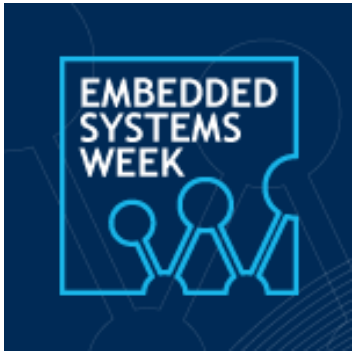
Automotive Networks
– Are New Busses and Gateways the Answer or Just Another Challenge?



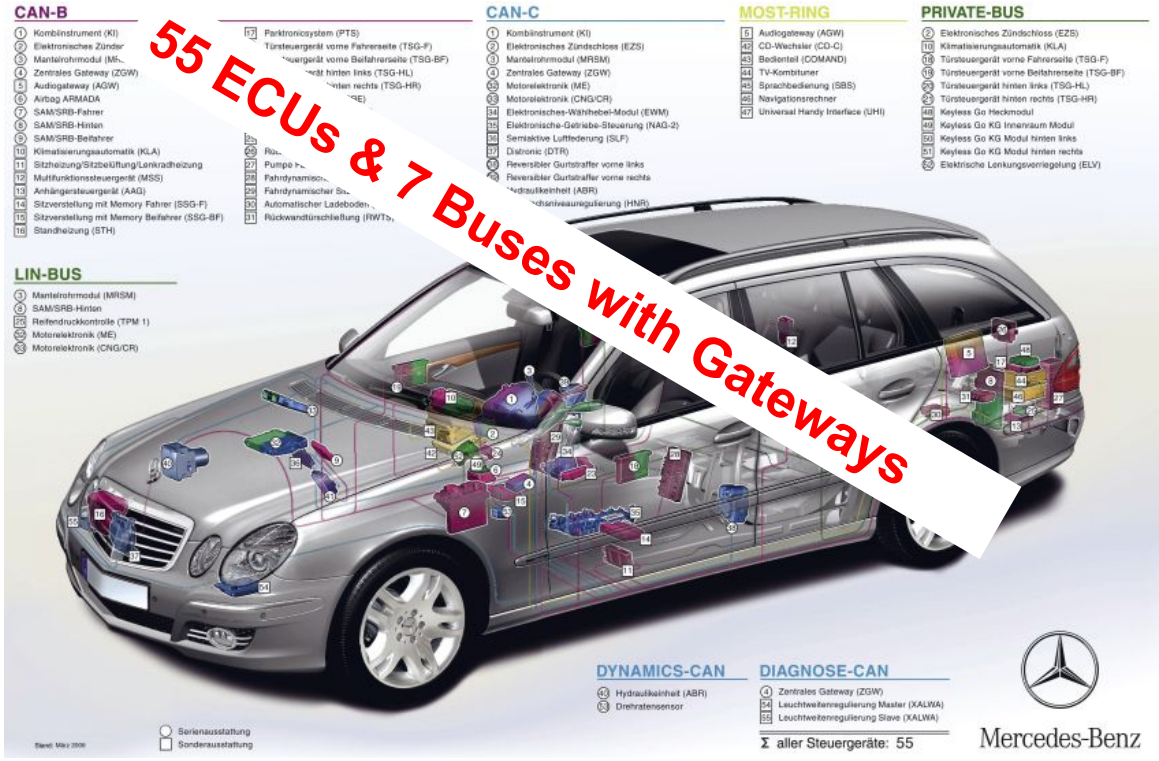
ESWEEK Panel

Oct. 3, 2007

Automotive Networks

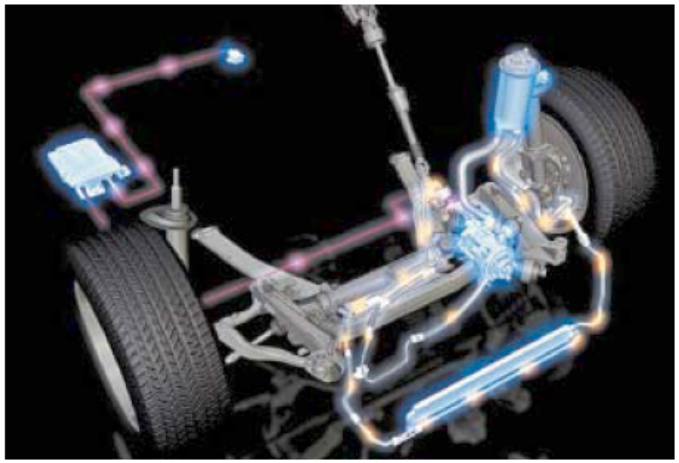
- **complex networks**
  - **hundreds of functions**
  - **50+ ECUs (Electronic Control Unit)**
  - **networked functions**
  - **many suppliers**
  - **heterogeneous**
- ***why is this so complicated?***

