FERAL

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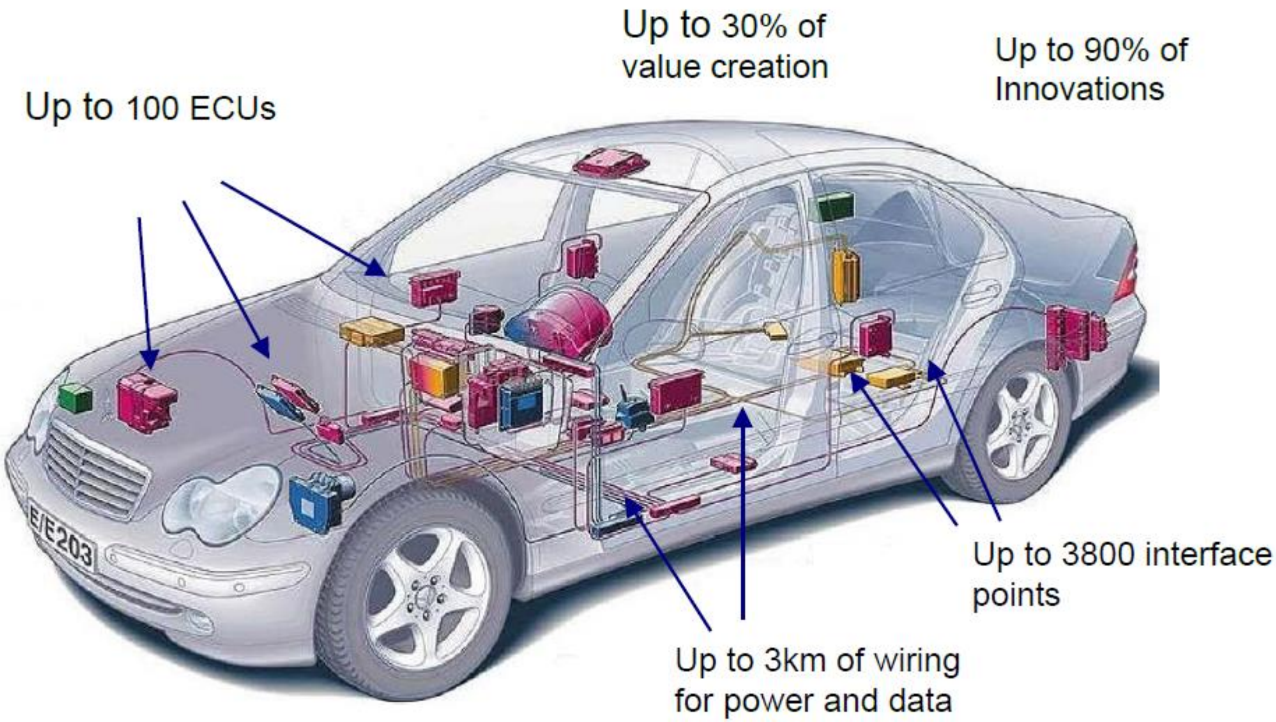
Motivation – Embedded Software Development

Growing importance of Embedded Software



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Motivation – Embedded Software Development

