IEEE 802.1 & 802.3 Packet Transmission Pre-emption Reasons for its needs

Previous 802.1 presentations

Edited by Yong Kim @ Broadcom

Pre-emption Need

- Control Loop use cases in Automotive and Industrial, converged onto rest of Ethernet network infrastructure.

- Automotive -- 100 uS over three bridge hops @ 100 Mb/s and above –
  (from March 2011, 802.1:
  in public area: http://www.ieee802.org/1/files/public/docs2011)
  - new-avb-KimNakamura-automotive-network-requirements-0311.pdf
  - new-avb-nakamura-automotive-backbone-requirements-0907-v02.pdf (revised)
- Industrial -- <5 uS per hop, ~32 bridge hops @ 1000 Mb/s and above –
  (from January 2011, 802.1). 125 uS over 32 hops desired.
  - new-goetz-avb-ext-industrcom-0113-v01.pdf
  - ba-goetz-industrial-profile-0509.pdf ← /docs2009
  - Refined objectives from system vendors expected.

- Problem Statement:
  (Ignoring the bridge and other delay for the moment)
  - Max Length Ethernet Frame @ 100 Mb/s =~120 uS – greater than automotive requirements.
  - Max Length Ethernet Frame @ 1000 Mb/s =~12 uS – greater than industrial requirements.
  - "Head of Line" blocked behind Max Length Frame exceeds the requirements above.

Automotive Use Case 1 - Trends

- 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.

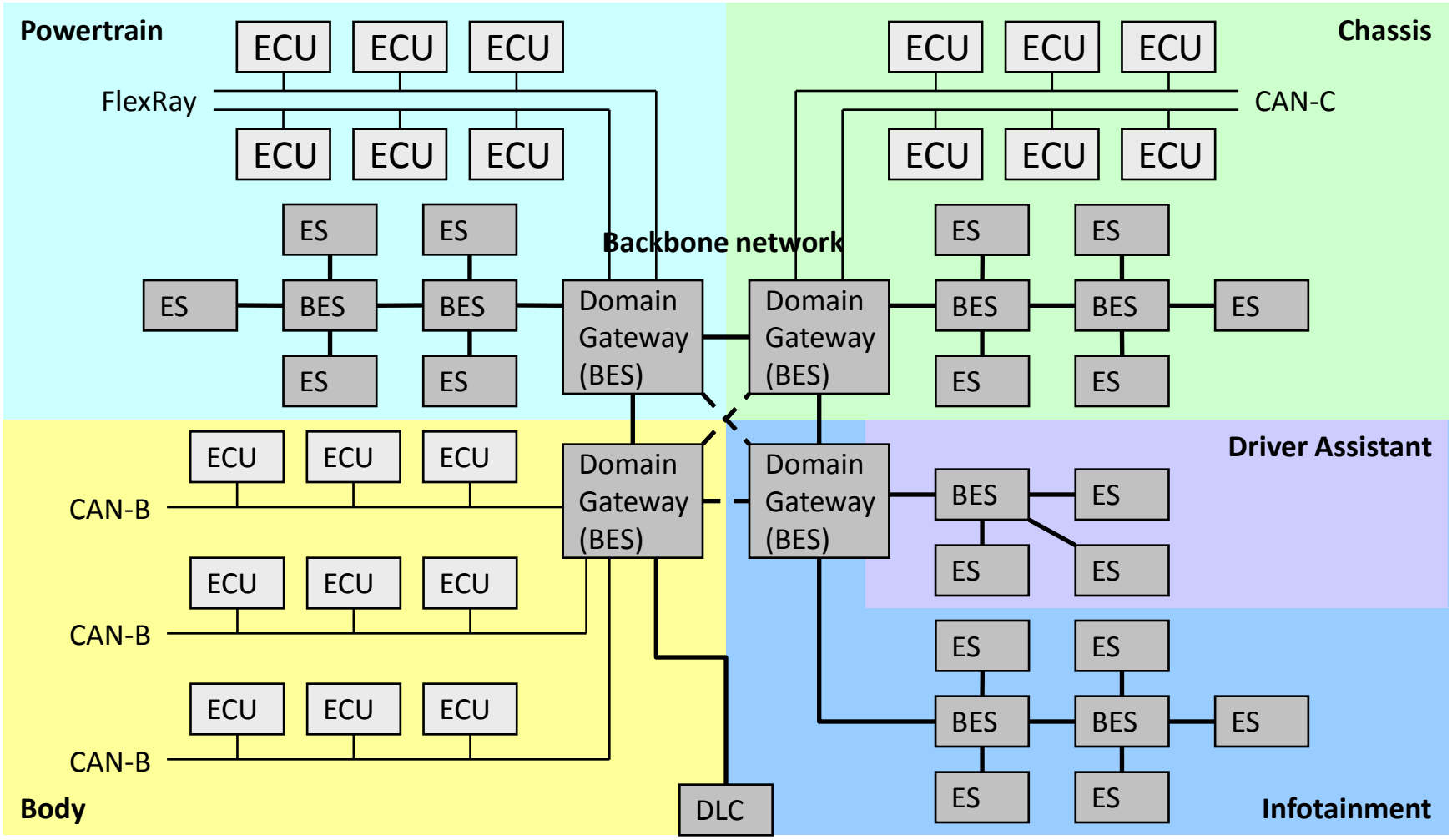
- Vehicle Communication Zones
  - Powertrain: Engine, transmission
  - Chassis: Steering, ABS, Tire pressure
  - Body: Doors, Lamps, Seats, A/C
  - Safety: Air-bags, Sensors, Actuators, Occupant Safety System
  - Infotainment & Driver Assist: Navigation, Telematics, TV/Radio/CD/DVD, RSE, Cameras