source DaimlerChrysler



Network is subject to diverging requirements

- communication
  - periodic communication (control engineering)
  - event triggered communication
  - data rates from few kbit/s to > 10Mbit/s (entertainment)
- real-time
  - guaranteed throughput
  - max. end-to-end latencies
- safety
  - different safety levels
    - entertainment → comfort function → active front steering → x-by-wire
  - defined by SIL levels - IEC 61508 (automotive ISO26262)



source BMW

Network is subject to different cost targets

- cost
  - different volumes – few thousand to several million cars
  - cost of model updates and special model editions
  - different cost budgets
    - feature dependent - engine controller ↔ interior light
    - safety level dependent
    - different price/performance
      - high end feature (luxury) ↔ commodity feature (low end)

Wide scope of technical solutions in one network

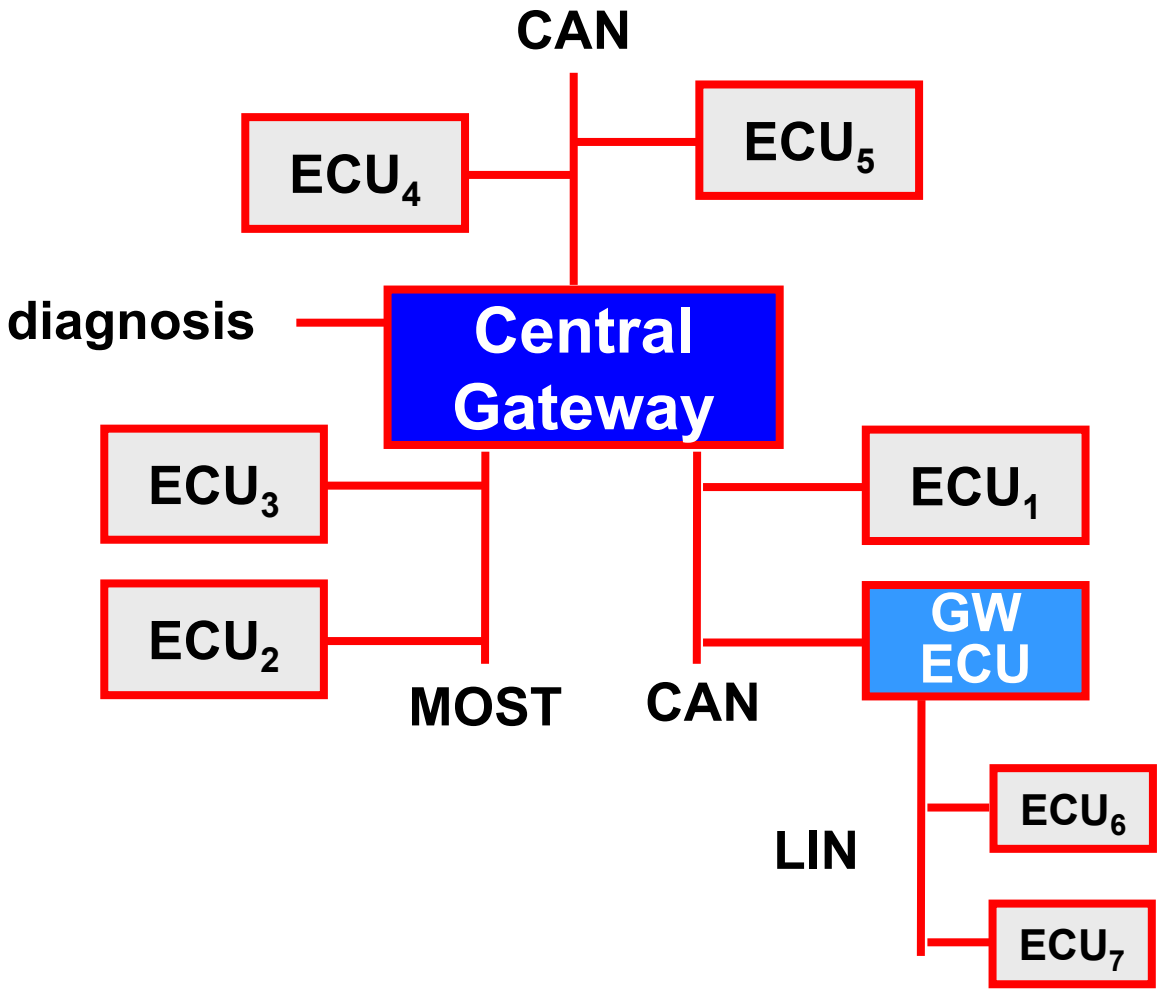
- **CAN**
  - **the „traditional“ bus, defined in 1983, still dominant today**
  - **packet based, variable frame length**
  - **CSMA/CD, static priority arbitration**
  - **ranges from 125kbit/s up to 1Mbit/s (ISO 11898-2)**
- **FlexRay**
  - **covers wide range of communication requirements, upcoming**
  - **two parts:**
    - **static segment using TDMA based protocol, fixed slot assignment**
    - **dynamic segment with prioritization**
  - **10 Mbit/s, higher cost than CAN, used in first cars (BMW)**
- **LIN - low cost, single wire, single master, up to 20kbit/s, round-robin, power ctrl.**
- **MOST –** optical **ring bus, 24Mbit/s**