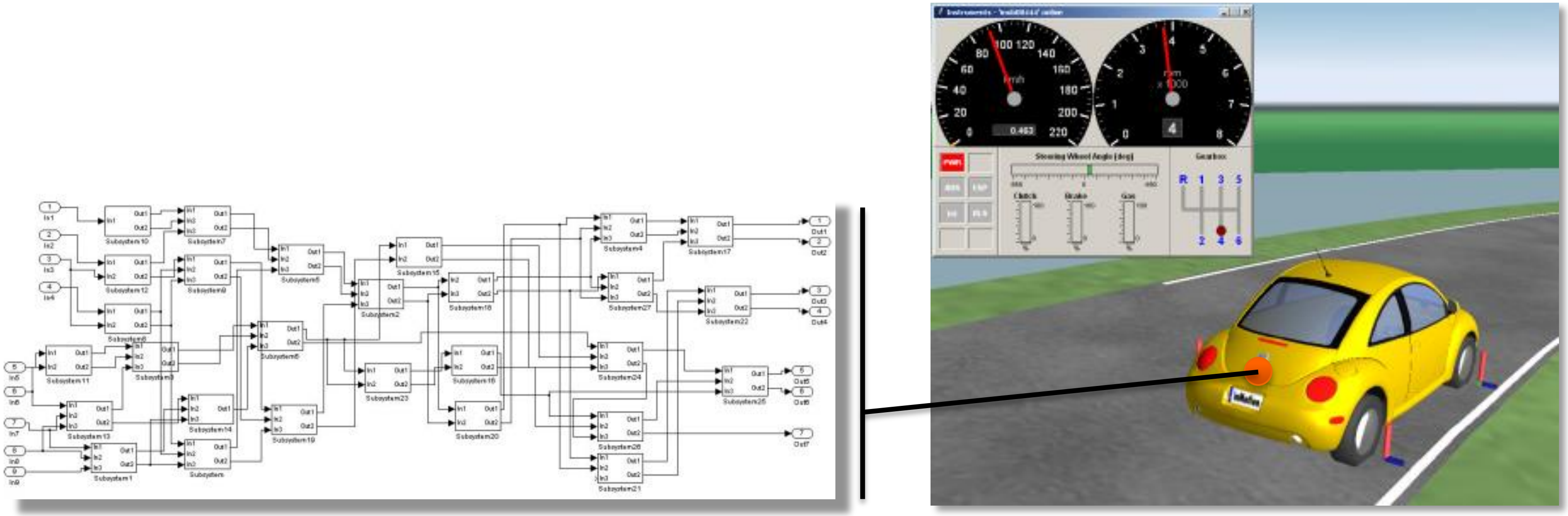
Challenges when developing and testing embedded software

- Embedded (Control) Software is developed using Model Driven Development approaches
  - Simulink, ASCET, Scade
- Tightly integrated with other system components
  - Interacts through sensors and actuators with the environment
  - Interacts with other software components
  - Shares platform and network resources with other software components
- Testing of embedded software needs to take this into account
  - Existing simulation solutions enable virtual testing of embedded software
  - Virtual platforms, Environment simulators, Network simulators

Motivation – Embedded Software Development

Simulators

- Enable early evaluation of embedded software in realistic context
- Provide accurate, yet specialized environments

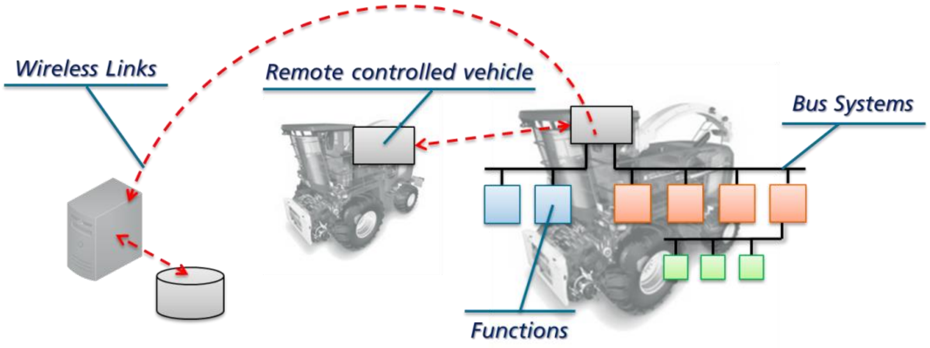


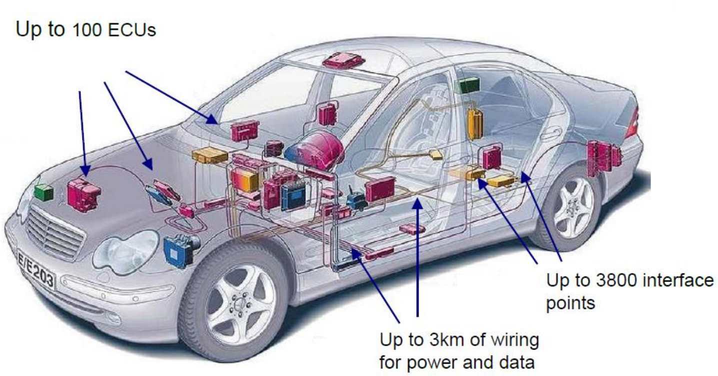
Motivation – Embedded Software Development

But: Embedded Software complexity is increasing

- Open Systems of Systems
  - Wireless links raise safety and security concerns
- Consolidation of functions
  - Potential for significant cost savings
  - How to ensure that concurrently executing functions do not interfere?

