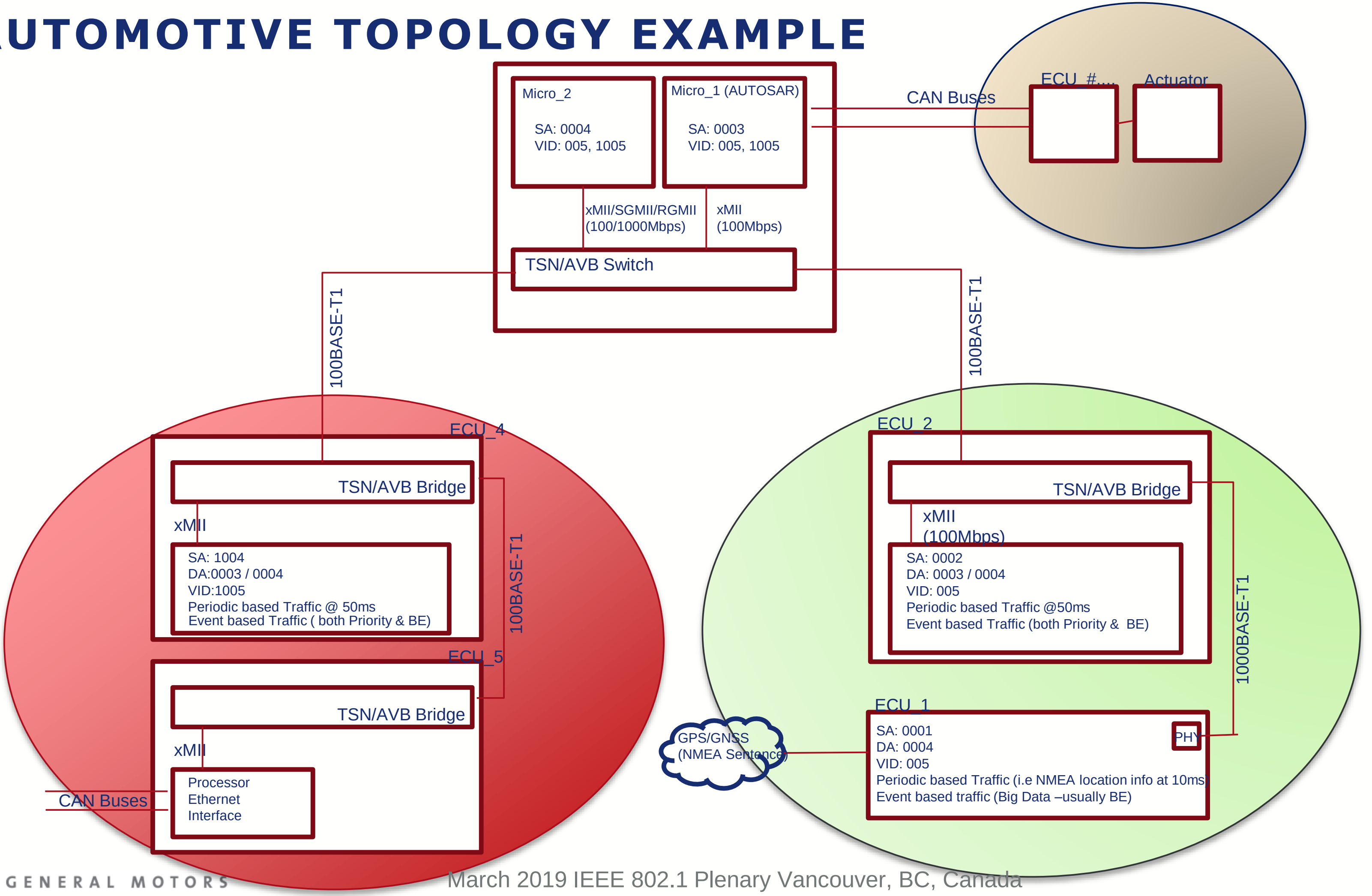
MANAGING AUTOMOTIVE NETWORK ACCUMULATION CONGESTION POINTS – USE CASE

Automotive Considerations: (con't)

