Urgency Based Scheduler

- Automotive Use -

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Contents

Brief Recap (May 2014)

- Discussion on further proceeding with the UBS proposal
- Technical Updates:
  - Proposed token-bucket algorithm in sub-shapers instead of leaky-bucket to increase aggregation capabilities
  - Limited number of sub priorities/removal of priority queue

Received Feedback

- TSN Members need more information on the purpose of UBS

This Slide Set

- UBS in Automotive Networks

AUTOMOTIVE NETWORKS

Topologies

Now/Near Future

Backbone + Domains by purpose

- Active Safety, Infotainment, Chassis,…

Wiring

- Bus-like chainsEasy physical placement in cable channels
- Short overall wire length
- Single Twisted Pair @ 100 Mbit/s
- Fault tolerance requirements

Gateways to other technologies

- CAN, CAN-FD, FlexRay, LIN, …

May Include Small Subnets

- Single- / multi-ECU Tier-1 building blocks

Future (as far as we can imagine …)

Optimized Topologies …

- Defined by physics/car structure
- Fading domain boundaries (domains and local gateways migrate from CAN/FlexRay to switched Ethernet)
- Rings/Redundancy

Economic Impact

- Even shorter overall wire length
- Single Twisted Pair @ 1 Gbit/s

Other technologies

- Less Gateways – use Ethernet in more Areas

Streams & Applications

Now/Near Future

Traffic Types in automotive networks

- Sensor Values (radar, lidar, ultrasonic, video camera/or smart camera sending object data)
- Control Loops
- Diagnosis
- Notifications
- Infotainment
- …

Routes

- Within domains by purpose
  - A/V Streams in Infotainment
  - Engine Control Loops
- Inter-domain
  - Sensor values from “everywhere” for Active Safety

Future (as far as we can imagine …)

More Safety Critical Traffic

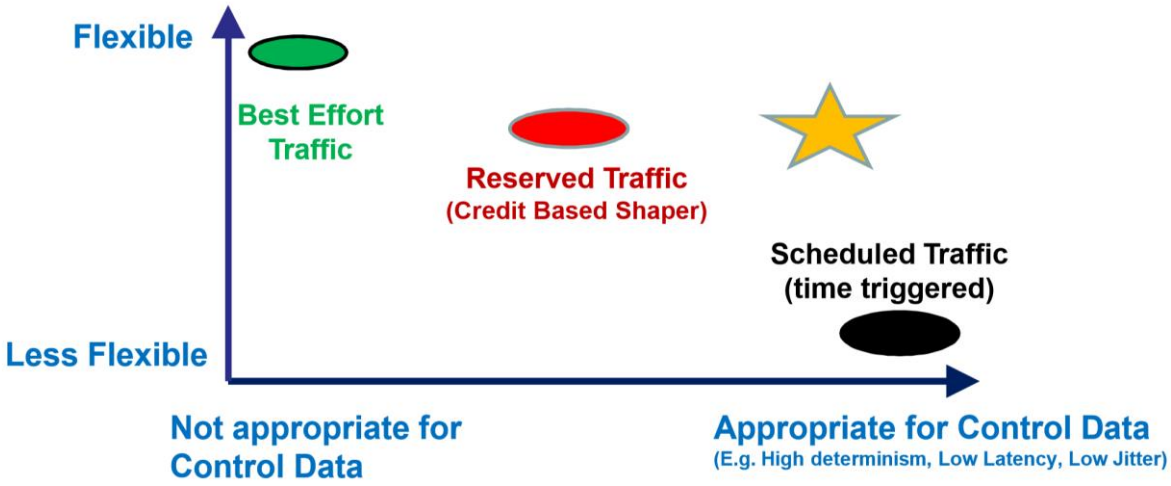
- Higher ASIL (ISO 26262), fail operational
- Sensor-Fusion, Autonomous Driving, by-wire systems, Replacement of mechanical Systems, …
- Mode Changes/Partial Network Reconfiguration, …
- Actuation over Ethernet

Routes

- Arbitrary, i.e. in line with the topology which is itself defined by car structure/physics (cmp. prev. slide)

URGENCY BASED SCHEDULER

What is it good for?