- 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

    – <u>There is a need for a converged in-vehicle backbone network</u>

Example next-generation automotive network architecture

Ethernet AVB applied to automotive control data transmission between domain gateways and in powertrain/chassis domains



: Possible AVB network (bold line)

ECU: Electronic control unit, DLC: Diagnostic link connector
BES: Bridged end station (ECU), ES: End station (ECU)

Automotive Use Case 3

QoS requirements for automotive control data class

Performance requirements for automotive control data class

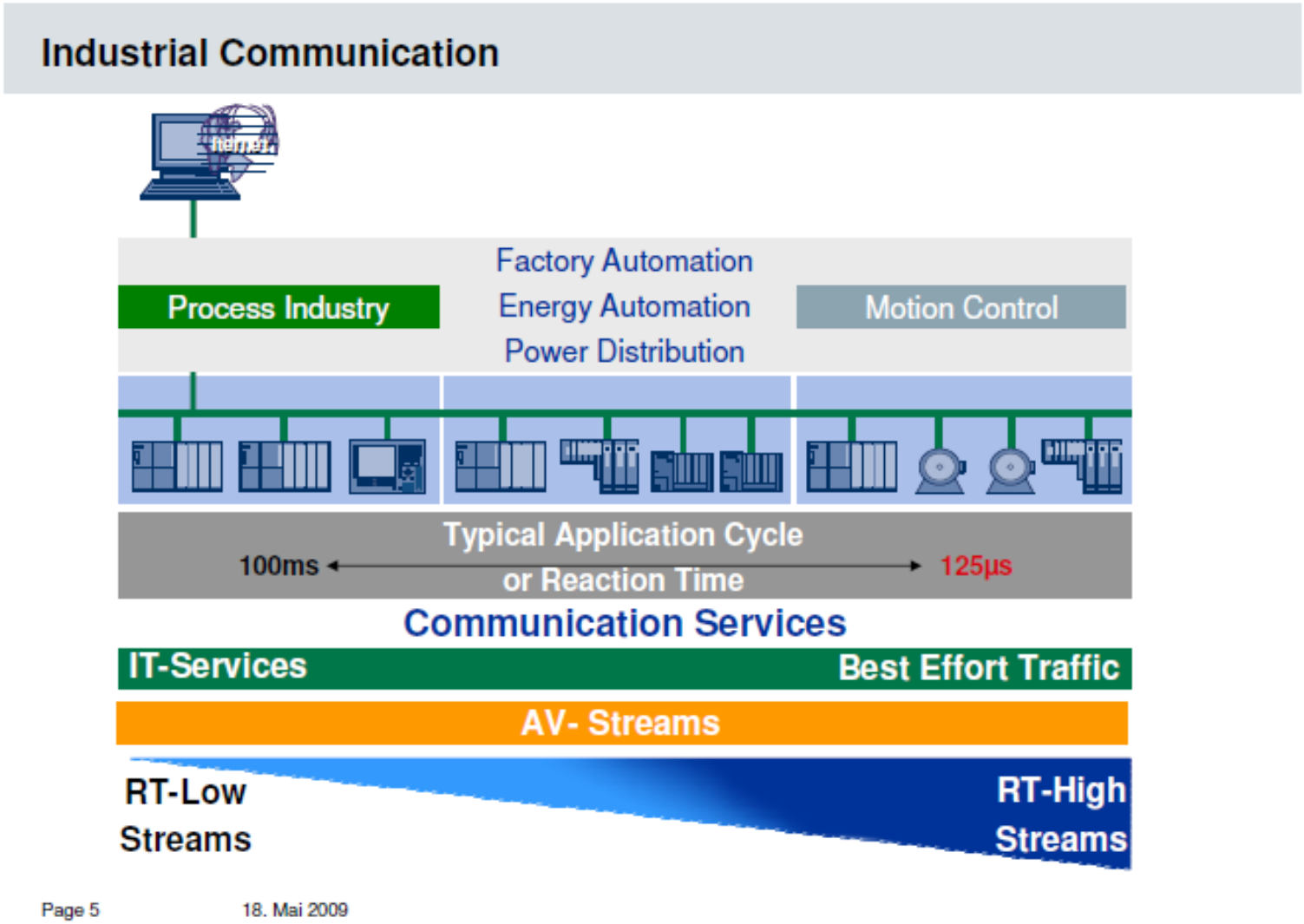
- Maximum latency: 100 us / 5 AVB hops
  - Guaranteed latency
  - Topology independent
  - Automotive control data class to have higher priority than SR classes
