TECHNISCHE UNIVERSITÄT DRESDEN

Putzmeister

A Study of OpenModelica in Realtime Simulation for Virtual Reality Environments

Linköping, 08.02.2010

Virtual Reality Simulation of a Concrete Spraying Machine

Software Environment

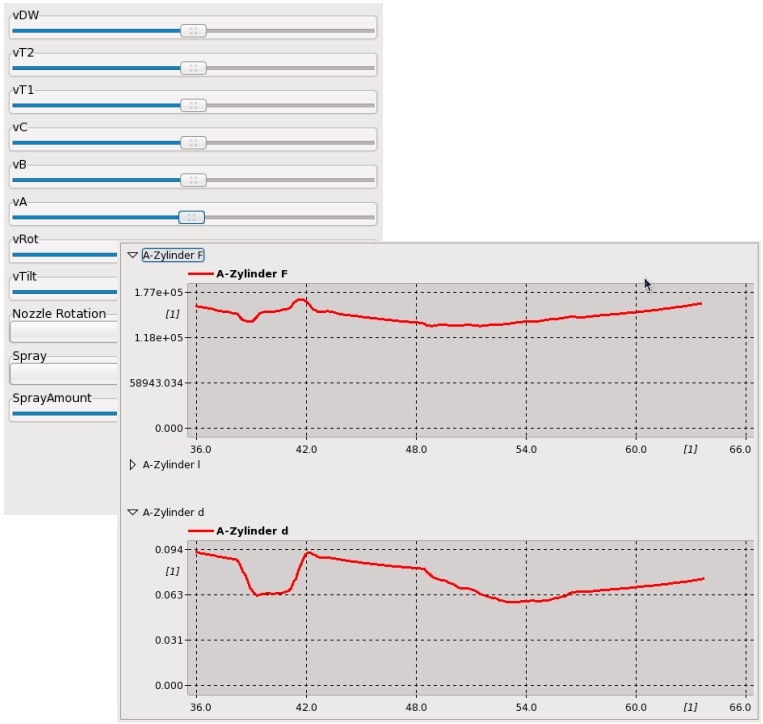
- Need for a flexible simulation environment
- Different use cases
  - Mechanical problems
  - Design of hydraulic systems
  - Controller and machine software development
  - Operator acceptance
- Reusability of (parts of) models is very important

  Modelica is the right choice
- Simulation environment should be as flexible as modelling
- Virtual reality is no playback for simulation results
- Available desktop simulation tools are limited

Open Source Software and Standards

OpenSceneGraph (OSG)

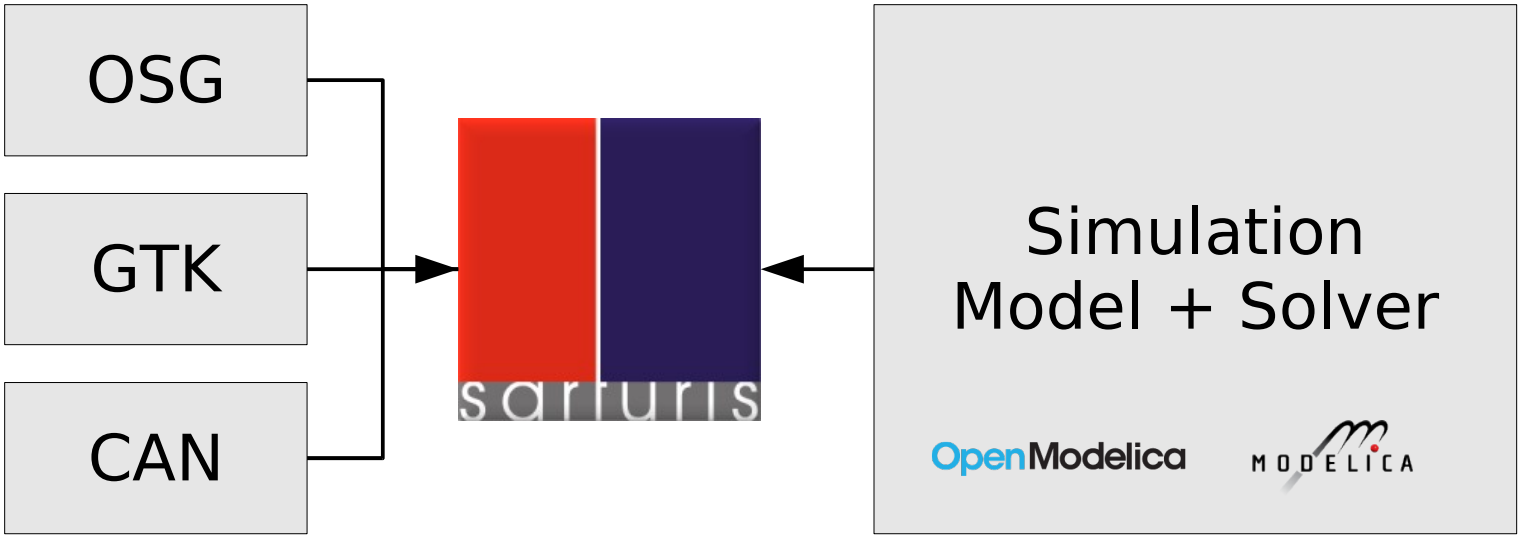
Gimp Toolkit (GTK)