} System level concerns





System Level Design and Testing

Evaluating E/E Architecture properties

- Current solutions for embedded systems focus on component development and testing
  - Functional development of individual components
  - Board level + mandatory devices for evaluating behavior of system under test

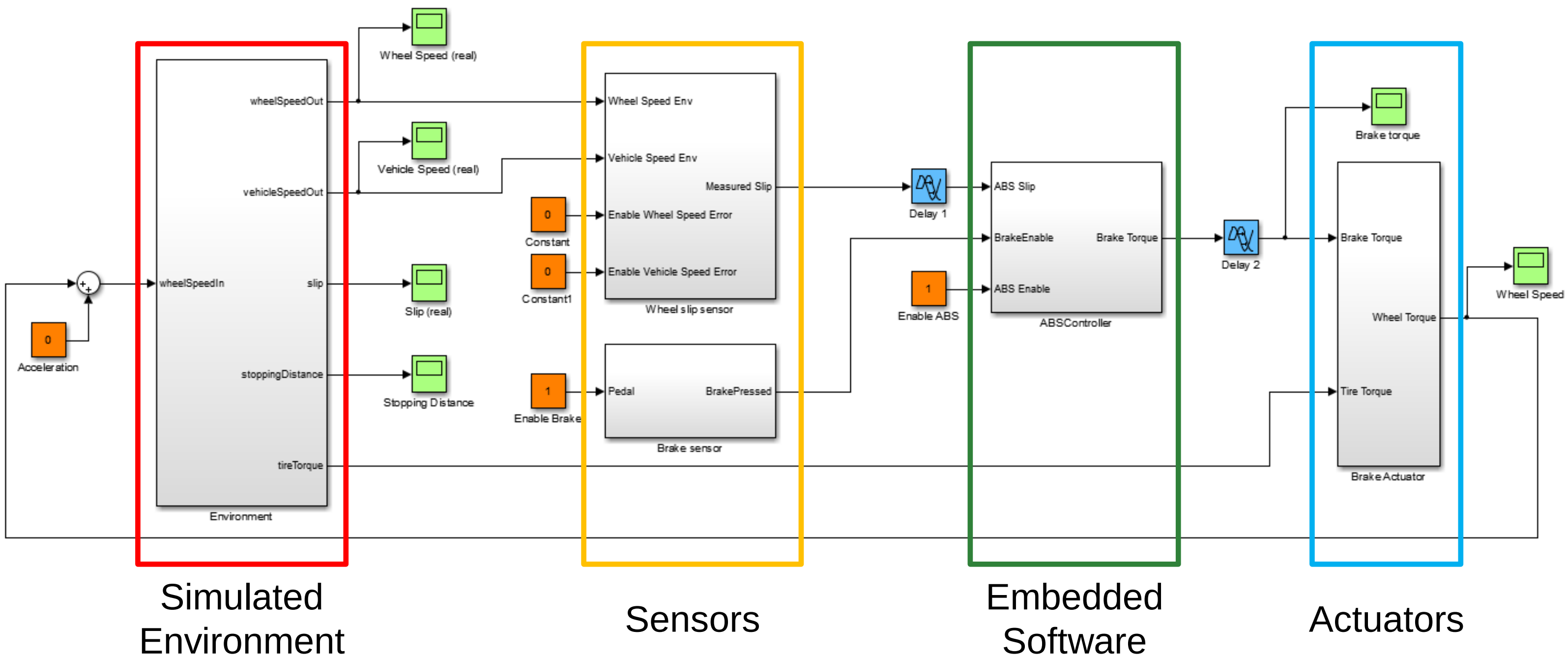
- Next generation embedded systems require more complex E/E Designs
  - How many ECUs are necessary for my product variants and expected growth?
  - Where to consolidate software functions?
  - How to segregate safety relevant functions on same hardware from each other?
  - Which busses are necessary? Wireless access? How to configure and to protect them?