    - Maximum 2 priority classes (e.g. Control data class and SR class A)

Preconditions for performance requirements

- Network type: Dedicated network in a vehicle
- Network attributes
  - Maximum AVB hop count: 7
  - Maximum number of nodes (bridged end station & end stations): 32
  - Maximum cable length: 24 m
  - Maximum end-to-end cable length: 30 m
- Automotive control data class attributes
  - Maximum data size (payload size): 128 bytes @FE ~ 256 bytes @GE
  - Maximum number of simultaneous transmission: 8 @FE ~ 32 @GE
  - Transmission period: 500 us
- Payload size for other/lower traffic classes: 256 bytes @FE ~ 1500 bytes @GE

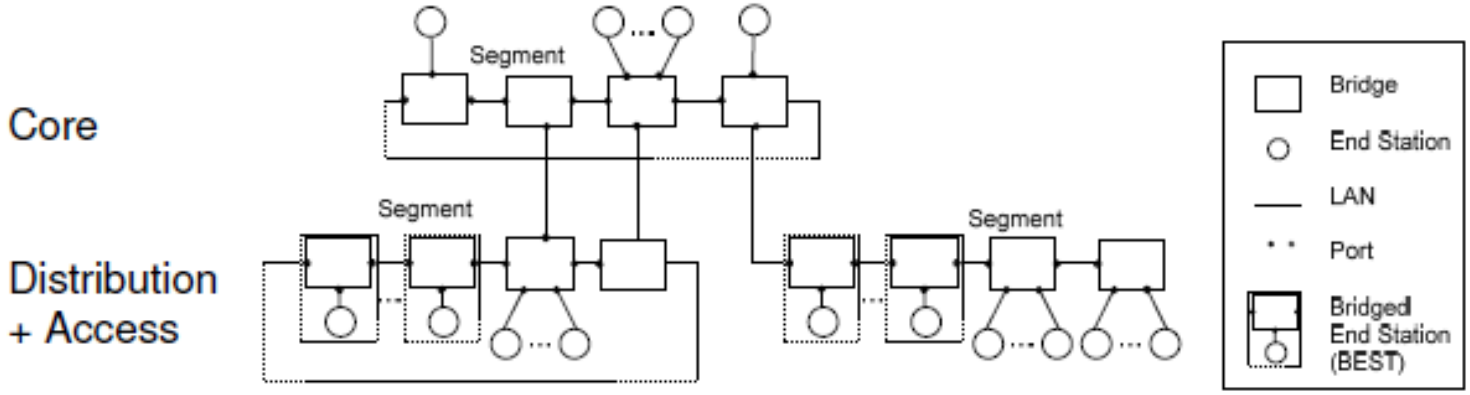
These are our best estimates derived from multiple assumptions of the current and future automotive applications.