Flexible Traffic Class for Automotive Control Traffic

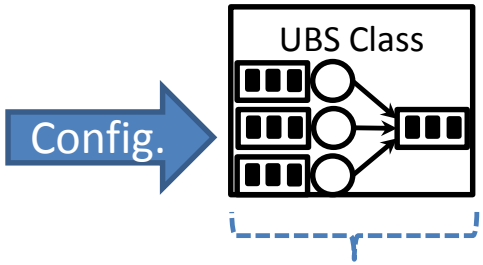
- UBS attempts to fulfill the needs of a flexible traffic class for automotive control streams:
  - Fast enough to fulfill the E2E latency requirements most automotive control applications
  - Not as strict as time triggered traffic
- Co-existent to time-triggered scheduled traffic, i.e. TAS:
  - TAS needed for applications which require “close to zero” E2E latency

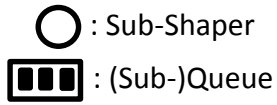
Cmp. http://www.ieee802.org/1/files/public/docs2013/new-tsn-jochim-aaa2c-requirements-for-control-traffic-0713-v01.pdf, later referred to as [FCTC]

UBS – Quick overview

Max. frame length	Datarate
672 bit	672 bit/sec
1024 bit	204.8 kbit/sec
2048 bit	5 Mbit/sec

Sub-shaper parameters





UBS operation is based asynchronous Shapers (similar to CBSA*)

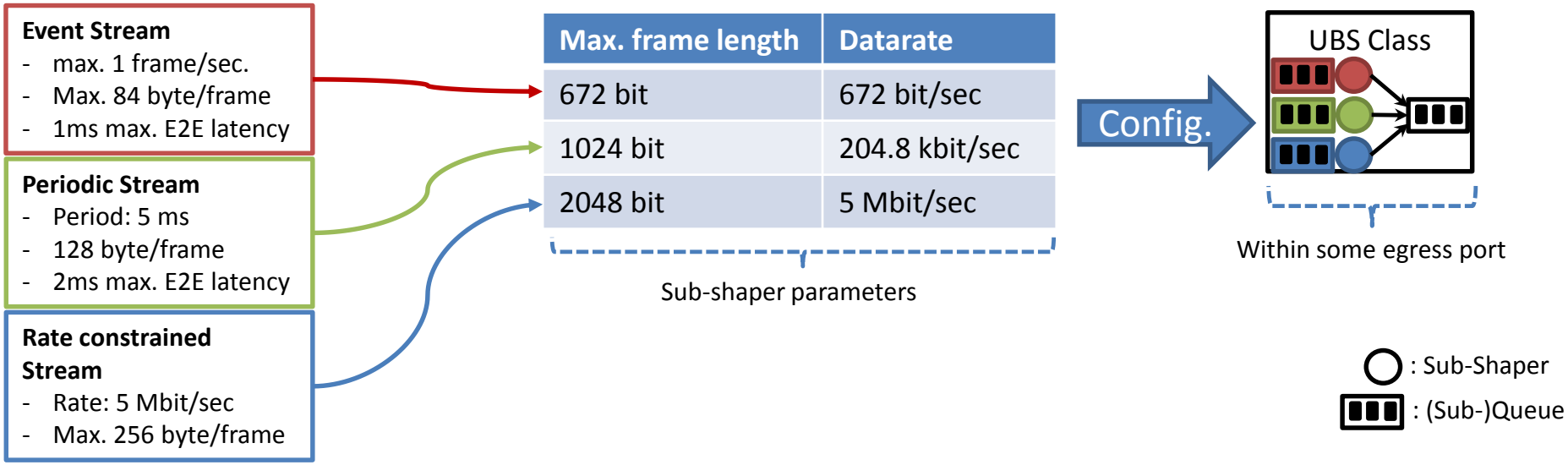
- Streams are mapped to **sub-shaper** parameters of the UBS class egress ports along the paths:

  datarate and ***max. frame length***
- Sub-shapers regulate the traffic at every hop per stream/stream-aggregate allowing moderate low latency and **independent per hop latency guarantees** (cmp. [UPC]).
- Sub-shapers in egress ports can be assigned to different **sub-priorities** to map latency requirements of each stream.

So why is this good for automotive networks?

