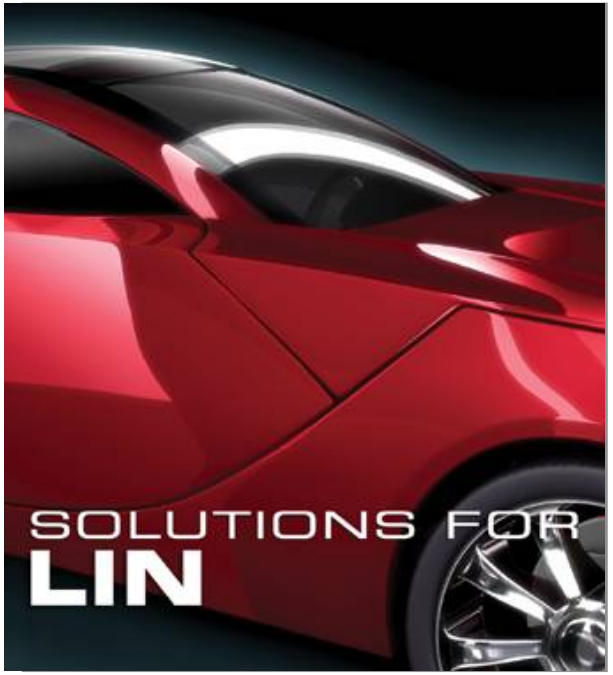

Experiences with LIN Network Design at Porsche

Vector LIN Symposium 2008
Hans Quecke, Vector Informatik

Agenda

> **LIN Design Challenges**

LIN Design at Porsche

Trends and Outlook

Conclusion

LIN Design Challenges

General

- Timing
  - Meeting of cyclic time requirements due to application
  - Minimization of gateway work load and routing latencies
- Communication
  - Avoidance of inter-slave communication
  - Creation of consistent communication and LIN Description Files
- Design process
  - Coordination of application requirements with network design
  - Interaction with other bus systems

LIN Design Challenges

Routing

- Application routing vs. direct routing
  - Direct routing is done by the COM layer -> routing code is generated
  - Application routing has to be done by the application -> programming is needed
  - Signals with different encoding rules have to be routed by the application
- Direct routing is more efficient than application routing
- Enable direct routing by design

LIN Design Challenges

Configurability of Slave Nodes

- Non-configurable Slaves
  - Node settings (e.g. NAD, IDs) are not configurable and stored in non-volatile memory (NV-RAM)
- Configurable Slaves
  - Preconfigured Slaves
    - Node settings are configurable, but also stored in NV-RAM
    - Configuration either by supplier or OEM
  - Runtime configured Slaves
    - Node settings must be configured by Master
    - Configuration either stored in RAM (or NV-RAM)

LIN Design Challenges

Reusable Nodes

- Off-the-shelf nodes
  - Fixed functionality
  - Fixed frame layout and signal encoding
    - Node address and frame IDs configurable
- Carry-over nodes
  - Same as off-the-shelf nodes
  - Additionally fixed node settings if not configurable, e.g.
    - Configured node address
    - Published and subscribed frame IDs

Agenda

LIN Design Challenges

> **LIN Design at Porsche**

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LIN Design at Porsche

General Topics

- Used LIN protocol versions: 1.2, 1.3, and 2.0
- Fixed baud rate of 19.2 kBits/s for all LIN networks
- No use of event-triggered frames
  - Worst case latency times (i.e. after collision) too high with LIN 2.0
  - Expected improvement with LIN 2.1 due to collision resolving schedule
- No use-case identified yet for sporadic frames

LIN Design at Porsche

Configurability and Reuse of Slave Nodes

- Configurability of Slave nodes
  - Mostly configurable but preconfigured by supplier
  - Some not configurable
- Off-the-shelf nodes
  - Not used by Porsche
- Carry-over nodes
  - Largely used by Porsche during development phase
  - Carry-over nodes from existing projects
    - LIN configuration settings fixed and not changeable
  - Newly developed nodes
    - LIN configuration settings coordinated between all expected users (Porsche and development partners)

LIN Design at Porsche

Network Topology

- LIN network topology
  - Regional clustering
    - LIN network for the left doors and the right doors
  - Functional clustering
    - LIN network for climate control
  - All LIN Master nodes are CAN-LIN gateways
- Public LIN networks
  - Networks are fully designed by Porsche
  - 5 public LIN networks with 3 multi-channel Masters
- Private LIN networks
  - Networks are fully designed and integrated by suppliers