→ System level architecture design and architecture evaluation is getting more important

System Level Design and Testing

System level architecture evaluation requires new simulation approaches

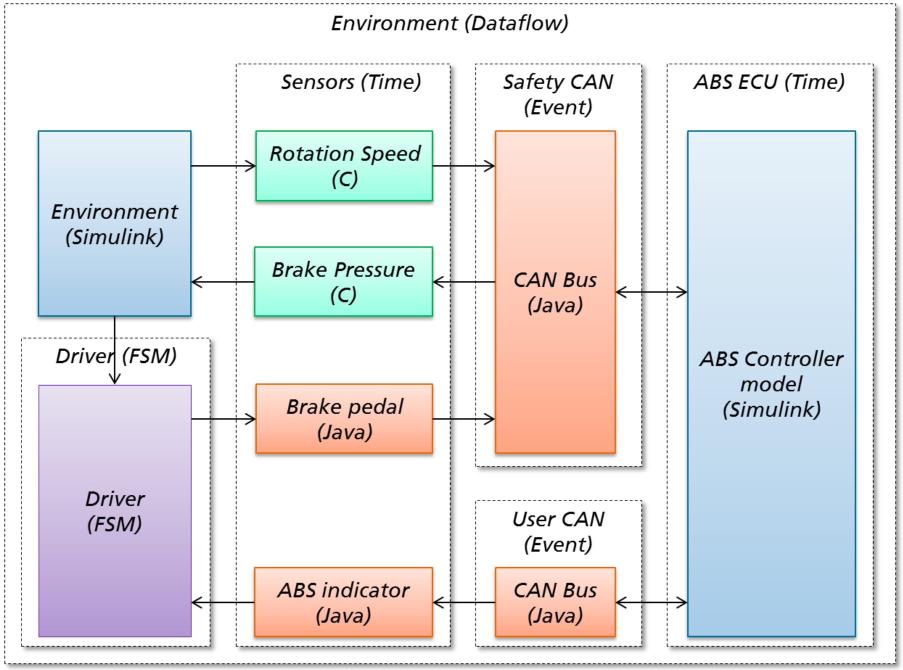
- Let’s consider a (simple) example Simulink system



Simulator Coupling

A simulated deployment of the example system requires many components

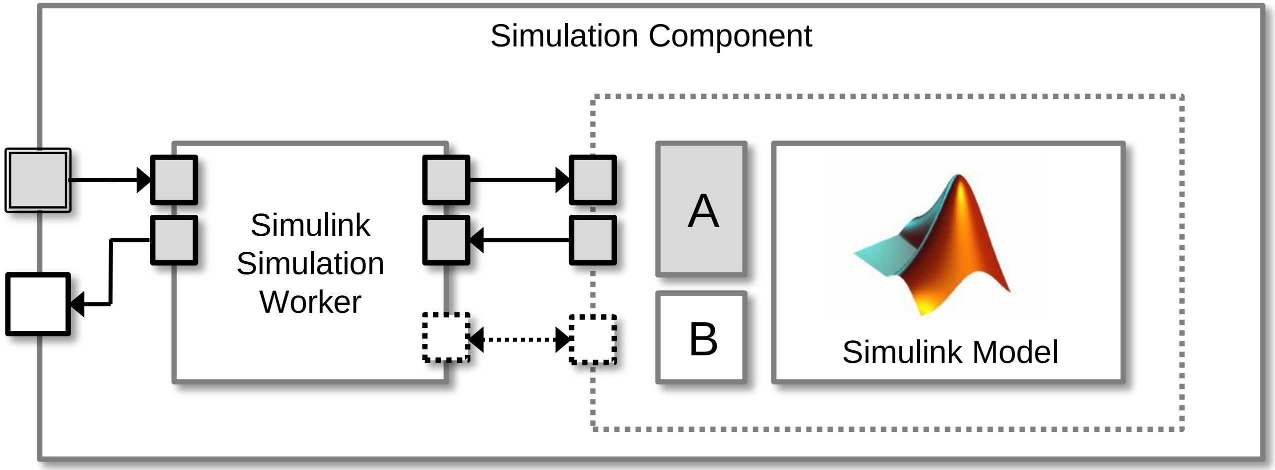
- E/E evaluation on system level requires coupling of specialized simulators
  - One integrated holistic scenario
  - Coupling on different abstraction levels must be supported to manage complexity
  - Project specific development and modeling environments
  - Possibly additional simulators
    - Wireless networks
    - Fault injection
    - …



Simulator Coupling

The FERAL simulator coupling framework

- Simulator coupling requires syntactic and semantic integration
  - Syntactic integration: Simulated network messages, value types, Simulator API
  - Specific to most simulators
  - Encapsulated as simulation components