Industrial Use Case 1 - Applications



Industrial Use Case 2 - Topology

Typical Topology for Bridged LANs in Industry



Linear Topology (Line, Ring)

- Applications mostly feature distributed linear dimension, i.e. production lines
- The network is tailored to the application, i.e. line topologies
- To reduce total cost, 2-port-bridges are integrated into the end stations
- For enhanced availability, lines are closed to rings
- Homogeneous segments (100MBit or GBit)

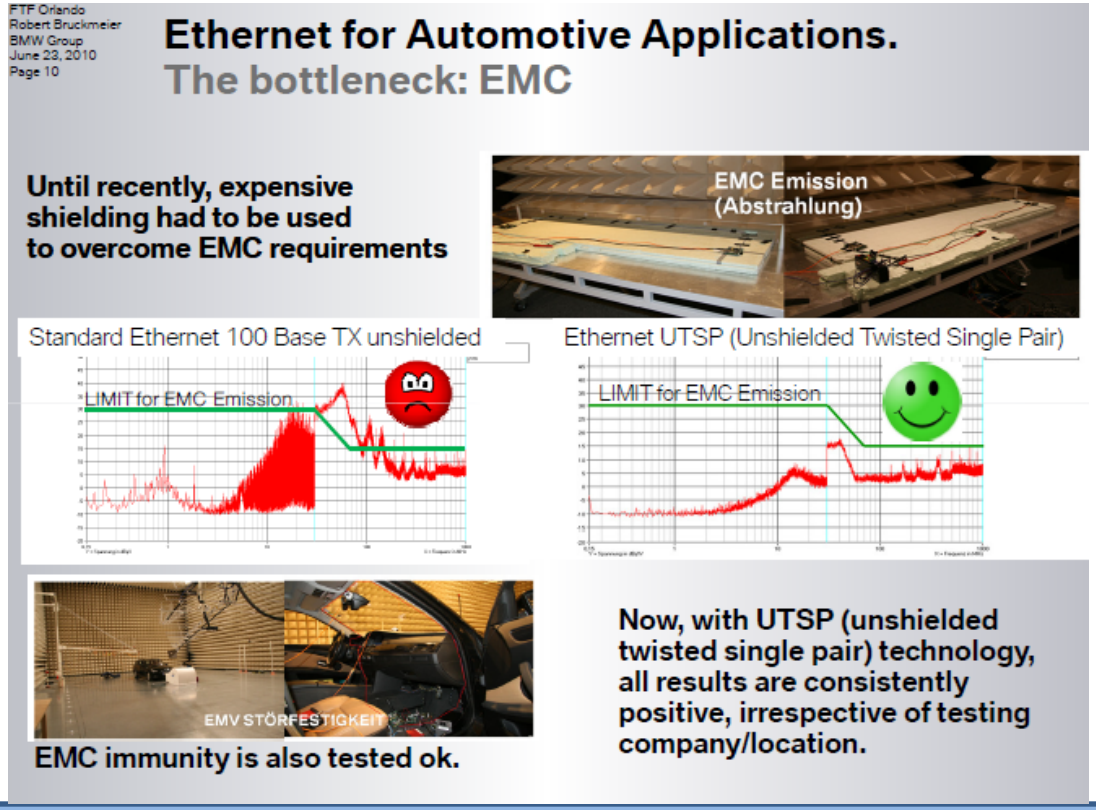
Industrial Use Case 3 - Requirements

Requirements for MSRP to support low latency SRclass

- **Low Latency SRclass with Burst**
  - Low Latency < 125µs over ~32 hops, data < 300 Bytes
    (-> avoid interference Best Effort Traffic with Low Latency Traffic)
- **Stream Preemption**
  - Defined Ranking for SR
  - Higher ranking SR must be able to preempt lower ranking SR
- **Multiple Talker with TDMA**
  - Mechanism to allocate fixed slot numbers to talkers

Common Feedback 1a

- Why don't Automotive just use higher speed?
- Answer: EMC is the bottleneck (from Pg 10, BMW presentation @)
  - http://www.freescale.com/files/ftf_2010/Americas/WBNR_FTF10_AUT_F0558.pdf



Common Feedback 1b

- Why don't Industrial just use higher speed?
- Answer: It does (adopts Gigabit Speeds), and the dominating latency comes from the electronics (bridges, PHYs) when cascading. There is limit on how much latency you could improve.

Common Feedback 2

Why can't you just use shorter max size frames?

- Answer: It could and it is an interim solution.

Why Interim solution?

- Answer: Limits converged infrastructure of data, streaming, control unless every device in the network needs changes to adopt new max size
- Answer: Payload efficiency goes down significantly.
  100 Mbps link with 128 byte max frame versus 1500 byte would be 41% versus 95% of link SW.