CAN bus

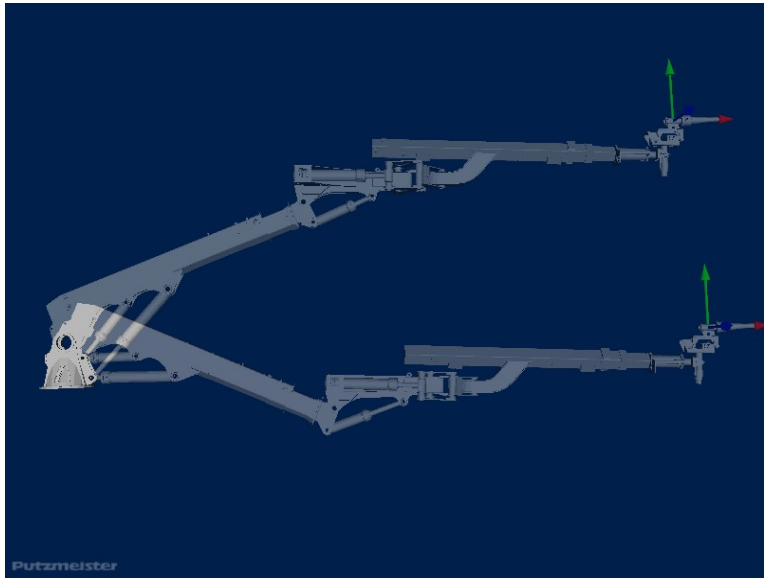
Organization in a Plugin Architecture

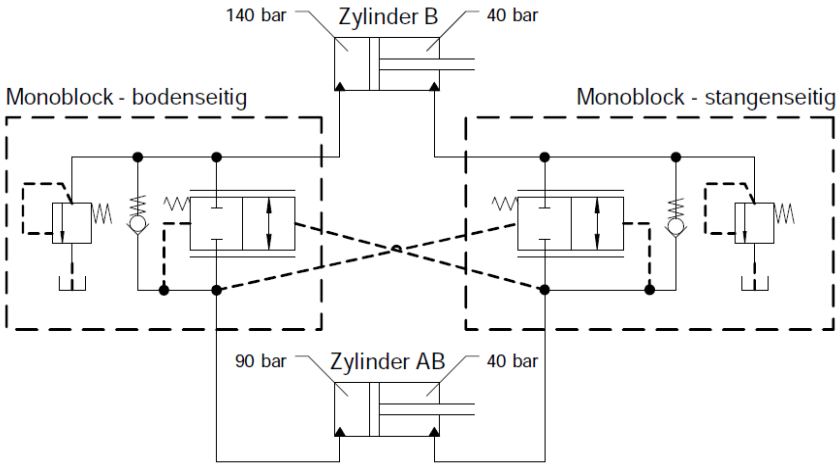
- Definition of standard inferfaces
- Lightweight application
- Functionality is distributed accross plugins
- Plugin composition described with XML



