FlexRay Communication Protocol for an innovative scalable X-By-Wire platform

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R. Reichel, M. Armbruster, E. Zimmer, H. Tjaden, W. Mutikani, S. Gandhi / Institut für

Luftfahrtsysteme, Universität Stuttgart
A. Sulzmann / DaimlerChrysler Truck, DaimlerChrysler AG, Stuttgart
G. Spiegelberg / Siemens VDO Automotive AG, Regensburg

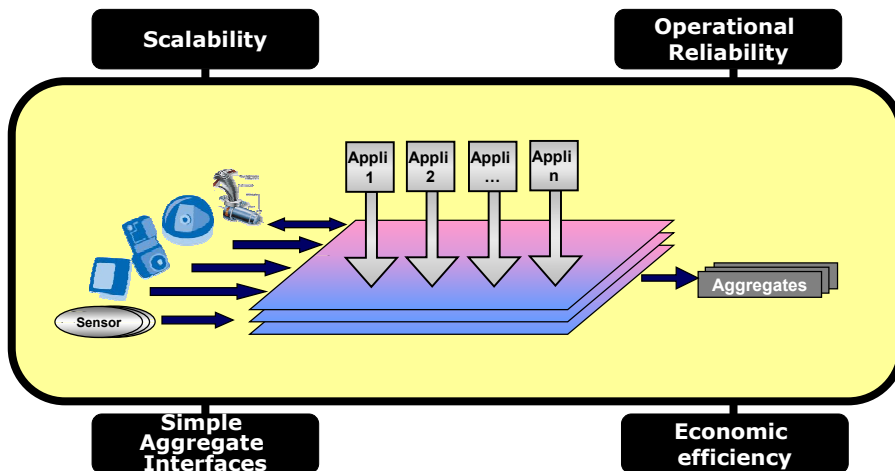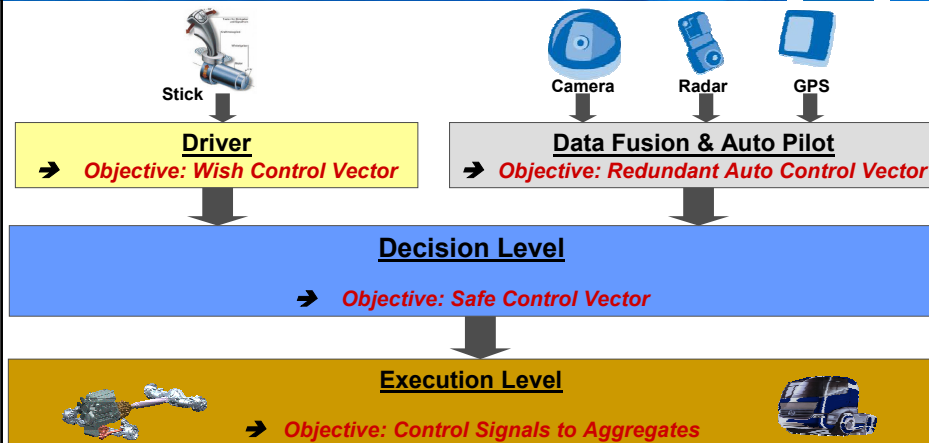**SPARC - S**ecure **P**ropulsion using **A**dvanced **R**edundant **C**ontrol   www.sparc-eu.net

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Motivation

Scalability

Operational Reliability

Appli 1 Appli 2 Appli ... Appli n

Sensor

Aggregates

Simple Aggregate Interfaces

Economic efficiency

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X-by-Wire Platform developed in SPARC

Stick

Camera   **Radar**   **GPS**

Driver
➔ *Objective: Wish Control Vector*

Data Fusion & Auto Pilot
➔ *Objective: Redundant Auto Control Vector*

Decision Level
➔ *Objective: Safe Control Vector*

Execution Level
➔ *Objective: Control Signals to Aggregates*

SPARC: EU program coordinated by DCAG

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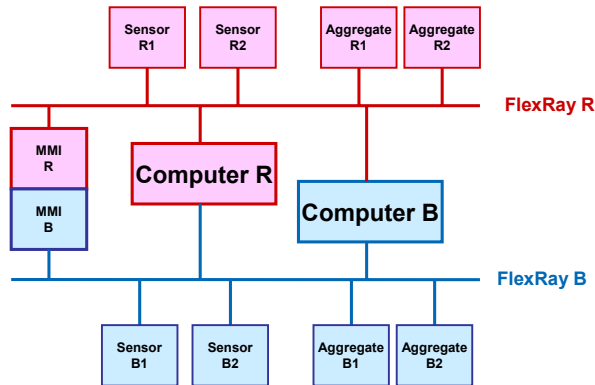# Requirements of the Platform