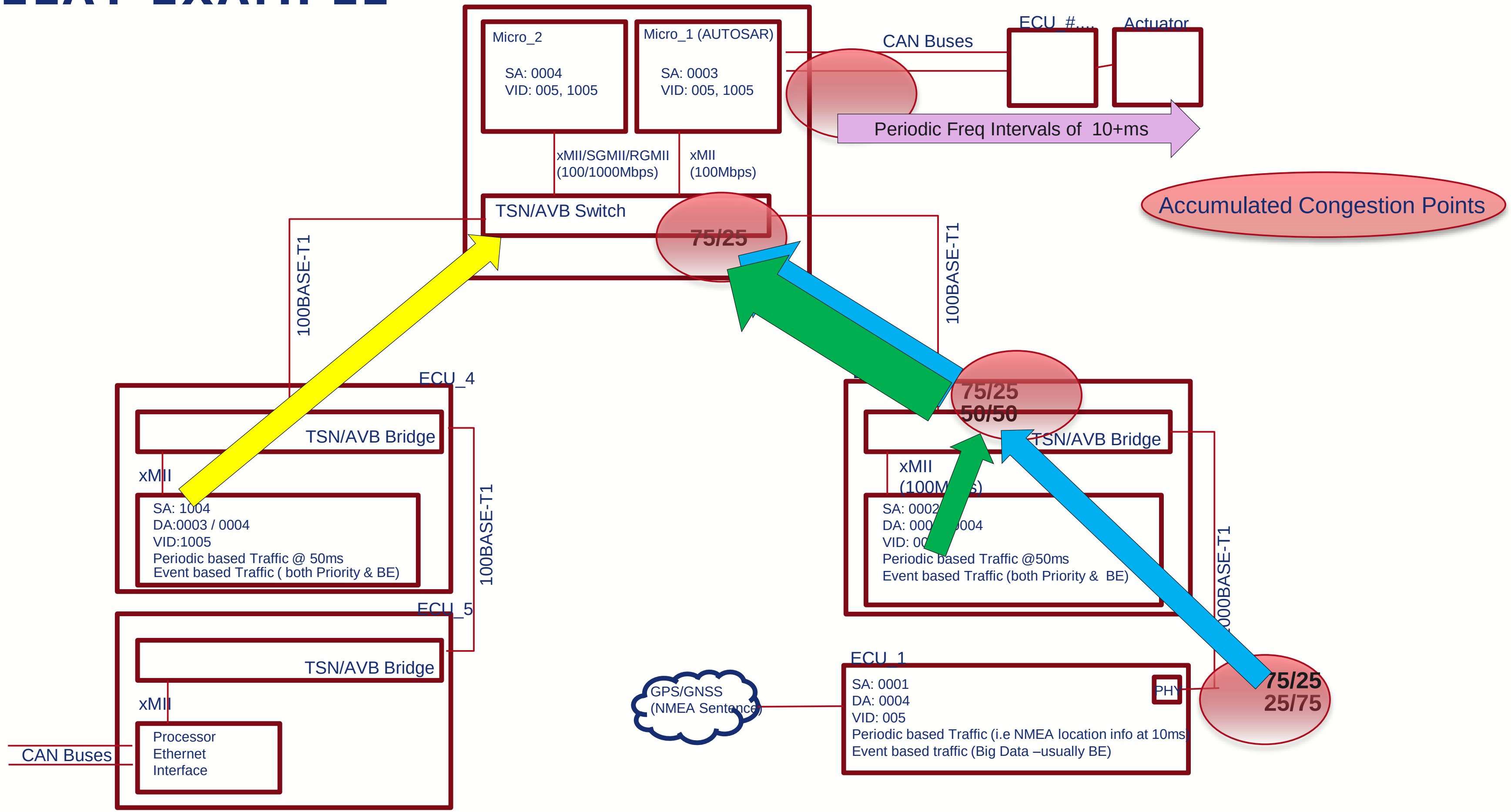
Overall System

- Startup fast (< 100 ms)
  - Store (default) configurations in endpoints wherever possible to eliminate additional communication and convergence times at startup (e.g.. MSRP cannot be effectively used)
  - If clock sync is needed:
    - Let it startup before real-time streams are emitted without congestion by streams
    - Multiple sync messages needed at startup for consistency
    - Fast intervals needed for startup
- Power considerations:
  - Fast re-integration after standby/sleep