Bus applications

- **CAN**
  - **low-speed: typically body electronics**
    high-speed: typically powertrain, chassis
- **LIN:**
  - **typically for simpler peripheral ECUs, e.g. door (central locking, power window …)**
- **MOST:**
  - **for multimedia applications in high-end cars (in mid-priced cars, CAN is used also for media traffic)**
- **FlexRay:**
  - **to replace high-speed CAN when 500kBit/s not enough**
    + for safety-critical applications + as backbone

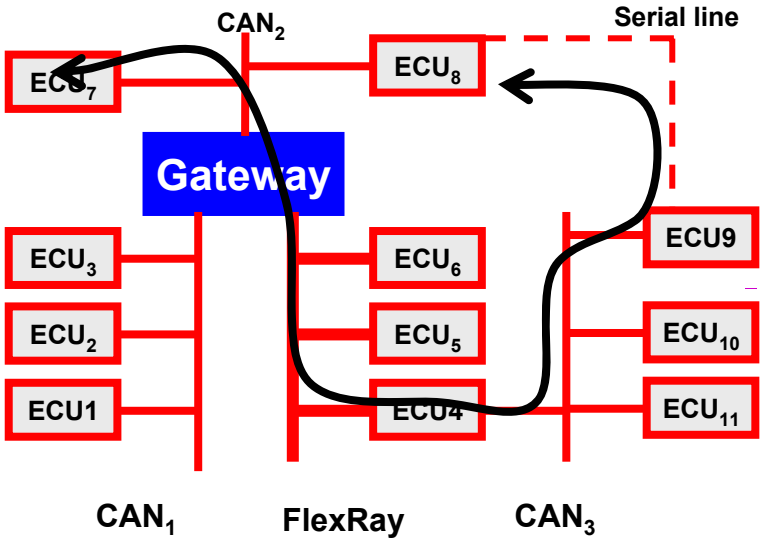
Typical network today

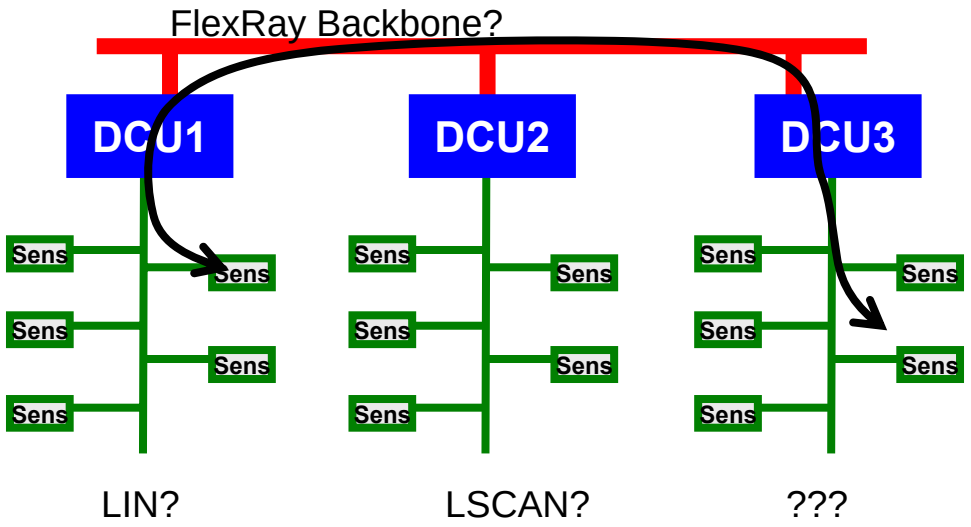
- component and function sharing needs bus coupling
  - example: wheel rotation sensor



Network topology evolution

- timing, cost, function increasingly difficult
- alternative topologies investigated