Key Requirements of the Platform

- No Single Point failure in the Platform independent of its probability
- Scalability to failures in terms of F/S, F/O-F/S, F/O-F/O..-F/S
- Capability of Dissimilarity / Diversity
- Minimum Wiring between Central Unit and Aggregates
  - Information via Bus
  - Power via Energy Bus
- Simple Interfaces in Aggregates

Detailed Key Requirements of the Platform

- System is split into two Sides
- Each Side has its own independent Bus (FlexRay)
- Only the Processing Units of the Central Computer have access to both FlexRay Busses
- Simplex Aggregates are linked to one FlexRay Bus only

Structure of the Platform

FlexRay R

FlexRay B

Sensor R1 · Sensor R2 · Aggregate R1 · Aggregate R2
MMI R · MMI B · Computer R · Computer B
Sensor B1 · Sensor B2 · Aggregate B1 · Aggregate B2

- Two FlexRay Buses
- Two Platform Computers
- Simplex Aggregates are linked to one bus only
- Redundant Aggregates are linked to both busses (MMI)

MMI…..Man Machine Interface

Drive-by wire system architecture
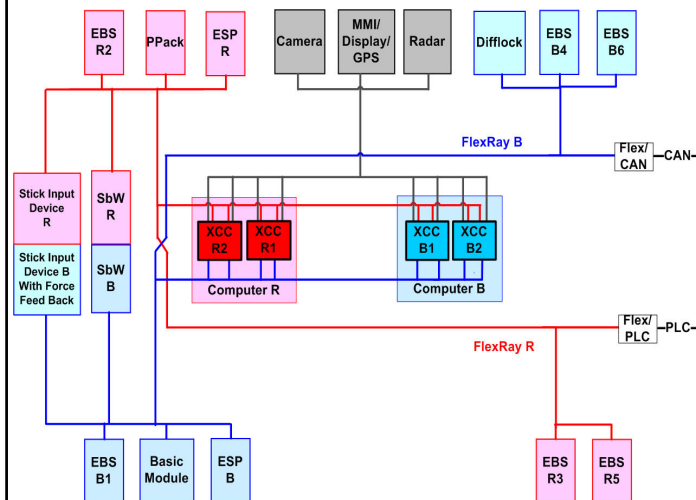
- Each Platform Computer consists of two XCC
- Each XCC is built up as a dual Unit
- Each XCC runs in strict Fail/Passive Mode
- XCC/R run synchronously to Bus R
- XCC/B run synchronously to Bus B
- Each Aggregate receives Data from Computer B and Computer R
- Which XCC runs specific application is transparent to external aggregates
- Each XCC can receive Data from all Aggregates resp. Sensors, MMIs

EBS…..Electr. Brake
SbW…..Steer by Wire
ESP…..Electr. Stab. Program (Sensor)
XCC…..Universal Control Computer

Redundancy-Management Basic SW-Modules

Vehicle dependant functionality

Application 1   Application 2   ...

Functional Control-SW

Integration of „Simplex Minded Designed Applications"

Redundancy Management

Application-Management
Sensor/actuator resource -management, application (partition) – control , ...

Platform-Management
Generic Management of the redundant control -platform , ...

IO-Management
Interactive data -consistency

Generic, vehicle and function-independant

OS
Scheduler , Device-Drivers , Partition-Management , ...

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Reconfiguration of redundant systems

- Application A1 is more important than Application A2
- Both Applications are available on each XCC (Universal **C**ontrol **C**omputer), but only one is running on one XCC

- Restart with same functional configuration will cause collisions on FlexRay

FlexRay Red

| XCC A1 | XCC A2 | ⇒ | XCC ▨ | XCC A1 | ⇒ | XCC A1 | XCC A1 | ⇒ | XCC A2 | XCC A1 |

FlexRay Blue

- Power Interrupt or
- Restart after internal error

- Reconfiguration

- Communication mechanism required to detect wrong configuration and to force right reconfiguration

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Reconfiguration – collision detection

XCC- A1   **XCC- A1**

Coldstart Listen		Coldstart Listen
Coldstart Collision Resolution	Collision Avoidance Symbol → Data_XCC	Initialize Schedule
	Data_XCC	Integration Coldstart Check
	Data_XCC	
	Data_XCC	
Coldstart Consistency Check	Data_XCC Data_XCC	Join Coldstart
	Data_XCC Data_XCC	
NOP	Data_XCC Data_XCC Data_APPLI	
NOP	Data_XCC Data_APPLI Data_XCC Data_APPLI	NOP

- **Data_XCC:**
  - Hardware dependant timeslot
  - Fixed to exact one node in cluster
- **Data_APPLI:**
  - Function dependant timeslot
  - Fixed to function running on XCC
- Hardware dependant timeslot required to guarantee collision-free start-up even in case of wrong configuration
- In case of running the same functionality on both XCCs, collision is detected by wrap-up of duplex HW.