LIN Design at Porsche

Gateways

- Direct routing is achieved by design
  - Using the same signals on all networks is a precondition for efficient direct routing
  - A common signal pool is used for all networks
- Only use encodings of type unsigned integer to enable direct signal routings

LIN Design at Porsche

Frame Packing and Scheduling

- Persons responsible for the ECUs define signal cycle times
- Signal cycle times are used as requirements for schedule design
- When packing the signals into LIN frames the following restrictions have to be considered
  - The maximum acceptable cycle time is about 100 ms. Higher cycle times will have negative effects on the functional behavior
  - Since a frame with 8 data bytes has a transfer time of approx. 10 ms, only 10-15 frames can be transmitted on a single LIN bus
  - With typically at least 4 Slaves per network, each Slave must not send more than two or three frames
- Frame packing is not particularly complex due to the limited degree of freedom

LIN Design at Porsche

Frame Packing and Scheduling

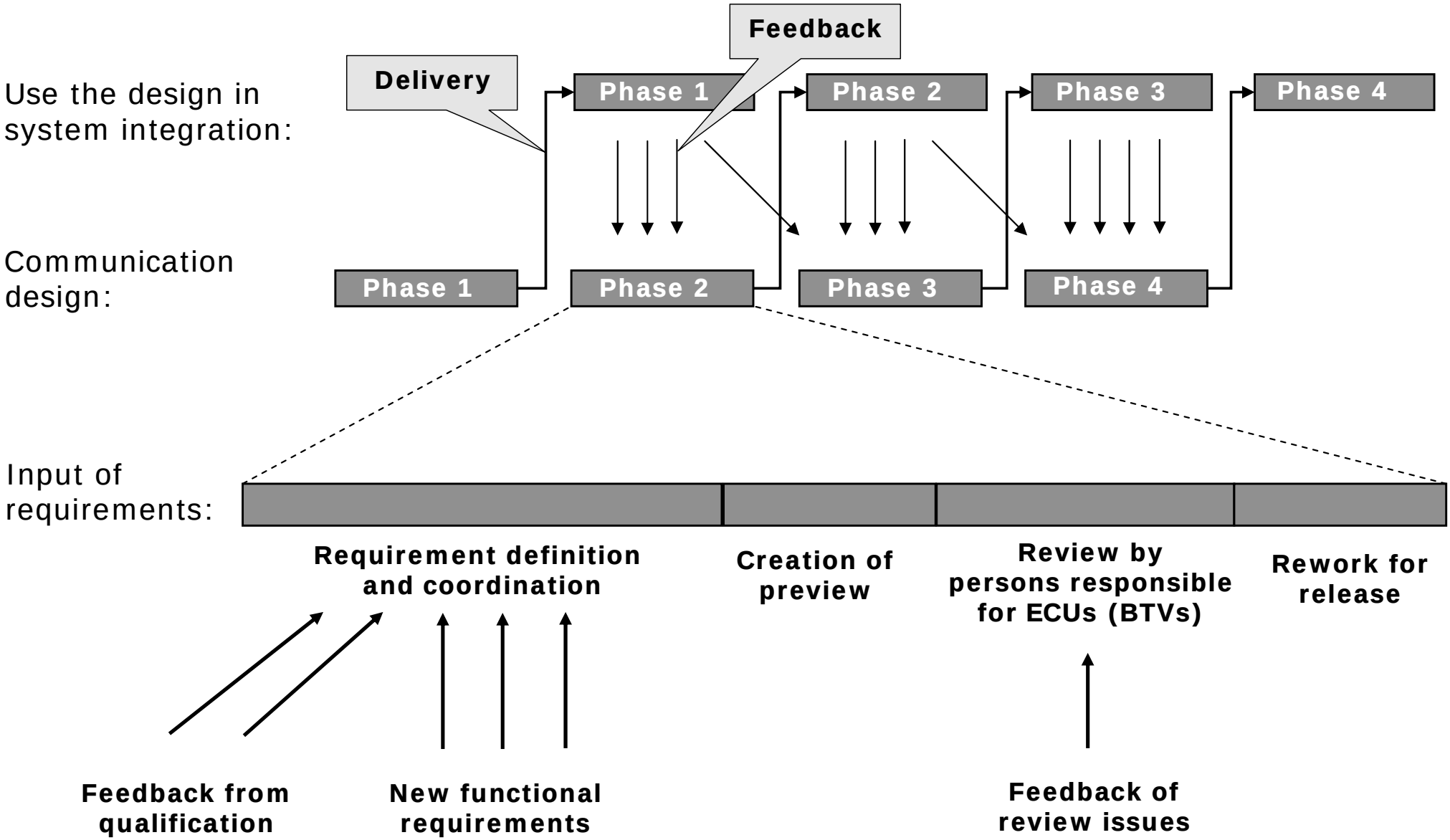
- The initial schedules for LIN networks are created with DaVinci's schedule table wizard
- These schedules are then revised in order to
  - Avoid work load peaks for the LIN Slaves by preventing sequencial addressing of the same Slaves
  - Support of diagnostics frames
  - Achieve compatibility with other models at Porsche (cross car line approach)