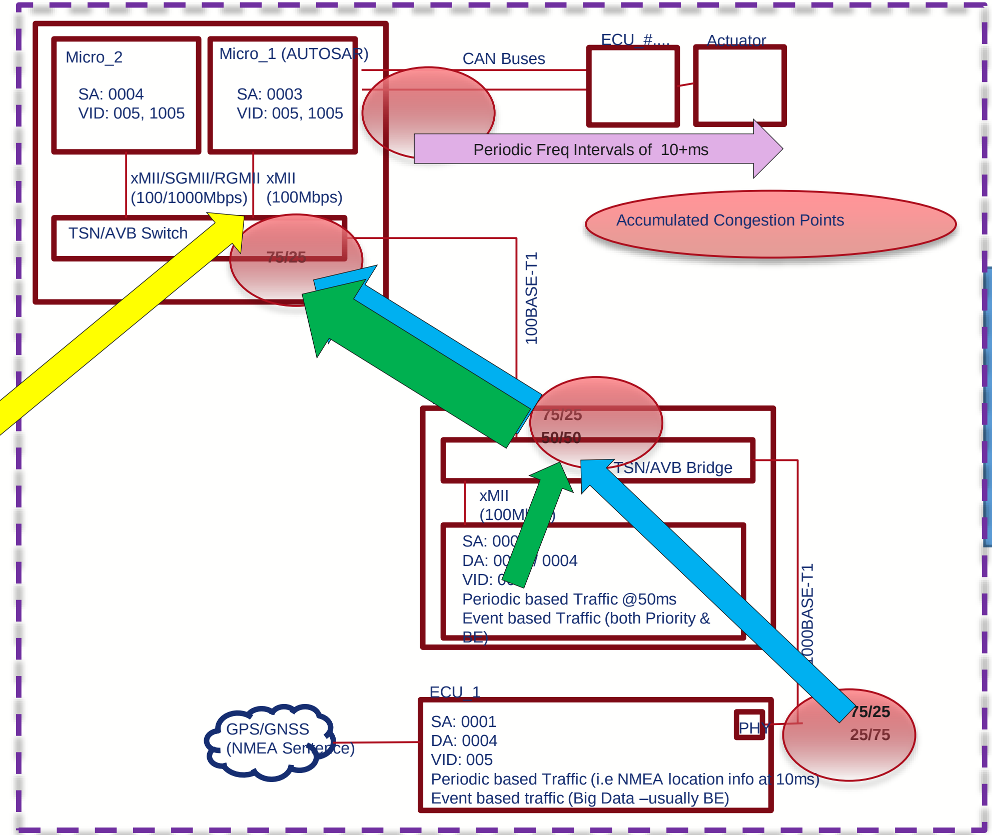
AUTOMOTIVE TOPOLOGY EXAMPLE

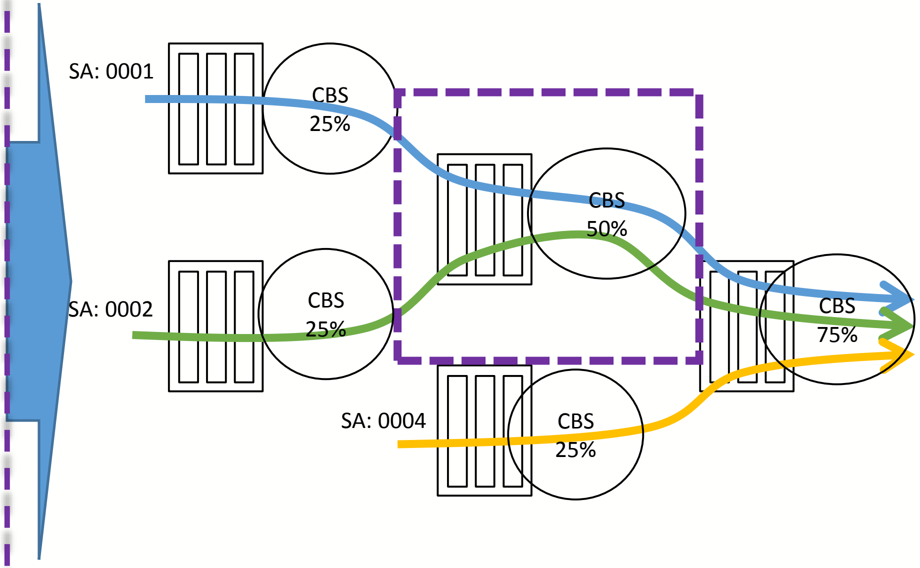


DELAY EXAMPLE

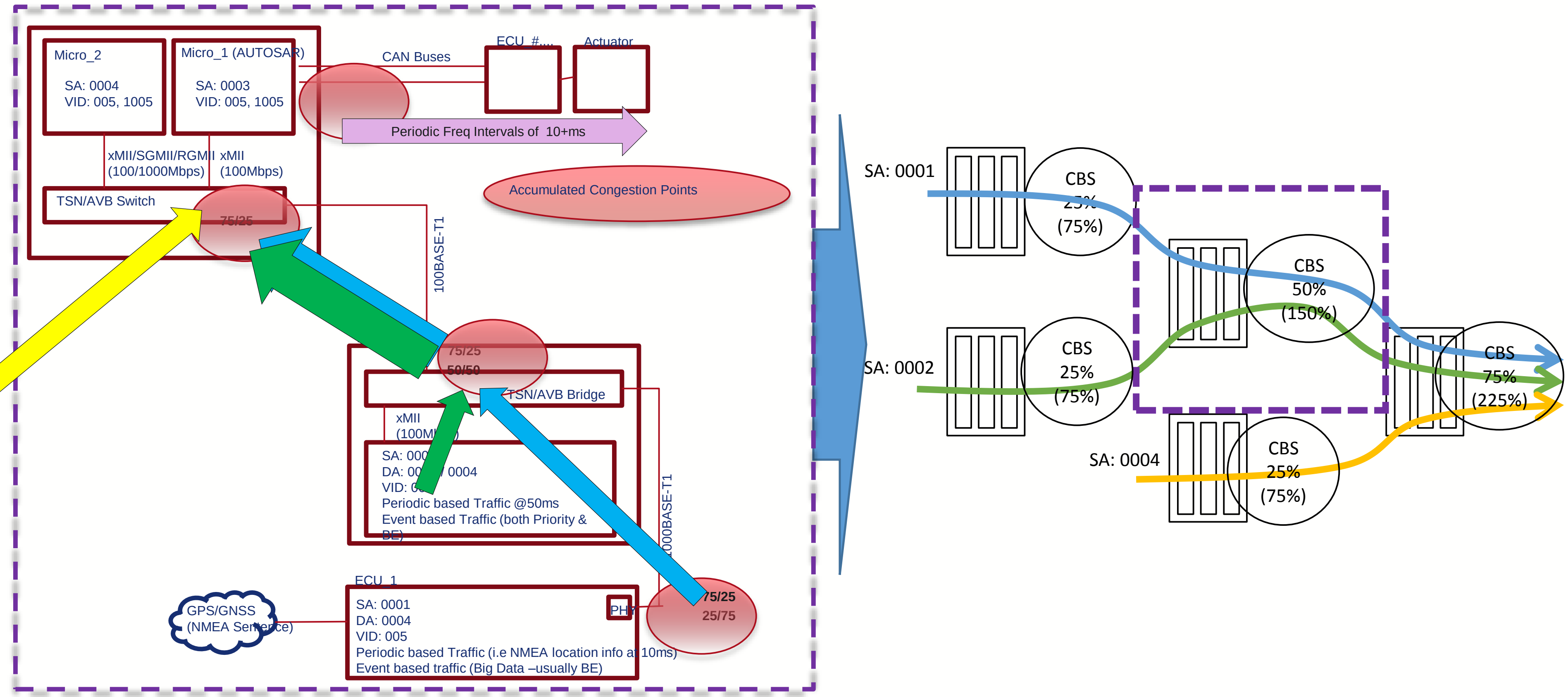


AS WE ALREADY KNOW…
ADDED BURSTS INCREASES DELAY





FAN-IN-DELAY



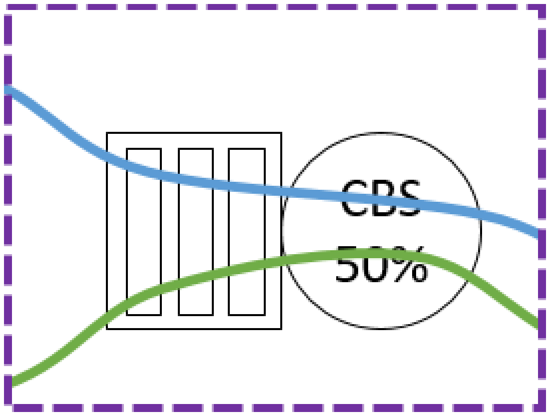
Micro_2
SA: 0004
VID: 005, 1005
Micro_1 (AUTOSAR)
SA: 0003
VID: 005, 1005
CAN Buses
ECU #....
Actuator
Periodic Freq Intervals of 10+ms
xMII/SGMII/RGMII xMII
(100/1000Mbps) (100Mbps)
Accumulated Congestion Points
TSN/AVB Switch
75/25
100BASE-T1