*CBSA is a special case of leaky-bucket shaper, leaky-bucket shaper is a special case of token bucket shaper

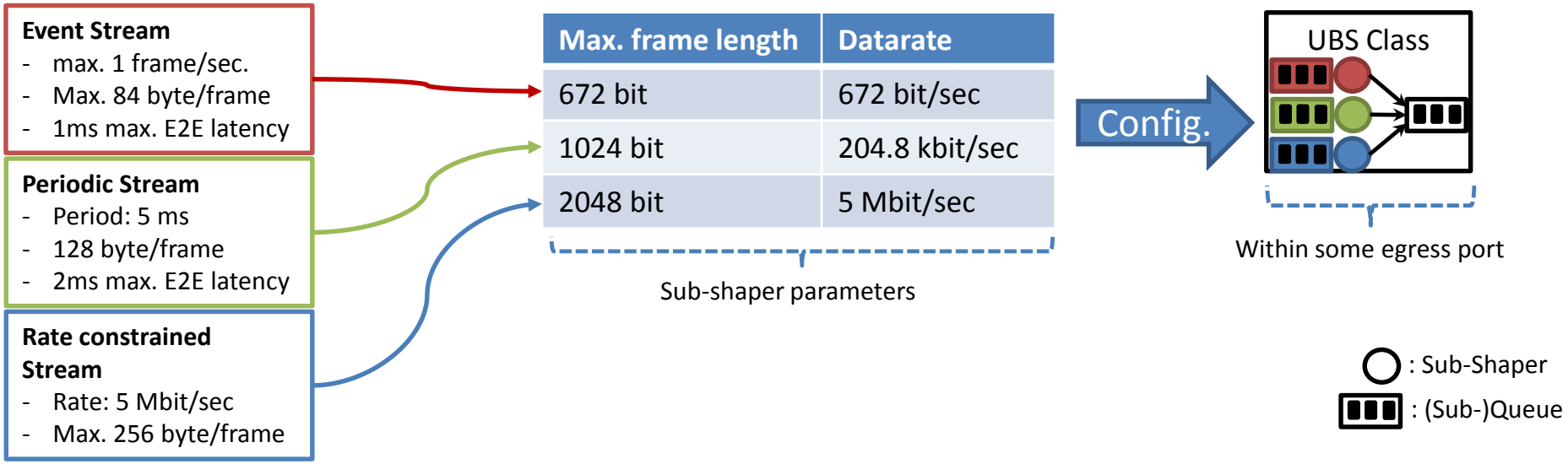
Automotive Control Streams



Automotive Control Streams in UBS

- Automotive networks need to transport control stream (cmp. [FCTC]):
  - Periodic Control Streams
  - Event-based Control Streams
- **Both are supported** by UBS and **treated as rate constrained streams**, i.e. there is no differentiation between stream types.
- Streams transferred via UBS get **automotive grade E2E latency guarantees** (cmp [FCTC]) - even without latency-requirement-to-priority mapping (i.e. use UBS *unscheduled*) and at 100MBit/s link speed (cmp. [UWC])

