MANAGING AUTOMOTIVE ACCUMULATED NETWORK TRAFFIC CONGESTION POINTS – USE CASE

IEEE Vancouver Plenary – March 2019

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AGENDA

SCOPE OF PRESENTATION

AUTOMOTIVE CONSIDERATIONS

AUTOMOTIVE USE CASE TOPOLOGY

DELAY EXAMPLE

EFFECT OF ADDING BURSTY TRAFFIC

SUMMARY

March 2019 IEEE 802.1 Plenary Vancouver, BC, Canada
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
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
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

Micro_2
SA: 0004
VID: 005, 1005
xMII/SGMII/RGMII
(100/1000Mbps)

Micro_1 (AUTOSAR)
SA: 0003
VID: 005, 1005
xMII
(100Mbps)

TSN/AVB Switch

SA: 0002
DA: 0003 / 0004
VID: 005
Periodic based Traffic @ 50ms
Event based Traffic (both Priority & BE)

TSN/AVB Bridge

ECU_4

TSN/AVB Bridge

Micro_2
SA: 0004
DA: 0003 / 0004
VID: 005
Periodic based Traffic @ 50ms
Event based Traffic (both Priority & BE)

TSN/AVB Switch

SA: 0001
DA: 0004
VID: 005
Periodic based Traffic (i.e. NMEA location info at 10ms)
Event based traffic (Big Data – usually BE)

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**Delay Example**

- **Micro_2**
  - SA: 0004
  - VID: 005, 1005
  - xMII/SGMII/RGMII (100/1000Mbps)

- **Micro_1 (AUTOSAR)**
  - SA: 0003
  - VID: 005, 1005
  - xMII (100Mbps)

- **TSN/AVB Switch**
  - 75/25

- **ECU_4**
  - 100BASE-T1

- **ECU_5**
  - 100BASE-T1

- **TSN/AVB Bridge**
  - xMII
  - SA: 1004
  - DA: 0003 / 0004
  - VID: 1005
  - Periodic based Traffic @ 50ms
  - Event based Traffic (both Priority & BE)

- **CAN Buses**

- **ECU #...**
  - Actuator

- **Accumulated Congestion Points**

- **GPS/GNSS (NMEA Sentence)**

- **TSN/AVB Bridge**
  - xMII (100Mbps)
  - SA: 0003
  - DA: 0003 / 0004
  - VID: 005
  - Periodic based Traffic @50ms
  - Event based Traffic (both Priority & BE)

- **TSN/AVB Bridge**
  - xMII
  - SA: 0004
  - DA: 0004
  - VID: 005
  - Periodic based Traffic (i.e. NMEA location info at 10ms)
  - Event based traffic (Big Data –usually BE)

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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

xMII/SOMII/SGMII (100/1000Mbps)

100BASE-T1

CAN Buses

Periodic Freq Intervals of 10+ms

Accumulated Congestion Points

ECU #... Actuator

ECU AVB Switch

TSN/AVB Bridge

Micro_1 (AUTOSAR)
SA: 0003
VID: 005, 1005

xMII (100Mbps)

100BASE-T1

ECU 1
SA: 0001
DA: 0004
VID: 005
Periodic based Traffic @50ms
Event based Traffic (both Priority & BE)

GPS/GNSS
(NMEA Sentence)

SA: 0001
DA: 0004
VID: 005
Periodic based Traffic (i.e. NMEA location info @10ms)
Event based traffic (Big Data – usually BE)

SA: 0002
DA: 0004
VID: 005

Periodic based Traffic @50ms
Event based Traffic (both Priority & BE)

SA: 0004
VID: 1005, 10005

Periodic based Traffic @50ms
Event based Traffic (both Priority & BE)

CBS
25% (75%)

CBS
50% (150%)

CBS
75% (225%)

SA: 0001
DA: 0003/0004
VID: 005
Periodic based Traffic @50ms
Event based Traffic (both Priority & BE)

Trademark: Micro 1 (AUTOSAR)

100BASE-T1

xMII

100/1000Mbps

Micro_2

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ECU AVB Switch

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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
Note: in the beginning ATS was called UBS

Summary

Sub Shapers – what has been shown

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

<table>
<thead>
<tr>
<th>Sub Shaper</th>
<th>Latency</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBSA</td>
<td>5612.2 µs</td>
</tr>
<tr>
<td>UBS Sub</td>
<td>1432.32 µs</td>
</tr>
</tbody>
</table>

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.
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 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”
  - Validatable

- Is it an IEEE 802.1 “one size fits all” solution or a profile choice?
ADDITIONAL CONTRIBUTIONS ARE WELCOMED
THANK YOU