  Any additional header overhead make this efficiency worse.

Packet Length	64	128	256	1536
IPG	12	12	12	12
Preample	8	8	8	8
MAC Header	16	16	16	16
L2 Payload	28	92	220	1500
L2 Payload/Pkt Size	**44%**	**72%**	**86%**	**98%**
IPv4 HDR	20	20	20	20
L3 Payload	8	72	200	1480
L3 Payload/Pkt Size	**13%**	**56%**	**78%**	**96%**
TCP HDR	20	20	20	20
L4 Payload	-12	52	180	1460
L4 Payload/Pkt Size	**NM**	**41%**	**70%**	**95%**

Common Feedback 3

Why can't you just use star-wired network?

- Answer: Industrial – it does when it could. Legacy cabling is combination of star, ring, overlapping rings, and daisy-chains. One of the attractiveness of Ethernet is that it could supports existing wiring. Rings offer attractive low-cost and complexity redundant paths.
- Answer: Automotive – One of the attractiveness of Ethernet is reduction of wiring (400~600 lb of cabling in a car). Combination of star and daisy chain topology allow for ease of wire routing and managing optional package connections.

Thank you!

Relevant 802.1 documents.

Relevant 802.1 documents

All located in: http://www.ieee802.org/1/files/public/docs2011, except noted.

- Automotive
  - new-avb-KimNakamura-automotive-network-requirements-0311.pdf
  - new-avb-nakamura-automotive-backbone-requirements-0907-v02.pdf
- Industrial
  - ba-goetz-industrial-profile-0509.pdf ← /docs2009
  - new-goetz-avb-ext-industrcom-0113-v01.pdf
  - at-klein-kleineberg-avb-redundancy-continuation-0711.pdf
- Preemption Related
  - new-avb-kim-8021-8023-Preemption-Problem-Statements-0911-v04.pdf
  - new-avb-kim-8021-Preemption-DRAFT-PAR-5C-0911-v05.pdf
  - new-imtiaz-goetz-fragmentation-0511.pdf
  - new-kim+goetz-Ultra-Low-Latency-Switching-v5.pdf
  - avb2-cgunther-sr-class-preemption-0711-v05.pdf
  - new-avb-boiger-ultra-low-latency-shaper-0711.pdf