75/25
50/50
TSN/AVB Bridge
xMII
Periodic based Traffic @50ms
Event based Traffic (both Priority &
BE)
100BASE-T1
ECU_1
GPS/GNSS
SA: 0001
DA: 0004
VID: 005
Periodic based Traffic (i.e NMEA location info at 10ms)
Event based traffic (Big Data –usually BE)
PHY
75/25
25/75
SA: 0001
CBS
(75%)
SA: 0002
CBS
25%
(75%)
CBS
50%
(150%)
CBS
75%
(225%)
SA: 0004
CBS
25%
(75%)

FAN-IN-DELAY

Observation

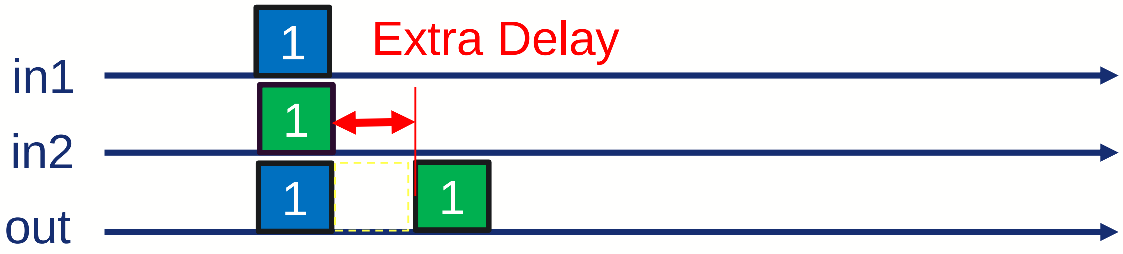
At merge points, CBS adds delay *inversely proportional* to the configured bandwidth (~idleSlope)

The higher the Fan-in, the bigger the delay. E.g., N identical inputs means N-1 times the extra delay.



ATS

Frames are sent back to back. No extra delay injected.



ADDED BURSTS INCREASES DELAY

Observation

If source ECUs use the required max available bandwidth, the delay will increase due to this burst:

- Credit becomes positive while CBS class can't transmit a queued frame (e.g., the link is used by BE)
- Positive credit will shift the frames together (burst)
- The burst will increase the inter-packet gaps