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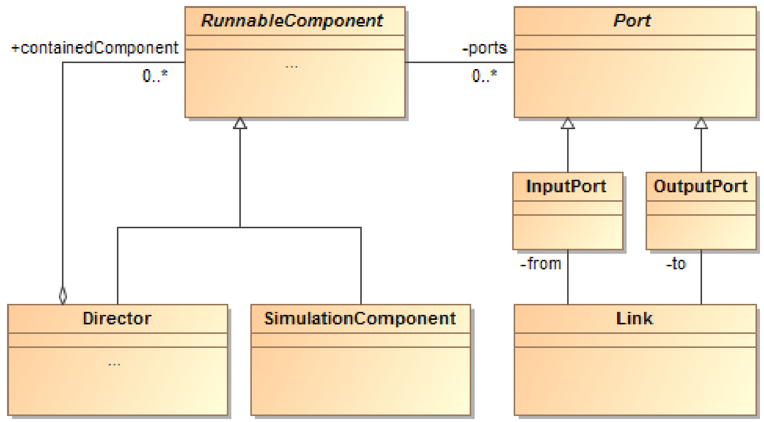
Simulator Coupling

The FERAL simulator coupling framework

- Semantic integration is provided by directors
  - Encapsulate models of computation and communication
  - Directors may be nested - ensure proper linking of simulator semantics into one integrated scenario
  - This is supported by semantic contract between nested directors



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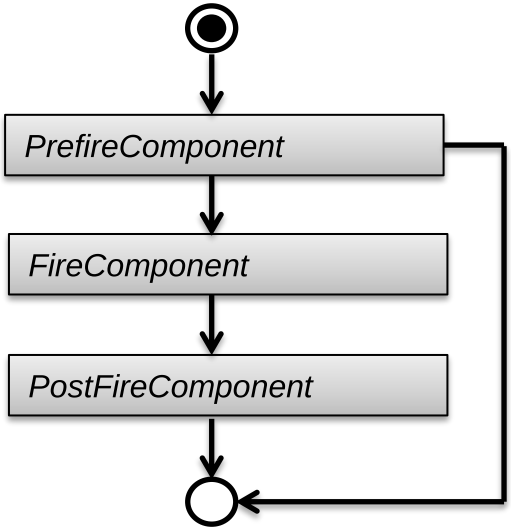
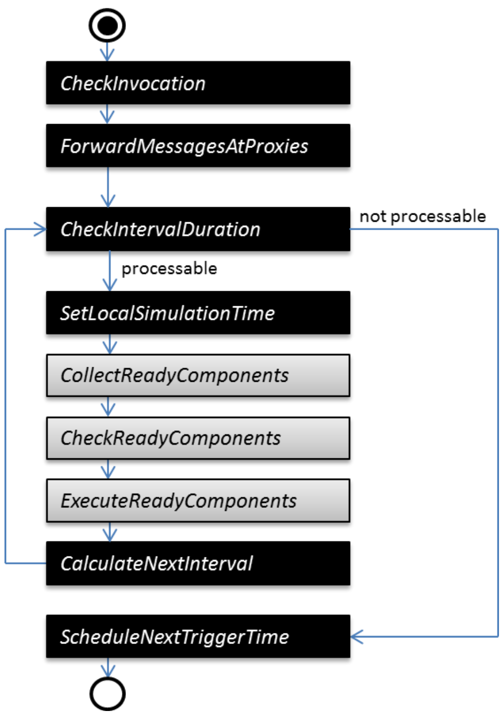
Simulator Coupling