Simulation Model of the Concrete Spraying Arm

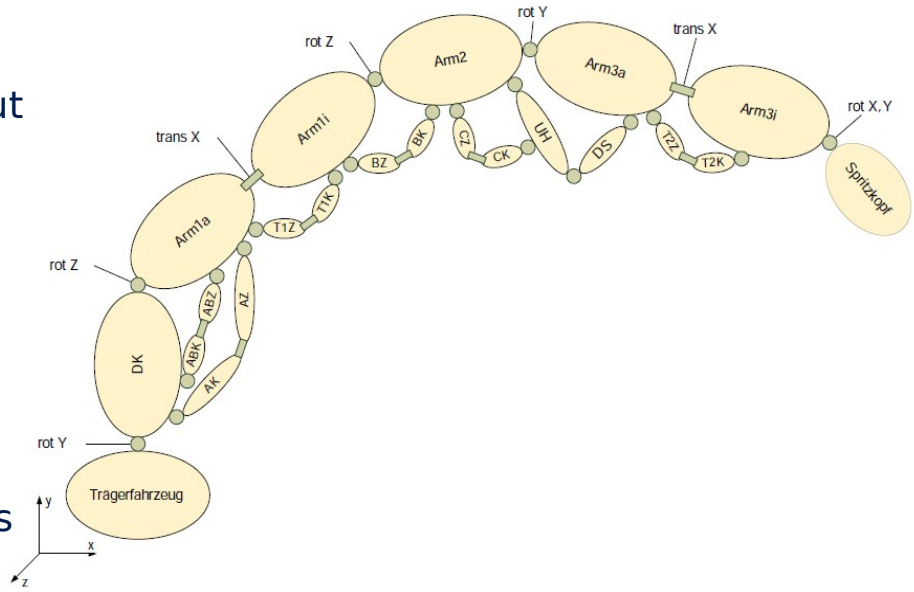
- Main goals
  - Test of operator acceptance
  - Analysis of parallel kinematics (hydraulic coupling)





Model of the Mechanics

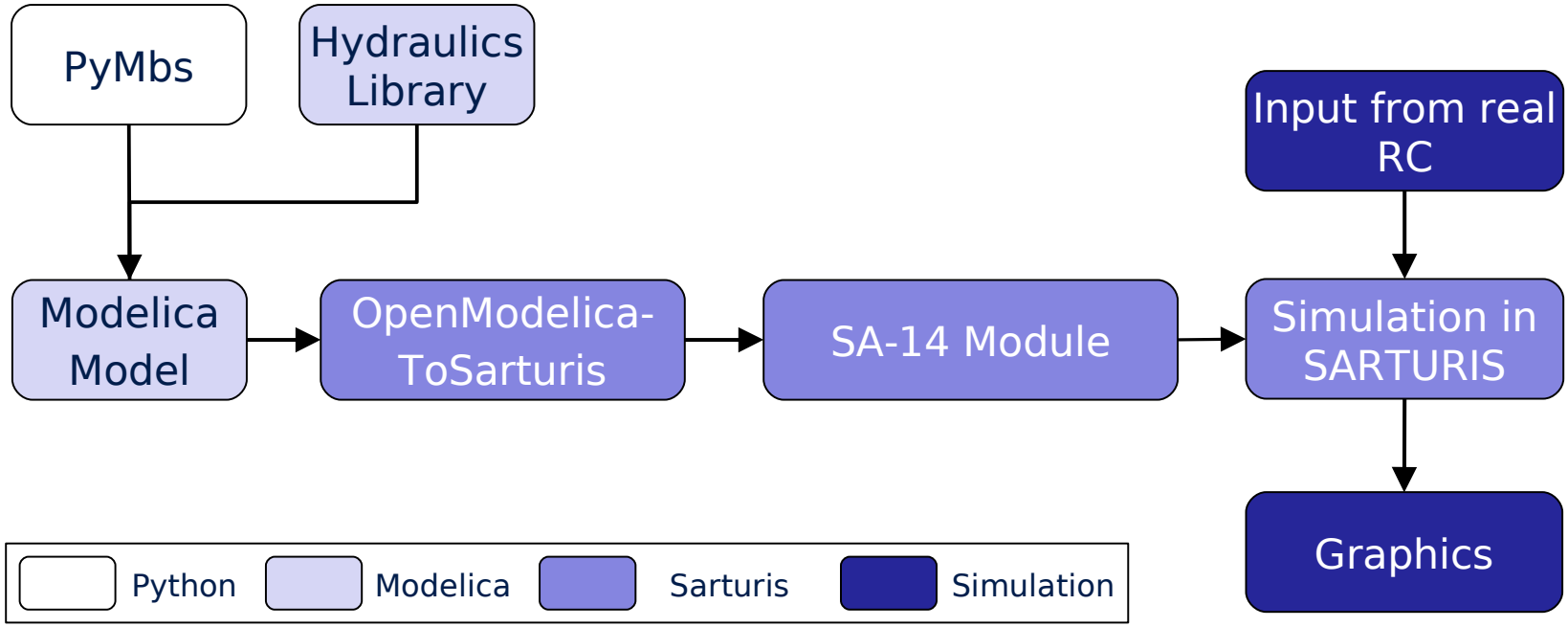
- No support for standard multibody library in open modelica
- PyMBS with flat modelica output
- 22 Bodies
  28 Joints
  7 Internal forces and torques
  6 external forces and torques
  Simplified jet head kinematics
- Events due to mechanical stops of hydraulic cylinders
- Outputs for body positions