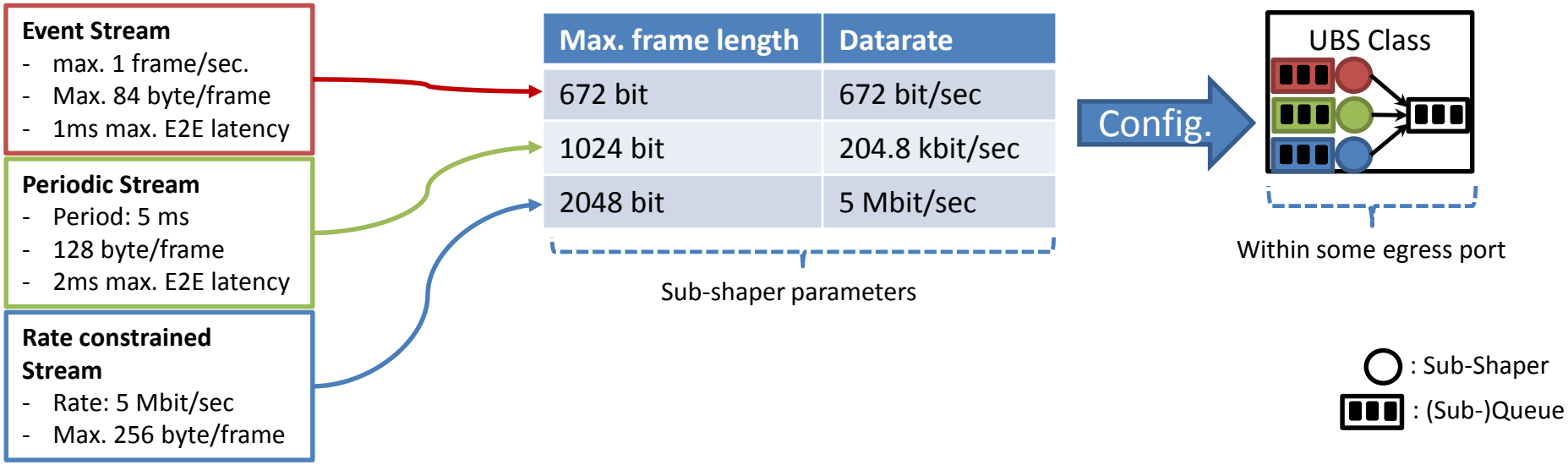
Maximum Link Utilization



Using Asynchronous Shapers

- Automotive: high link utilization allows to put more data on the (slow) wires – topologies not built for highest E2E throughput in first place.
- Sub-shapers operate asynchronous: Talkers decide when to send – as long as talkers don't exceed their rate limit, there is no penalty in latency.
- There is no need for any kind of oversampling to achieve E2E latencies for
  - Event-based control streams
  - Periodic control streams with asynchronous talkers

Periodic Control Streams

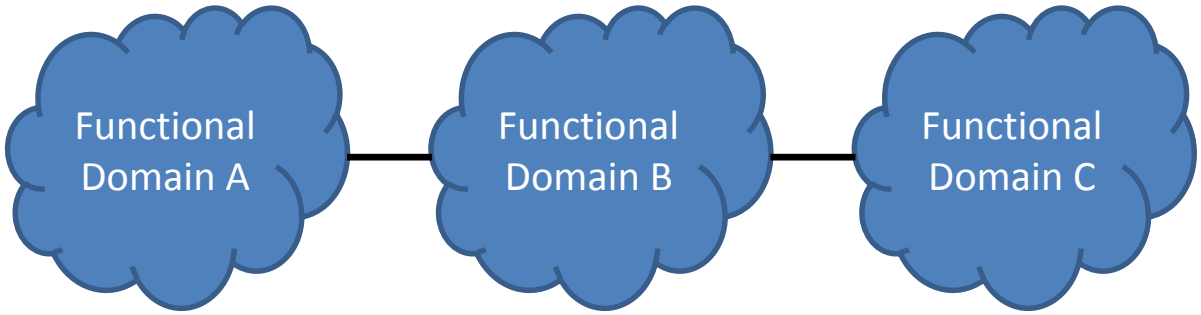


Arbitrary periods for Periodic Control Streams

- By mapping all stream types to rate constrained streams, the period of periodic control streams get‘s lost …
  … and that‘s ok and desired(!):
  - It does not matter whether multiple streams at one path shall be transmitted at 1ms, 1.93ms, 2.03ms, 13.23ms
  - The rate-based operation allows every periodic control stream in the network to transmit at any period desired by the applications (cmp. [FCTC]).

A BIGGER PICTURE

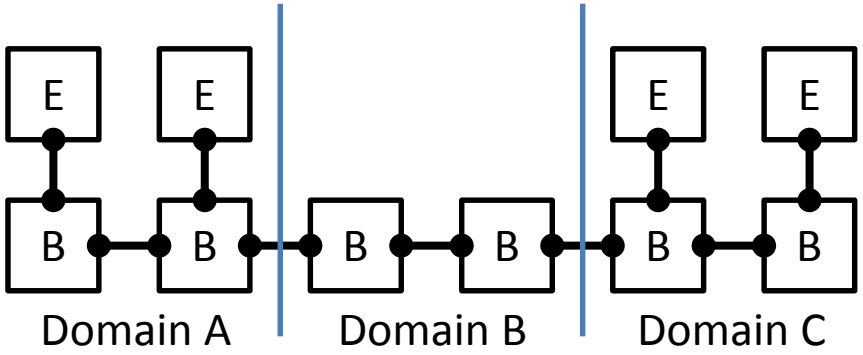
A small Automotive Network



Automotive networks can be considered entirely scheduled … BUT:

- Multiple parties build domains in automotive networks:
  - OEM divisions (backbone, active safety, infotainment,…)
  - Tier1 suppliers (steering system, engine control, …)
  - …
- These parties doesn‘t have/want to care about intra-domain details of their neighbors.

Why should they use Ethernet?



