rtb_either = power_window_con_B.passenger_control_b || power_window_con_B.passenger_control_a;

rtb_temp34 = power_window_con_U.driver_up && !(rtb_either);

/* Logic: '<S13>/allow_action' incorporates:
 * Inport: '<Root>/driver_up'
 * Logic: '<S13>/overrule'
*/

Pieter J. Mosterman
pieter.mosterman@mathworks.com
Senior Research Scientist
The MathWorks, Inc.
Introduction

- Model-Based Design
  - Exploit computational models
  - Increasingly adopted in industry
- Modeling at an enterprise level
  - Many different modeling formalisms
  - Relate and combine models
    - Different parts of a system
    - Different design stages of a system
- Challenges
  - Efficiently manage models, formalisms and levels of abstraction
  - Efficiently evaluate dynamics of different computational semantics
Agenda

- Model-Based Design
- Model elaboration demonstration
- Implementing a functional specification
- Summary
Model-Based Design

Requirements and Specifications

Functionality

Implementation

Test and Verification

Excel
Word
Scenario diagrams

Block diagrams
Statecharts
Hybrid Automata
Bond graphs

C/C++
Java
HDL
ASM

DEVS
Automata
Numerical Values
Polynomials
Mercedes-Benz trucks cruise controller

• Created and implemented modular cruise control software on a target ECU

• Results
  • Compact, efficient code
  • High test efficiency
  • Fast development

“MathWorks tools for modeling and code generation enabled us to quickly and seamlessly perform design and test iterations, and release our product within a hard deadline of 18 months.”

Mario Wunsche, DaimlerChrysler
Satellite attitude control system

- Developed the attitude control system for Ministat-01

Results
- Accelerated simulation
- Substantial time and cost savings
- Problem-free performance, helping to extend the satellite mission’s life

“We faced the challenge of not only developing the software for the attitude control system for Ministat-01 in less than one year, but also completing exhaustive tests before the integration of the software with the other satellite systems, all within 14 months. It would not have been possible to develop, produce, and test the software within that timeframe without MathWorks tools.”

Jose Ramon Villa, SENER Ingenieria y Sistemas, S.A.
Enterprise wide Model-Based Design

- Multiple teams of experts working on
  - Different parts of the system
    - Engine, transmission, suspension
    - Fuel injection, shift logic, ABS
  - One part in different phases of development
    - Requirements, systems, controls, and software engineers
    - Requiring different levels of abstraction
- Challenges arise due to the partition of this effort
  - How to minimize dependencies, when the parts are inherently coupled?
  - How to integrate the parts and optimize the complete system?
Integration is two-fold

Same part needs to migrate through different phases

Different parts need to be integrated across phases

Different parts need to be integrated within the same phase
Ecosystem of computational models

- Make models electronically available
- Directly upload from within Simulink
- Proper modeling practice
  - Test harness with referenced core model
- Meta tags
  - Number of input and output ports
  - Continuous time integration
  - Cyclomatic complexity
Agenda

- Model-Based Design
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- Summary
Executable specification

Image From File

Sobel Edge Detection

Executable Specification/Edges

Video Viewer

Original Image

Executable Specification/Edges

Video Viewer

Original Image
Design elaboration

- Edge detection
  - Design space exploration using floating point
  - Conversion to fixed point
  - Elaboration to facilitate streaming data
  - Co-simulate with HDL
Agenda

- Model-Based Design
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Towards an implementation

- SoC platform
  - Heterogeneous
  - Highlights more common design challenges

\[ z^{-1} \rightarrow 2D \text{FIR Filter} \rightarrow |u| \]

- System
- Software
- Digital hardware
  - ASIC
  - CPU
  - Communication
- Analog hardware
  - A/D
  - RF
  - D/A
  - MEMS

cf. Jan Madsen
A new frontier ...

- No clear HW/SW separation
- Traditionally different design paradigms
- Reconfigurable
  - Hardware and software
  - Adapt to environment
- Novel
  - design paradigms
  - applications
Piecing it all together …

- **Compiler**
  - Combines
    - Functional design
    - Architecture
  - Generates
    - Hardware (HDL)
    - Software (C/ASM)

- **Simulator**
  - Explore design space
  - Verify design choices
    - Hardware in the loop
    - Processor in the loop
    - Silicon in the loop
    - …
Agenda

- Model-Based Design
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Summary

- Model-Based Design
  - Enterprise-wide usage
- Model transformation is everywhere
  - Design elaboration
  - Implementation design
- Strict hardware/software separation is fading
  - For example, cross discipline optimizations
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- ...