Nullframe

Filled Frame

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Generic behavior model of aggregates

General Requirements

- Minimum wiring
- Flexible
- Simple interface to redundant platform
- Degree of redundancy platform shall not be visible to aggregates
- Valid for all kinds of aggregates (sensors, actuators, etc.)
- Scalable in terms of amount of actuators and sensors
- Platform shall be able to manage the bahavior of aggregates

Considered aggregate states

Communication:
aggregates → platform

Aggregate states:
- Current state of aggregate (e.g. STBY, NOB, BIT, etc.)

Message counter:
- Increased by aggregate
- Indicates failure (e.g. frozen host-CPU of aggregate)

BIT (Built-in-Test):
- BIT-Status
- BIT-Type
- BIT-Result

FlexRay Configuration Version:
- Current version number of the FlexRay configuration file (*.chi)

Failure Code:
- Internal error of aggregate (e.g. Communication on one FlexRaychannel failed)

Communication: platform ← aggregates

Platform state:
- Current state of XCC (Master or Slave)

Message counter:
- Increased by XCC
- Used for Wrap-up (XCC-internal check-mechanism)

Mode command:
- XCC commands mode to the aggregate, which the aggregate should stay in or should take over (e.g STBY, BIT, NOP, etc.)

General message-format
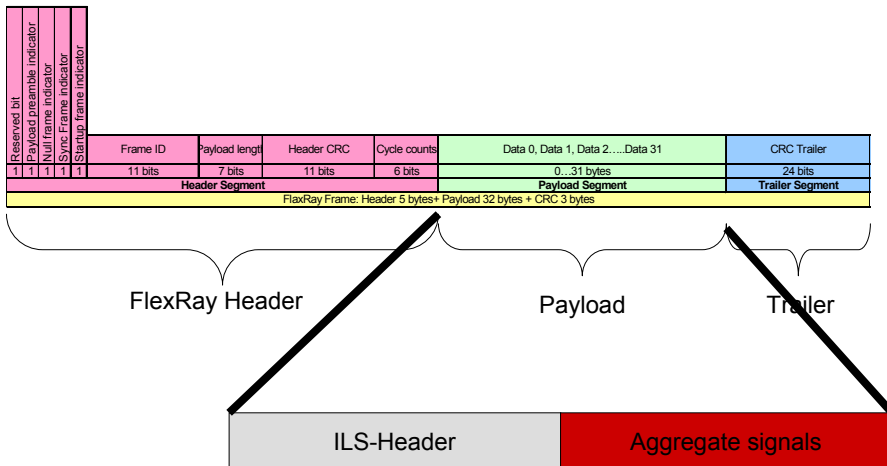
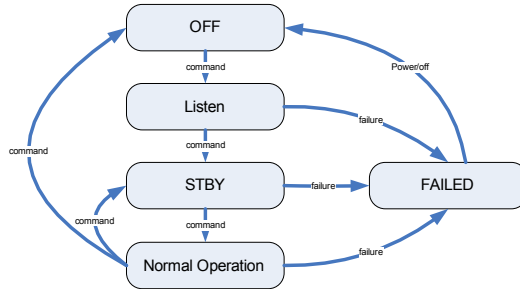Adding ILS-Header (4 Byte) in Payload Segment of each Frame

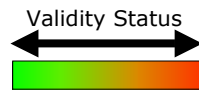# Scalability and Standardisation

The scalability requires standardisation with respect to:

- Behaviour-Model of
    - Sensors
    - Actuators

- Rating of resources
    - Sensors
    - Actuators

Validity Status

Platform-Scalability

Within SPARC the platform-approach is scalable with respect to:

- Number of sensors/actuators
- Amount of I/O-data

Scalability means that changes of the scalability-domains will not lead to a change-request of the concept.

Transferability of platform between vehicles

Conclusion

- X-by-wire Platform approach
    - Scalability
    - Economic efficiency (Minimum wiring, Efficient Use of Resources

- Reconfiguration
    - Intelligent reconfiguration mechanism by using available HW in an intelligent way

- Generic behaviour model for aggregates
    - Simple Interfaces in Aggregates
    - Control functionality
    - Error detection

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Prospects

- Application of XCP-Protocol for calibration and diagnosis purposes

- Flashing of SW-updates via FlexRay-Network

Thank you for your attention!

Universität Stuttgart
- Institut für Luftfahrtsysteme -
Eduard Zimmer
Eduard.Zimmer@ils.uni-stuttgart.de