J MAAB Vehicle Model Architecture and Two-Way Connection

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Contents

1. Introduction
2. Two-Way Connection
3. Application – Guidelines & Vehicle Model
4. Future Work
5. Conclusion
Introduction
Model Based Development

Virtual World

Validation

Combination

Plant Model

Controller Model

SILS

Rapid Prototype ECU

HILS

Real World

Plant
(Engine, Transmission etc.)

Controller
(Hardware, Software)

Combination

Validation
Component Oriented Modeling

Key Requirements
- partition based on actual parts composition
- standards to enable easy integration
Two-Way Connection
Simple Mechanical System

a schematic of the system

\[ T_{\text{ext},i} + k_i (\theta_i - \theta_{i-1}) + k_{i+1} (\theta_{i+1} - \theta_i) = I \ddot{\theta}_i \]

equation of motion for body \( i \)
Modeling with *Signal Flows*

Physical Architecture ≠ Model Architecture
Modeling with *Two-Way Connection*

Physical Architecture = Model Architecture

moving towards true *component oriented architecture*
Signal ↔ Two-Way Adapter Block

No Change to Numerical Behavior

Two-Way Connection block in R2007a Simscape v1
Application

JMAAB Style Guidelines

& Vehicle Model Architecture
JMAAB Plant Model Style Guidelines

- Component Hierarchy
- Model Implementation
- Methods for Connecting Components
- Integration of Controller and Plant Models
- Use of Data Types
- Use of Coord. Sys., Unit Sys. and Physical Consts
- Methods for Model Parameterization
Vehicle Model Architecture

- Component Hierarchy

vehicle model architecture (template)
subsystem layers & component partitions

Level
1. Driver, Vehicle, Tire-Road, Environment
2. Vehicle Ctrl, Vehicle Body
3. Power Train, Chassis, Electricity
4. Power Train Ctrl, Power Train Body
5. Engine, Engine Mount, Transmission, Differential
Vehicle Model Architecture

- Model Implementation
  general rules for plant modeling in Simulink
  prohibited blocks and constructs, use of fonts and colors, etc.

- Methods for Connecting Components
  rules for use of signal lines, Goto/From blocks, bus signals
  for good readability
Guidelines for Closed-Loop Simulation

- Integration of Controller and Plant Models
  for use in the hardware-in-the-loop simulation
  streamlining of the workflow of closed-loop simulation
Other Guidelines

- Use of Data Types
  - consistent choice of data types
  - physical value, logical value, Switch block etc.

- Use of Coord. Sys., Unit Sys. and Physical_consts
  - standard modeling practices among developers*
  *developers can span across OEM and suppliers.

- Methods for Model Parameterization
  - consistent use of parameters
  - workspace variables, M-files
Future Work for JMAAB PM-WG

- Further evaluation of the Style Guidelines with the vehicle model as a working example

- Identification of requirements for Two-Way Connection from the automobile engineering standpoint

- Benchmark of the vehicle model to examine the effectiveness of the style guidelines

- Consideration on Data Dictionary for Plant Models to enable smooth exchange of models
Conclusion

- Component oriented physical modeling
  two-way connection in R2007a Simscape

- Common rules for MBD plant modelers
  JMAAB Style Guidelines for Plant Models

- Test case in automobile industry
  vehicle model architecture
Thanks to...

T. Kubo, K. Nakashima (Aisin AW)
H. Iino, F. Yamazaki (Cybernet)
H. Mori (Denso)
M. Ichinose, H. Ogata (Hitachi)
A. Miyauchi, S. Shimada, K. Tsutsumi (Honda)
Y. Hanamura, M. Nishito (Isuzu)
F. Katsu, T. Matsumura (Jatco)
S. Komori, Y. Shinya (Mazda)
Y. Akemi, M. Yamada (Mitsubishi Electric)
M. Taira (Nissan)
T. Degaki, J. Kako (Toyota)

J. Wendlandt (MathWorks)