Providing an Ethernet-based QoS solution with …

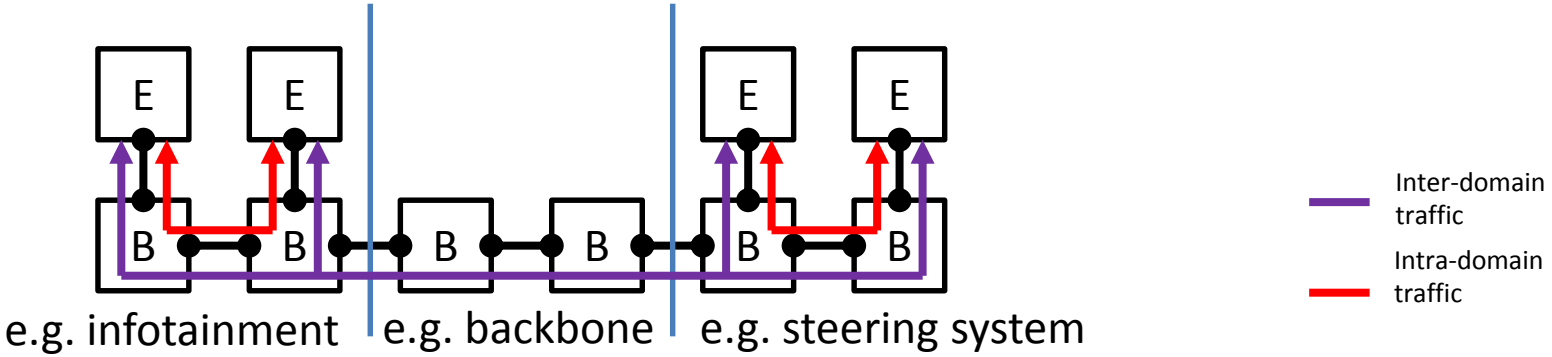
- little inter-domain dependencies
- good performance
- low configuration complexity/easy to use

That's the goal of UBS!

makes direct use of Ethernet more attractive for domain designers, instead of …

- using their "favorite" technology (e.g. CAN-FD),
- doing their own thing and
- connecting it to the neighbors via Gateways

Inter-domain Interfaces



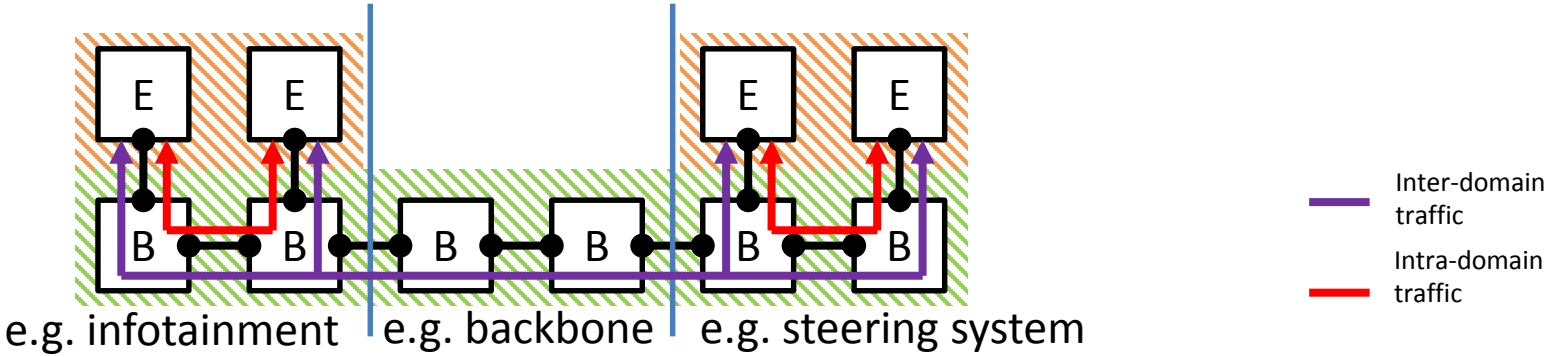
Inter-domain Interfaces

- Streams are classified just by datarate and max. frame length (both should to be known by communication peers across domain boundaries).
- E2E Latency can be split at domain boundaries, e.g. *"Stream x requires n µs to the domain boundary"*

No inter-domain interfaces

- Other bridges and end-stations along the path and in other domains are not forced to e.g. aligning and harmonizing cycle lengths or cycle offsets of their streams on each others streams…
- … It would even not be neccessary to care about a common clock sync.

