Automotive Networks – are new busses and gateways the answer or just another challenge?
Why new Busses and Architectures?

Wishful Thinking
- FlexRay → Higher Performance, Determinism
- AUTOSAR → Better Re-Use and Flexibility

Reality: Higher Integration Complexity and Cost
- FlexRay →
  - Optimization difficult → loss of bandwidth and flexibility
  - Determinism in evolving mixed async./sync. systems?
- AUTOSAR →
  - No good process for function to ECU mapping
  - No good process software-component integration
OSEK (preemptive OS) synchronized with FlexRay

- **Ideal situation:** all OK
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- **Typical situation:** some ok, some double, some lost
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- **No loss but all delayed by one full FlexRay cycle**
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„ok window“, given by FlexRay schedule
OSEK ECU Asynchronous to FlexRay

- bad synchronization $\rightarrow$ bad responsiveness

  [Diagram showing two FlexRay cycles with arrows indicating signal transmission and reception]

  2 FlexRay cycles (more when using mux)

- clock skew effects $\rightarrow$ large send & receive signal jitters

  [Diagram showing full FlexRay cycle with arrows indicating signal transmission and reception]

  full FlexRay cycle (more when using mux)

„ok window“, given by FlexRay schedule

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AUTOSAR System Timing Aspects

Signal Path / Data Flow

end-to-end timing chain

timing chain segments

INTER-ECU communication

INTRA-ECU communication

Actuator SWC

Sensor SWC

Actuator

Sensor
AUTOSAR SW-C vs. "Runnables" and Tasks

- SW architecture:
  2 SW components, 6 runnables

- Implementation: 3 Tasks

- Schedule and timing dependencies
End-to-End Analysis

from sensor
to actuator

inter-task communication with over- and under-sampling

buses with synchronous and asynchronous communication

gateways with additional delay and buffering
Oversampling in Detail

"first through" candidate

"max age" candidate
only if output is read
Synchronization in Detail

- CAN
- FlexRay
- Gateway

**asynchronous** COM and OS schedules

COM and OS schedule **synchronized**
Impact of new busses and architectures

- Integration challenges have little to do with specific architectures or protocols. They will not go away!

- A paradigm-shift is required: Performance and timing design must be treated as equal citizen to function design

- TODOs
  - Standardized timing semantics and requirements
  - Novel processes between application designer and network designer, also across OEM – supplier boundary

- Scheduling analysis is the missing link between architecture exploration and Network / ECU configuration