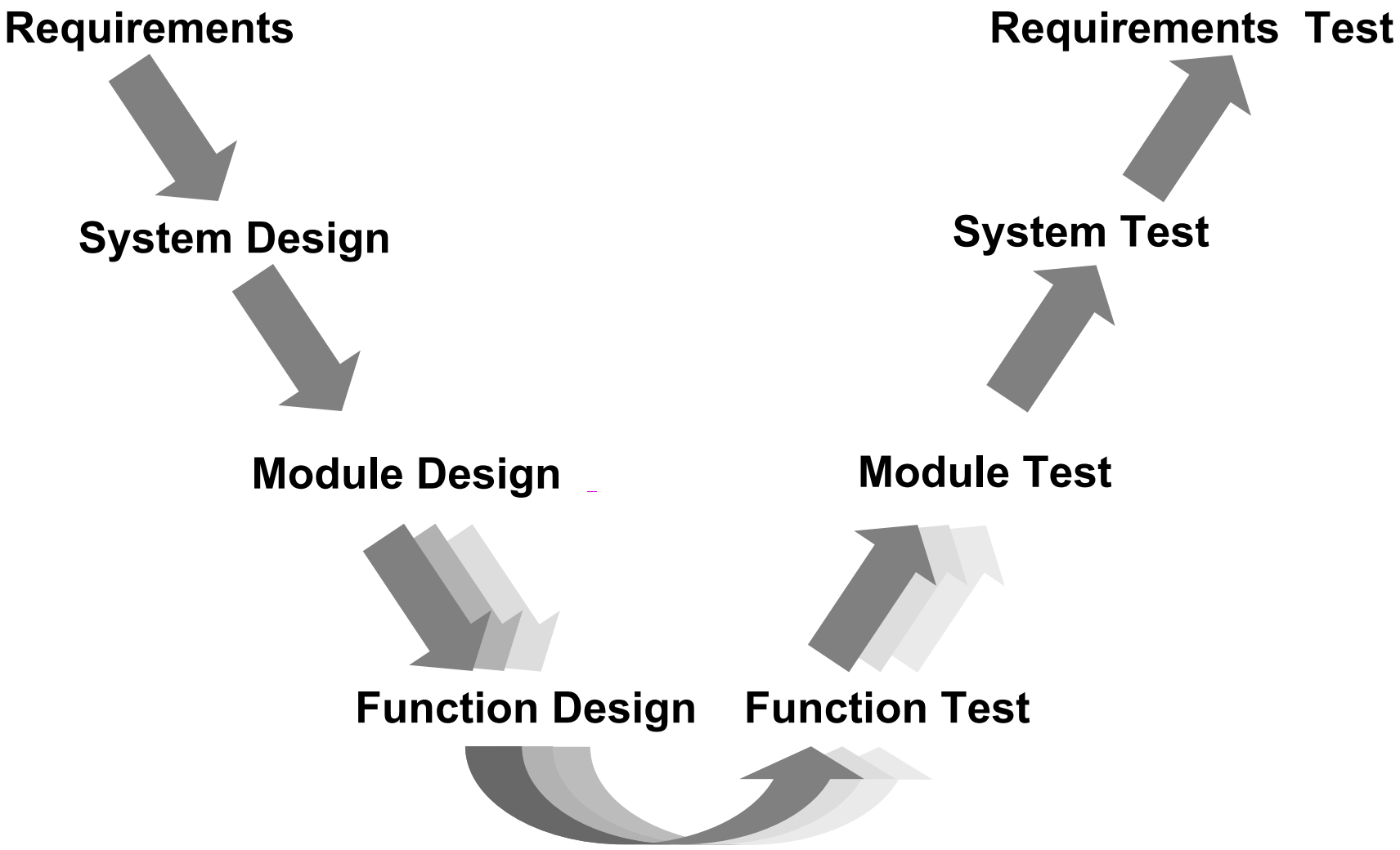




Network influenced by design process

- organizational structure
  - OEM defines bus topology and physical constraints
  - supplier defines ECUs (clients) and subnets
  - protocol parameters „by contract“
- design process
  - network is defined early in the design process
  - network planning cannot be based on executable code
  - must consider tradeoff *individual car* ↔ *product line* (platform)
  - must consider *legacy functions*
  - function integration and network verification need
    - verifiable specifications
    - efficient methods and tools