ATS

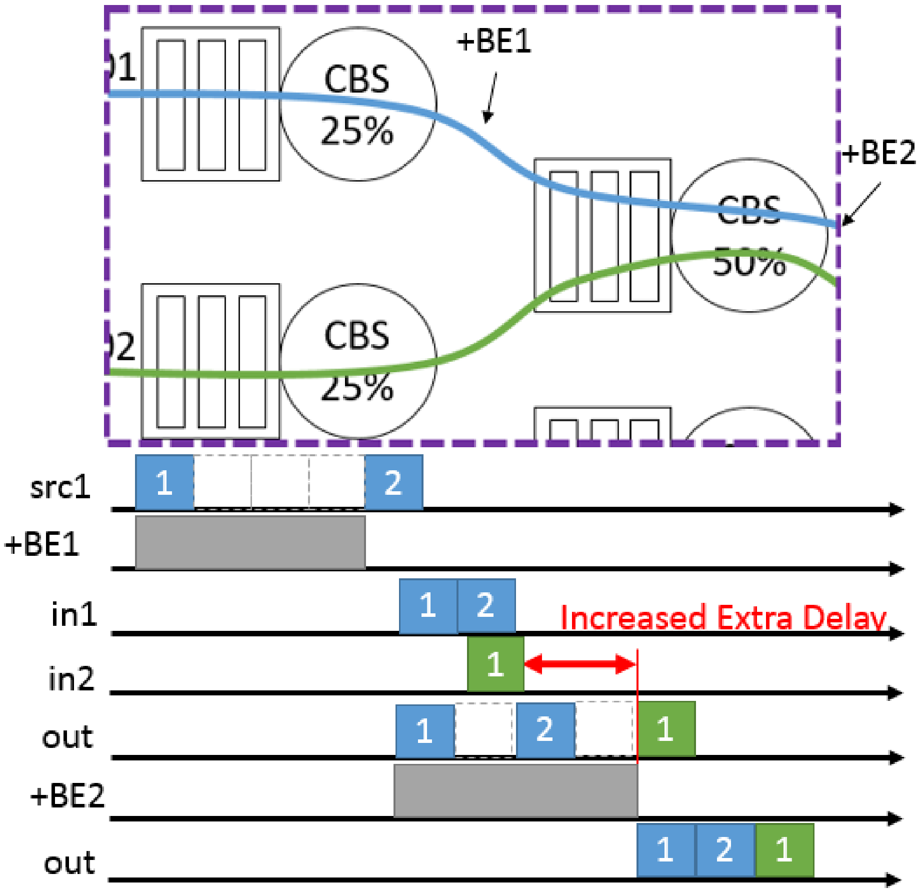
Queues *in1* and *in2* separately
→ frame 1 would not have to wait

BUT… this illustration is over-simplified

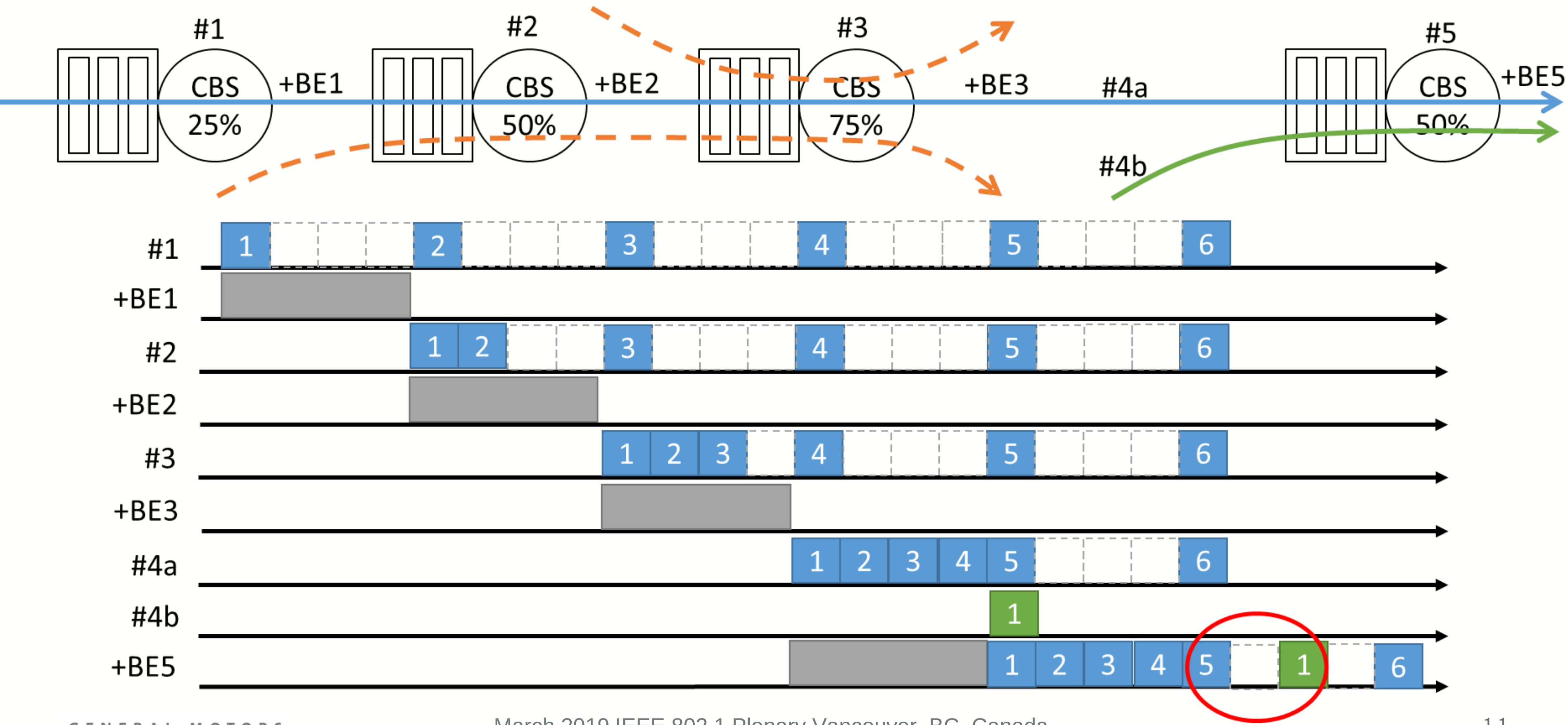
There also could be a BE frame at *out*, which would decrease the inter-packet gaps delay by positive credit