FERAL – Execution of Components

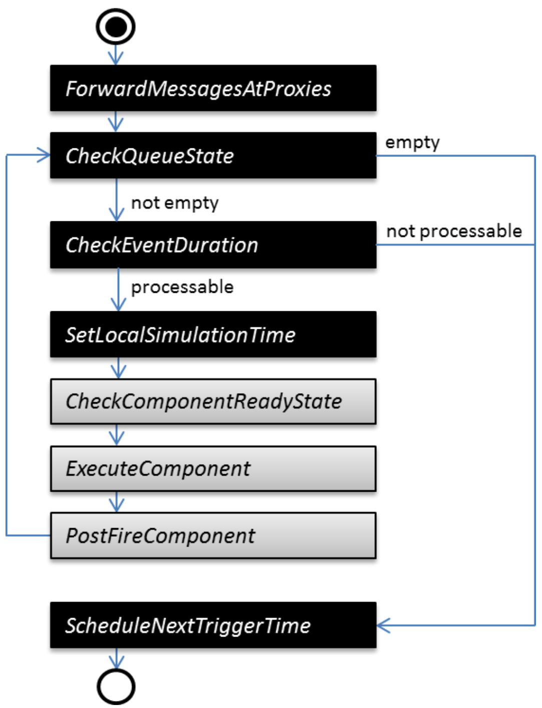


Simulator Coupling

FERAL - Time and Event based Director semantics



Discrete time director



Discrete event director

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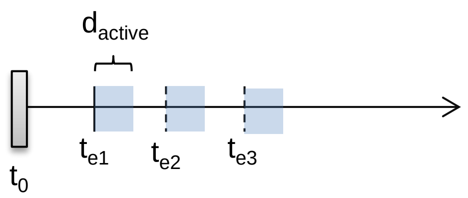
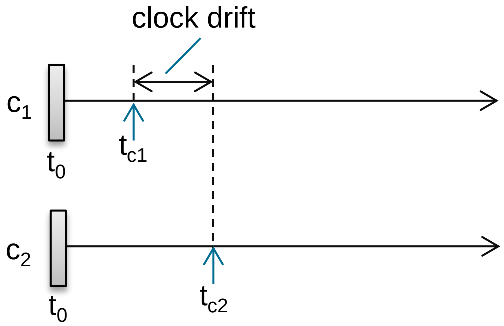
Simulator Coupling

Simulator coupling challenges

- Accuracy vs. efficiency
  - Simulator coupling is resource intensive due to synchronization overhead
  - Parts of a scenario require tight coupling, other parts allow a less tight integration
- Feral simulation model is based on Events and active periods
  - Foundation for all directors

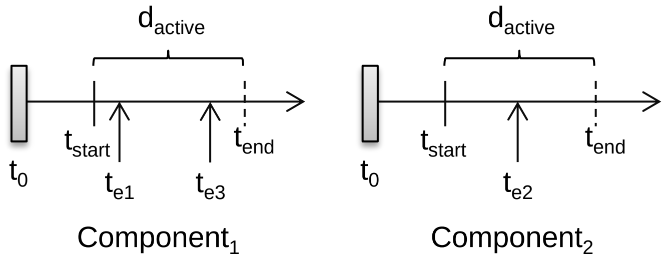


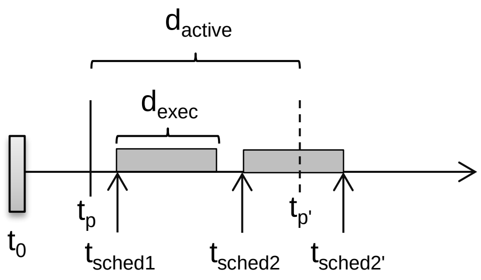


Simulator Coupling

Simulator coupling challenges

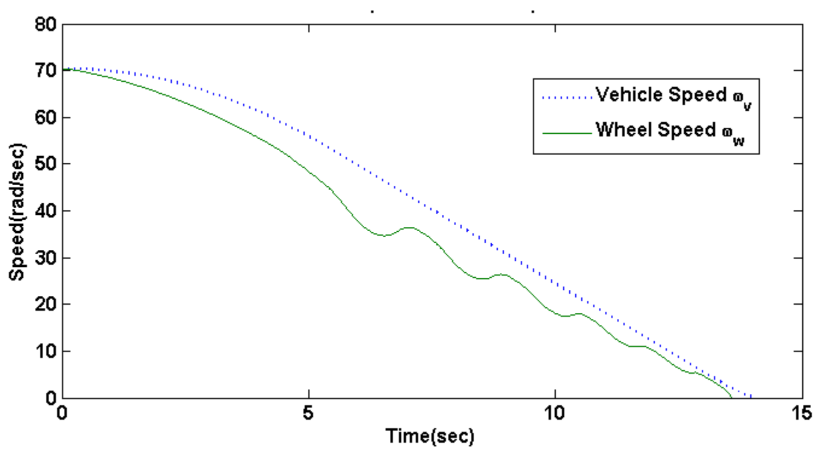
- Clock drift between simulators is permitted inaccuracy
  - Significantly reduces synchronization overhead
  - Enables components to process their active period without interferences
  - Foundation of distributed simulations
  - Deferring of events that exceed active period