Design Rules

- At project start Porsche defined a set of design rules
- Rules concerning signal distribution
  - Avoidance of inter-slave communication
- Rules concerning signal encoding
  - Use unsigned integers
  - Define initial and invalid values for all signals
- Naming conventions
  - Prefixes for signal and frame names defining sender or function
  - Maximum length of object names
  - Naming rules for signal specific types

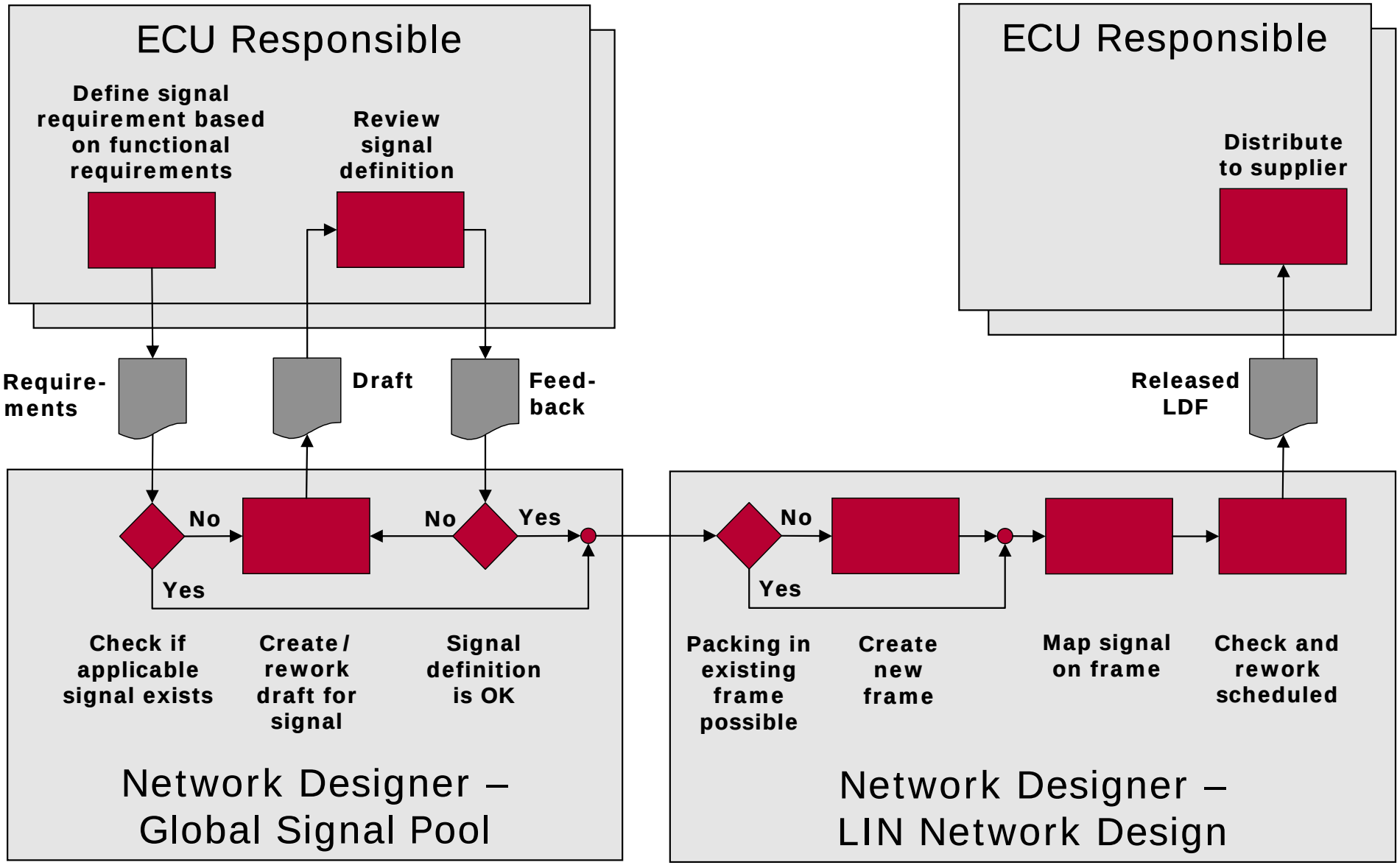
LIN Design at Porsche

Design Process



LIN Design at Porsche

Design Process



LIN Design at Porsche

Tool Support

- From project start Porsche relied on DaVinci Network Designer LIN as design tool
  - Decision based on good experience with Vector's CAN design tools
  - Porsche's experiences were taken into account for version 2.0
- Commonly used data is defined only once
  - Global signals usage in several networks
  - Signal types for a consistent definition of physical values
- Delivery of consistent LDF files to suppliers due to detailed consistency checks
- Import of signal descriptions of existing CAN and LIN designs (LDF, NCF, DBC, and FIBEX) made manual signal redefinition obsolete

LIN Design at Porsche

Experiences

- Consideration of communication volume must be part of early network architecture processes
- Functional changes have to be checked for their implications on the communication
  - Minor changes will influence the communication only partly
  - New functionality may be integrated without general rework of the communication
  - Major changes (e.g. functional repartitioning) may lead to a rework of the network architecture
- Problems in LIN design only occur when ECUs are implemented as LIN Slaves although their complexity exceeds a LIN Slave's standard capabilities
- Porsche is convinced that the usage of standard tools is the right way to achieving high efficiency and quality in network design

Agenda

LIN Design Challenges

LIN Design at Porsche

> **Trends and Outlook**

Conclusion

Trends and Outlook

General Aspects

- Integration of LIN design into the design process for all networks
  - All network design data have to be managed in a global repository
  - Common signals out of a global signal pool have to be used
  - A multi-bus design tool is needed (CAN and FlexRay too)
  - The tool has to be multi-user capable
- Integration of DaVinci Network Designer in data backbones
  - Vector eASEE as system for the management of engineering data
  - Integration in customer specific environments
  - The work of several users is coordinated via a central data repository