However

- With CBS, this burst size can grow per hop
- At a certain hop, the positive credit is consumed before the end of the burst is reached
- Burst delay increase this cycle repeats itself with even more delay – **SEE NEXT SLIDE**



ADDED BURSTS INCREASES DELAY



CONTRIBUTIONS TO SUPPORT DELAY EXAMPLE

http://www.ieee802.org/1/files/public/docs2013/new-tsn-specht-ubs-avb1case-1213-v01.pdf

Note: in the beginning ATS was called UBS

Summary

Sub Shapers – what has been shown

(see also http://www.ieee802.org/1/files/public/docs2013/new-tsn-specht-ubs-perfchar-1113-v1.pdf)

- Bursts can't accumulate/propagate
- Latency can be calculated for each Hop independently
- Even without sub priorities, the end-to-end latency is low:

5612.2 µs (1 CBSA Shaper) **vs.** **1432.32 µs** (UBS Sub Shapers)

Underlying assumptions on Streams

- **Max. Rate** & **max. Frame Length**
- no further assumptions, e.g.
  - Talker transmission behavior
  - prev. Hops/topology

Further Cases

- Readers are encouraged to analyze UBS independently and present:
  - Counterexamples, other cases
  - Analyze whether the shown math. is totally wrong – or totally right
  - etc.

Latency for 1 CBSA Shaper taken from http://www.ieee802.org/1/files/public/docs2010/ba-boiger-bridge-latency-calculations.pdf

12/2/2013 Johannes Specht - University of Duisburg-Essen 8

SUMMARY
ACCUMULATION CONGESTION POINTS – USE CASE

- Automotive constraints must be taken into consideration (e.g. safety, design and cost requirements)
- Standards based as the basis for additional development (e.g. interoperability support)
- Minimize system level complexity complexity to develop
- Allow for system level modeling and simulation process/tools
- E2E determinism has to be maintained at Accumulated Congestion points
- System configuration has to be seamless
- Maintainable (e.g. system configuration has to be flexible to support new modules, applications, traffic types and multiple builds)
- Bandwidth usage has to be optimized
- Support multiple traffic types and classifications (e.g. periodic, event, bursty, BE, multiple priority classes, @ accumulated congestion points)
- Maintain minimal impact to micro processor and application requirements (this may change in future)
- One, or even two, integrators don’t know the intent of entire system configuration
- Implementation/configuration requirements given to integrators **HAS** to be:
  - Documentable
  - Simple to implement w/o custom coding
  - “Compartmentalized”
  - Validatible

- Is it an IEEE 802.1 “one size fits all” solution or a profile choice?

ADDITIONAL CONTRIBUTIONS ARE WELCOMED
THANK YOU