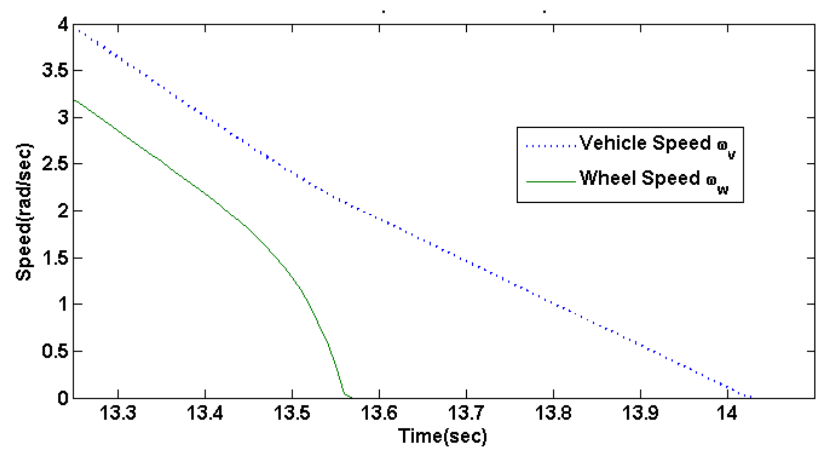




Evaluation

Impact of simulated network behavior to one function





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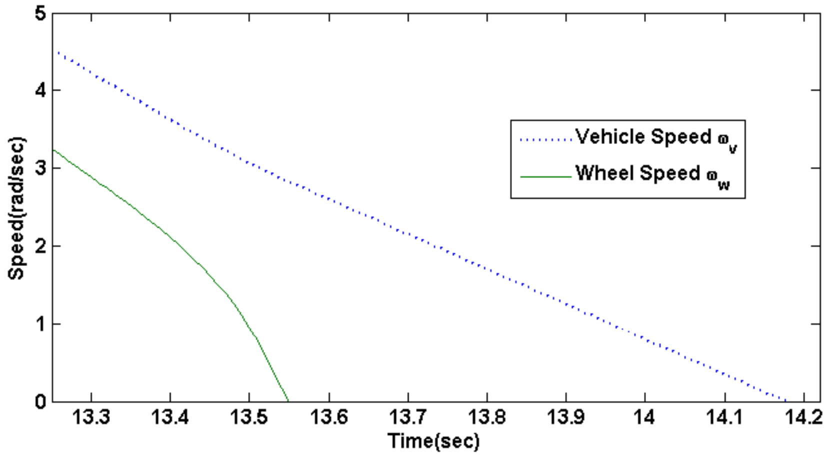

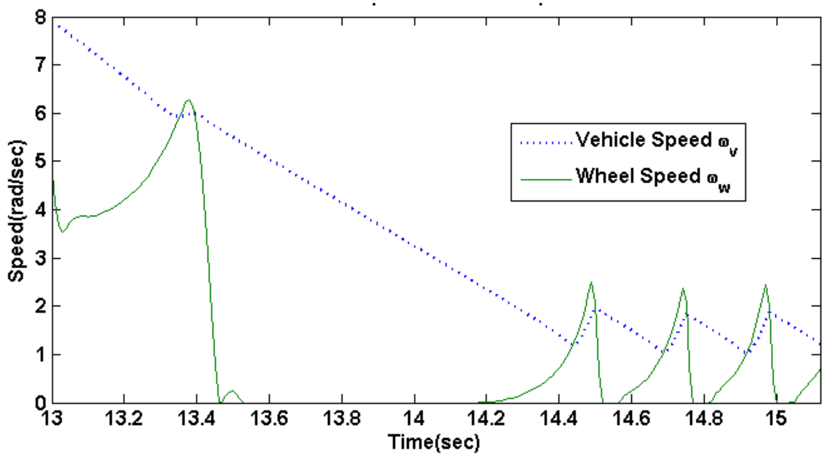

Conclusion

- Simulations are state of the art in embedded systems development
  - Individual and focused simulators
  - Early evaluation of system level decisions require simulator coupling
- Fraunhofer FERAL enables integration of simulators into holistic scenarios
  - Enables early validation of system behavior or function behavior in system context
  - Predict system behavior in realistic conditions
- Benefits
  - Prediction of communication performance
  - Evaluation of safety concepts
  - Substantiating architectural decisions