- Considerations regarding assignment of Supplier and Function IDs
- Selection of supplier ID
  - Which supplier ID has to be assigned to an ECU provided by several suppliers? (Affect on automated tests and configuration)
  - Which supplier ID should be assigned to an ECU supplied by a supplier that has no supplier ID?
- Procedure to assign function ID
  - Random allocation of function IDs (no structure, depending only on the order of assignments)
  - Structured allocation: allocating function IDs with regard of e.g.
    - Node type (MMI, Actor, Sensor, ..)
    - Node function (Wiper-Control, Roof, ..)
    - Node usage (Distributed System Name, ..)

Trends and Outlook

Porsche Specific Topics

- The activities of the LIN consortium concering the more effective use of off-the-shelf nodes are being observed
- The usage of several logical LIN Slaves in a single ECU (physical multiple ECUs) is being analyzed and may be used in the future
- Event-triggered frames may be used in the future
- With future projects a common repository for all network designs will be established
- Porsche expects a quality increase by considering quality aspects in the early design and implementation phase (e.g. testability of LIN Master functionality by using “prepared” standard software stacks)
- Porsche expects further increase in efficiency by using a single tool chain for overall network design including different bus technologies
- Porsche relies on the usage of standard tools further on

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LIN Design Challenges

LIN Design at Porsche

Trends and Outlook

> **Conclusion**

Conclusion

- LIN is an established bus system for sub-buses at Porsche
- A design environment increases the efficiency and quality of the LIN network design
  - Common design environment for all bus systems
  - Several LIN buses are managed in a single system
  - Common reuse of design elements like signals and encodings
  - High quality of design data due to consistency checks
  - Efficient routing based on the usage of common signals on all networks
- Usage of standard tools has major advantages
  - Additional functionality is provided early, e.g. support of LIN 2.1, FIBEX, …
  - Improvements are triggered by all tool users
  - DaVinci Network Designer LIN bases on Vector's wide-ranging LIN know-how

Thank you for your attention.

For detailed information about Vector

and our products please have a look at:

www.lin-solutions.com

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