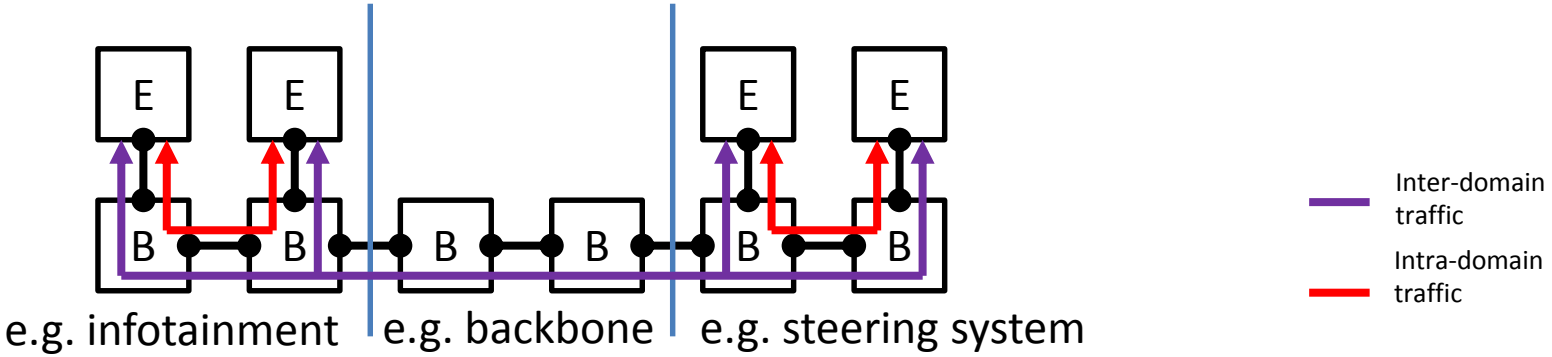
Late changes in the network



End Station Software and Configuration

- If changes (periods, etc.) of the End-Station Software of one Application can‘t be avoided, consequently changes of other end-station Software may be problematic:
  - Software is already certified
  - There is not enough processing power to just change the task schedules
- It may be possible to change bridge configuration (unsure)

Low configuration complexity



Mandatory

- Domain designers need to map their individual streams to the parameters datarate and max. frame length.

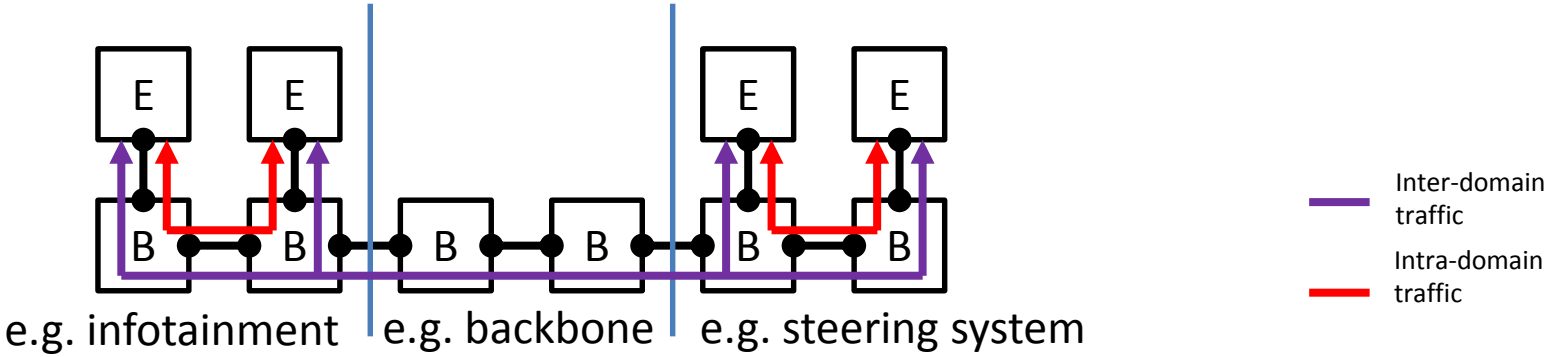
Optional

- If (and only if) streams would violate their E2E latency requirements, domain designers may start priorizing streams. But they are not forced to do so if streams are fast enough!

Latency Math

- Calculating whether a priority setup fulfills the E2E Latency is done by a independent per hop calculations (cmp. [UPC],[UWC]) and the sum of it along the paths.

Performance of End-Stations



End Station Software

- Asynchronous transfer UBS does not enforce that OS-tasks are aligned to network time or the tasks of non-communication peers.
- Full time alignment may not be possible easily:
  - End Stations are tiny, i.e. embedded systems – there‘s no processing power left for waiting
  - The End Station Software doesn‘t like it (this experience was made with FlexRay)

Thank you for your Attention!

Questions, Opinions, Ideas?

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