Model of the Actuation System

- Simple model with velocity proportional controllers
  - Operator acceptance
  - Controller and software development
- Model of the hydraulic system based on a library of TU Dresden
  - Hydraulic pump
  - Proportional valves
  - Check valves and pressure protection
  - Load stabilization
- Easy exchange due to common interface
  - Multi body model
  - Inputs und outputs for interaction with virtual reality

Transfer to Sarturis



Sundials Solver

- Sarturis has an implementation of IDA and CVODE
  - Wrappers around sundials-2.4.0
- IDA
  - General DAE solver
  - OMC could create a system of DAEs
- CVODE
  - Works fine in desktop simulation
  - Step size adjustment and event handling prevent hard real time capabilities
  - Interactive simulation works with moderate models (soft real time)
- Interactive simulation better with Runge-Kutta methods
- Nice discussions about inline integration

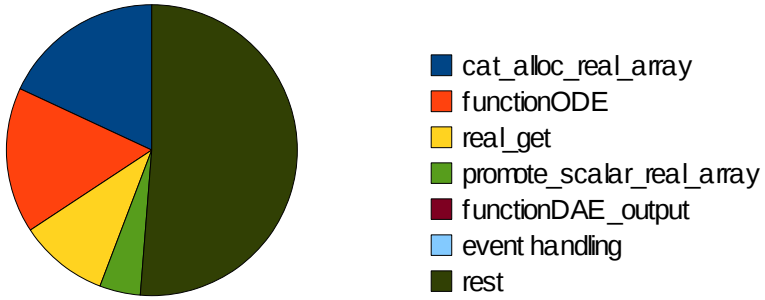
XML output

- Create a more sophisticated model transformation
  - Modelica -> XML -> C++ -> Sarturis
  - Could store meta information and equations in one file
  - No parsing of generated C code
  - Could be Python based
- 1.5.0rc2 and SVN revision 4909 produce parsing errors in annotations (simulation works)
- 1.4.5 generates incorrect XML
  - Example: `<zeroCrossingElement string=”vA < 0.0”>`
- State of XML ambiguous
  - DAE/ODE
  - Flat model

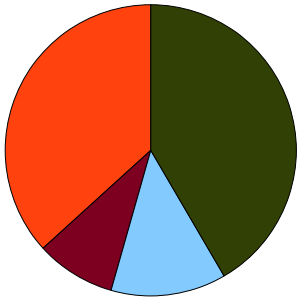
Some sysprof results

- Platform
  - AMD Athlon(tm) 64 X2 Dual Core Processor 5000+
  - Fedora Core 11, Kernel 2.6.30.10-105.fc11.x86_64
- Multithreaded application
  - Different cpu mask for every thread
- Waiting for real time sync is not measured

SVN revision 4042



SVN revision 4909



Optimization attemps

- PyMBS modelica output
  - Write "`constant Real`" instead of "`Real`" for parameters

- SVN version 4042
  - Increase of omc compile time from 60 sec. to more than 10 min.
  - Strong increment of code size (if you are patient)
  - Poor model calculation performance

- SVN version 4909
  - No mentionable effect in omc compile time and code generation

Conclusion

- OpenModelica and Sarturis give the opportunity for real time simulations in virtual reality
- Modelica enables a flexible way of modeling, covering a lot of different scenarios in product development
- Standard use case of modelica tools (transform to C, compile, run, plot the results) can not cover interactive simulations
- Flexible output of equations will allow lots if different use cases for models
- Generated C codes of 2MB even for simple models point to a future bottleneck