PtOlemy II
The automotive challenge problems version 4.1

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Overview
- Yellowstone recap
- Selected challenge problems
  - 1.1 Multiple-view modeling
  - 1.2 Automated composition of subcomponents
  - 3.3 Code generation
Yellowstone recap: Design of embedded control systems

- Different phases, different tools, different people makes it difficult to debug:
  - Control engineer view
    - plant dynamics, stability, phase margins, rise time, etc.
    - assumes: equidistant sampling with no or little latency
  - Embedded system engineer view
    - scheduling, priorities, memory usage, communication setup, etc
    - assumes: fixed controller design
- A good toolset supports close interaction between the different phases/teams
- The only interesting performance metric is the behavior of the controlled system

“Classical” development cycle

- Sign-offs are expensive
- Feedback slow
Closing the “system design/control design” loop

- hardware setup
- communication priorities
- RTOS tuning

**system design**
- evaluate system performance

**control design**
- controller parameters
- delay compensation
- reviewing specs

Idealized Model

Assumes equidistant sampling constant latency

More realistic model

- Multitasking
  - jitter, execution time
  - RTOS domain
- Communication
  - Transport, routing, medium access
1.1 Multi-view modeling

- Different granularity models
  - Level 1: Hybrid automata with continuous dynamics
  - Level 2: Discrete controllers and some scheduling info
  - Level 3: Platform-specific info

- Component refinement
  - Start with a naïve implementation and make it gradually more complex

- Ptolemy II
  - Component based
  - Hierarchical and heterogeneous
  - Functional behavior and control flow decoupled through the use of directors
  - Composite actors treated like atomic

Multi-view modeling in Ptolemy II

Hierarchical, heterogeneous model
Component refinement in Ptolemy II
Example model 1

Component refinement in Ptolemy II
Example model 2
Composite actors

- From top level view: the behavioral semantics of the component has not changed!
- Aggregation not just syntactical
- Composite actor is opaque

1.2 Automated composition of sub-components

- What is the actual problem?
  - Example: Many states and many signals in a Stateflow + Simulink gets means and whole lot of wiring
  - Lack of proper aggregation!
  - Ptolemy addresses the problem through hierarchy
  - Smarter editor vs. new languages
The ModalModel in Ptolemy II

- Wiring of the state refinements is done automatically,
- All wires are hidden under the hood

3.3 Code generation

- From Java to Java & Java to C at Maryland
- Actor libraries are built and maintained in Java
  - polymorphic libraries are rich and small
- Collapsing composite actors to atomic actors
  - Director + actors => actor
- Efficiency gotten through code transformations
  - specialization of polymorphic types
  - code substitution using MoC semantics
  - removal of unnecessary code
Outline of our Approach

Model of Computation semantics defines communication, flow of control

All actors are given in Java, then translated to embedded Java, C, VHDL, etc.

Conclusions

- Hierarchically heterogeneous modeling matches the applications well.
- Component based technologies and hierarchical heterogeneity gives good support for
  - Multi-view modeling
  - Piecewise refinement
- Tool integration as a more fundamental problem
  - About designing the proper protocol for communication between subsystems