Automotive Ethernet Network Requirements

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Automotive Ethernet Requirements for Converged backbone networks for critical control and multimedia

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Introduction

- There are multitude of in-vehicle bus systems to consider.
  - **LIN:** Multi-drop “UART-like” with synchronization, <=19.2Kbps
  - **CAN:** Widely available CSMA/CR bus system, <=1 Mbps
  - **FlexRay:** Time-triggered TDMA Bus and Star system, <=10 Mbps
  - **MOST:** Synchronous TDMA Ring, 25, 50, and 150 Mbps, Shared.
  - **Ethernet:** Switched Full-Duplex (modern) Star system, 100 Mbps +, switched.

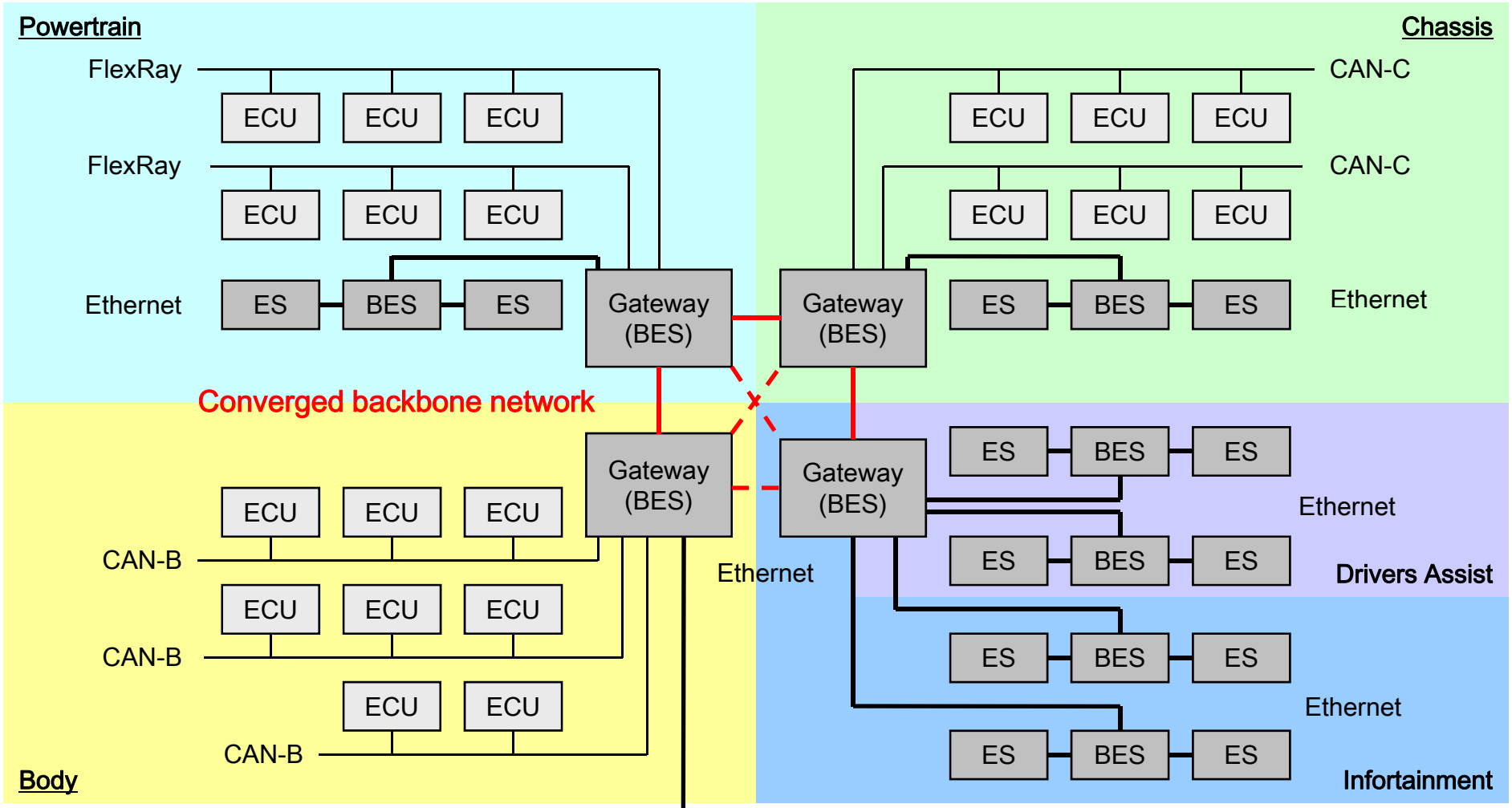
- Vehicle Communication Zones
  - Powertrain: Engine, transmission
  - Chassis: Steering, ABS, Tire pressure
  - Body: Doors, Lamps, Seats, A/C
  - Safety: Air-bags, Sensors, Actuators, Occupant Safety System
  - Infotainment & Driver Assist: Navigation, Telematics, TV/Radio/CD/DVD, RSE, Cameras

- Trends in in-vehicle communication needs
  - Infotainment and Driver Assist drives higher bandwidth (graphic panels, cameras, WLAN, BT)
  - Communication convergence: More buses are connected through use of gateways
  - Information sourced in one zone and used in many zones (e.g. camera, sensor data)
  - Vehicular Diagnostics interface is standardized to be over Ethernet and IP

There is a need for a converged in-vehicle backbone network

Converged backbone networks for critical control and multimedia

- An example converged backbone network for the domain architecture



Requirements for converged backbone networks

1. Reliability – Quick Recovery

- Fail-safe systems and quick recovery

  Maximum network recovery (Spanning Tree Reconfiguration) time is required to be less than 100ms for to support critical control applications. The recovery time is measured from the time that a failure happens to the time that the network is ready again to transmit data from applications . In order to achieve this quick network recovery, the below three functionalities are required.