The V process model

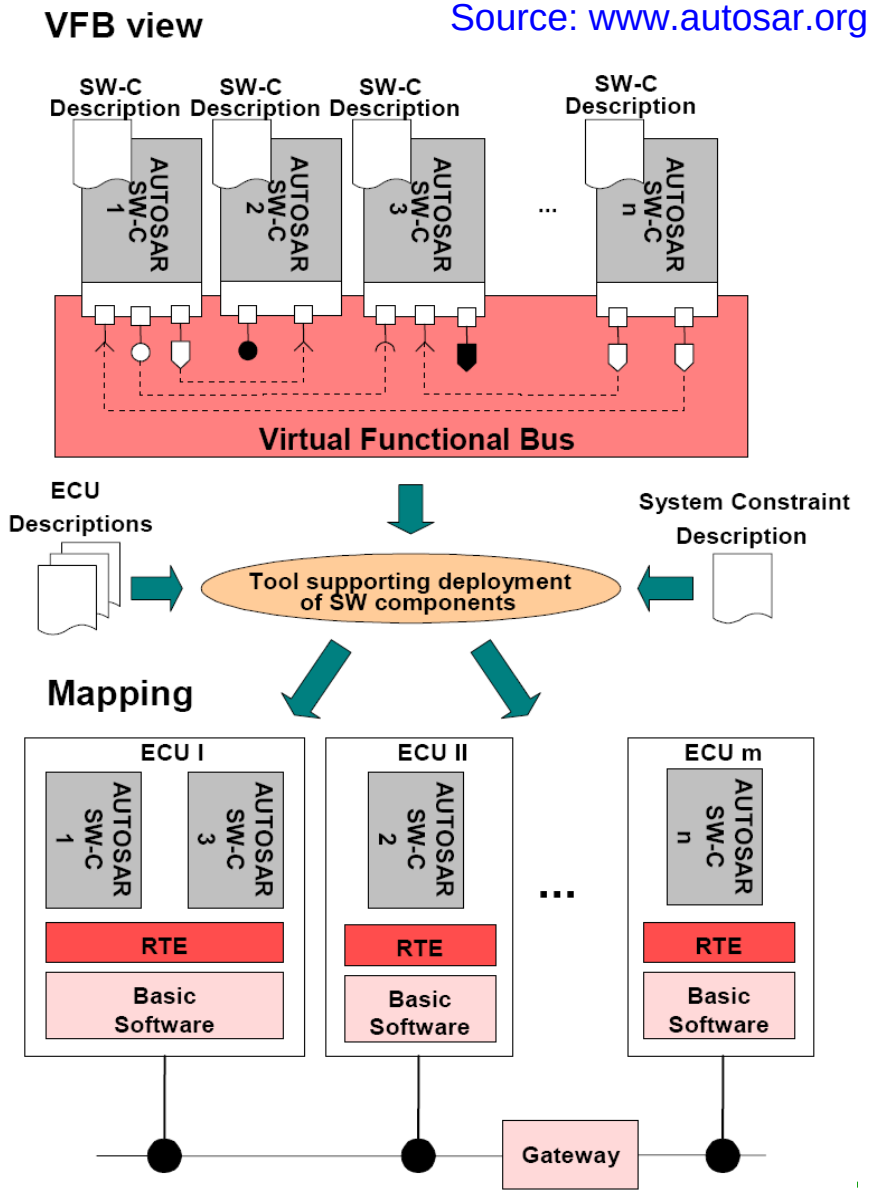


Software

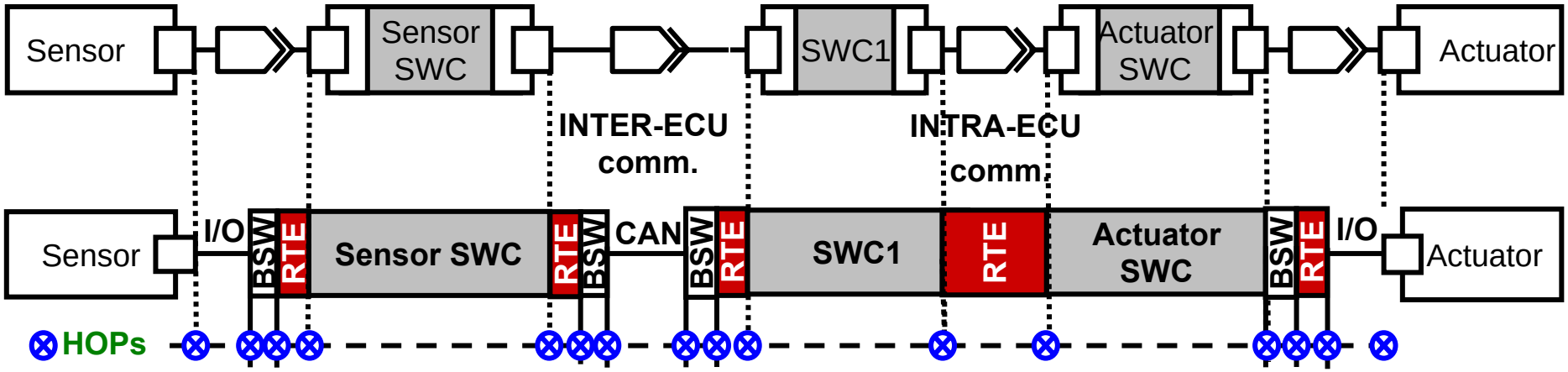
- different application models
  - periodic execution
  - automata based, event driven models
  - diagnosis software (C programs)
  - *no coherent model on the application language level*
- commercial tools e.g. Matlab/Simulink
- manually optimized combined with generated code
- code from multiple sources (OEM, supplier, 3rd party)
- growing efforts to find common run-time environment
  - AUTOSAR

AUTOSAR Methodology

- SW-Components (SW-C)
  - encapsulate the applications
- Virtual Functional Bus (VFB)
  - communication mechanisms
  - interface to Basic SW
- Runtime Environment (RTE)
  - VFB implementation on a specific ECU
- Basic Software (BSW)
  - infrastructural functionality on an ECU



Communication and timing chains in AUTOSAR



- AUTOSAR has an important influence on the network
- what will be the impact on network design?
  - Currently, AUTOSAR has no coherent timing model
    - ongoing projects (e.g. TIMMO)
  - will AUTOSAR entail a corresponding network initiative?

The panel

Industry

- Bernd Hedenetz, DaimlerChrysler AG, Germany
- Gernot Spiegelberg, Siemens VDO Automotive AG, Germany
- Marek Jersak, Symtavision GmbH, Germany

Academia

- Hermann Kopetz, TU Wien, Austria
- Alberto Sangiovanni-Vincentelli, UC Berkeley, USA

Introduction & Moderation

- Rolf Ernst, TU Braunschweig, Germany

Some questions

- are the current protocols, architectures, design methods, and tools appropriate? What innovations are most urgently needed?
- who shall develop the networks in the future, the OEM or a 1st tier supplier? What would be the consequence for the design process?
- Do we need interoperable network service standards, e.g. as a complement to AUTOSAR? Will there be a unified automotive “internet protocol” that eventually dominates all communication in a car?
- How will future car-to-car communication be included in the automotive network strategy if it shall be used for real-time applications, such as in driver assistance systems?