  - RSTP with quick recovery => it might need RSTP “quick “version (e.g. better timers).
  - 802.1AS with quick [re-]synchronization
  - 802.1Qat with quick stream [re-]reservation

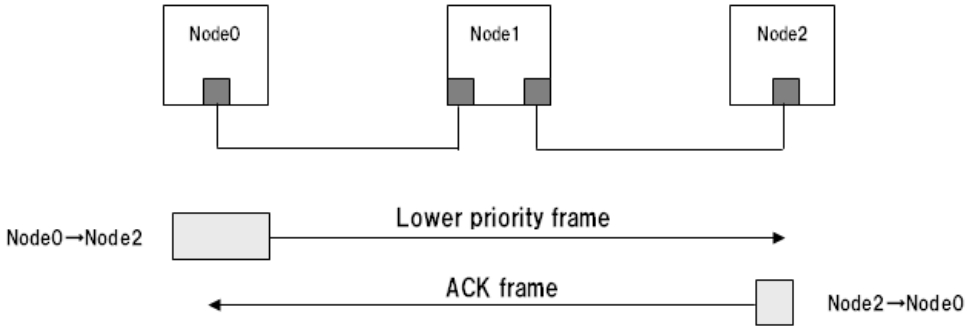
Requirements for converged backbone networks

1. Reliability – Acknowledge and Retry

- TCP/IP is a good solution, but too resource intensive for some application.
- Need Acknowledge and retry for non-AVB, lower-class data

  In order to avoid data loss of lower classes, usage of a simple confirmation procedure should be considered (as illustrated).
- **Applicable to protocols whose messages that fit into a single frame.**

  No Frame re-ordering, nor datagram re-assemby context to be handled.



The target node returns acknowledge frame to the sender node. If there is no acknowledge returned, or bridging node returns an acknowledge frame with Fail information, the sender retries the previous frame.

Requirements for converged backbone networks

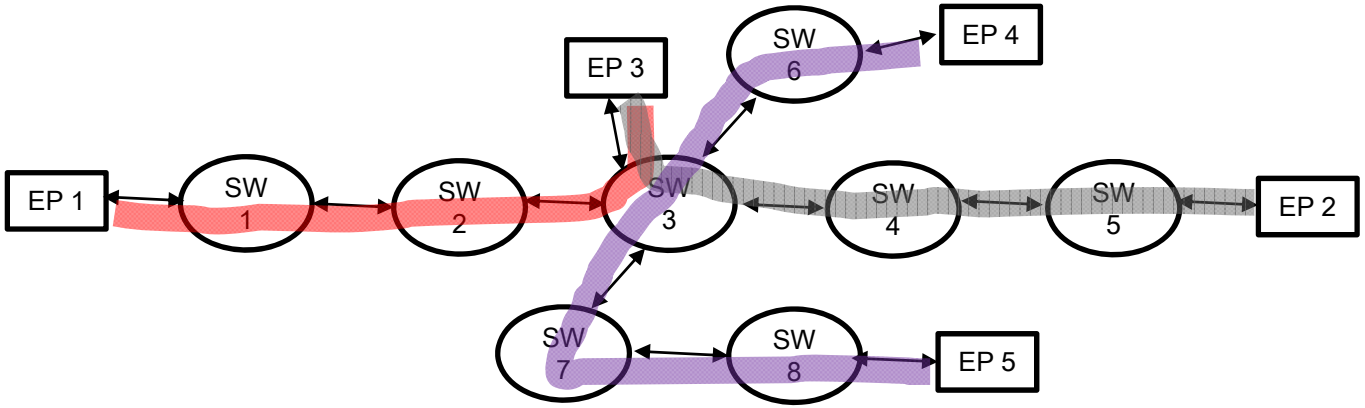
2. QoS - Latency

- Ultra-low latency for critical control frames
  - The AVB deterministic latency from the Class A will be sufficient for most of the current automotive applications such as multimedia and camera networks.
  - Some critical control applications such as driving (powertrain, chassis) control-loops require much smaller latency as follows.
    - Maximum latency: 100us over 3 bridge hops @ 100Mbps or 1Gbps
  - This Ultra-low latency class requires resource reservation as in 802.1Qat, but may not require shapers that may introduce additional latency.
  - In order to achieve generalized ultra-low latency requirement, a new method would needs to be developed.
    - An interim solution exist today by limiting maximum link MTU and trading off useable bandwidth for lower latency (next slide).

Requirements for converged backbone networks

2. QoS – Latency – Interim Requirements

- Use of Smaller MTU (frame size).
  - Reduce the frame size such that the latency caused by the maximum interfering frame is reduced to be acceptable time.
- Benefits
  - No changes to 802.1 AVB or 802.1Q Bridges.
- Issues
  - The useable link bandwidth is significantly reduced.



Switched paths 1 through 5 support shorter MTU.
Switched paths 6-3-7-8 support normal MTU.
Path between Endpoints EP1 to EP3 (red), and EP3 and EP2 (grey), support ultra low-latency requirements.
Path between Endpoint EP4 to EP5 does not, but shared SW3.

Summary: Requirements for converged automotive backbone networks

- Reliability
  - Rapid Spanning Tree Protocol (RSTP) is a good basis to achieve <= 100 mS network reconfiguration recovery time.
  - Simple Layer 2 Acknowledge and Retry protocol required for simpler control units that support protocol MTU that fits into a single packet.
- QoS
  - Ultra-low latency switching method is needed and required for control-loop applications with an objective to meet 100 uS over 3 switch hops.
  - An interim requirement to use smaller MTU that trades-off useable bandwidth and latency.