TECHNISCHE UNIVERSITÄT DRESDEN

Chair of Construction Machines and Conveying Technology

OpenModelica Workshop 2016

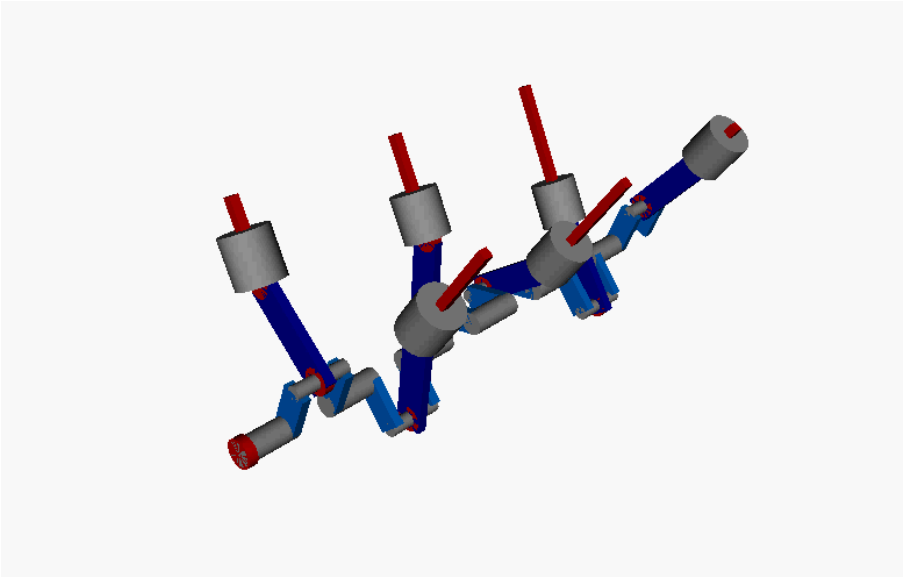
Multibody-System Visualization and Interactive Realtime Simulation of FMUs for OpenModelica based Simulations

Linköping, 01/02/2016

DRESDEN concept
Exzellenz aus Wissenschaft und Kultur

Outline

1. Motivation
2. OMVis - Visualization Tool
3. Interactive Simulator
4. Summary and Outlook



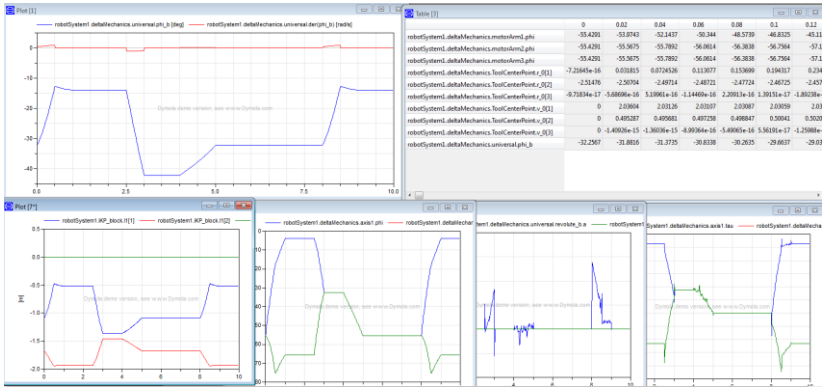
MOTIVATION

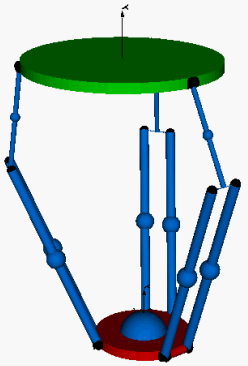
Presentation of Results

numerical values / line plots

+

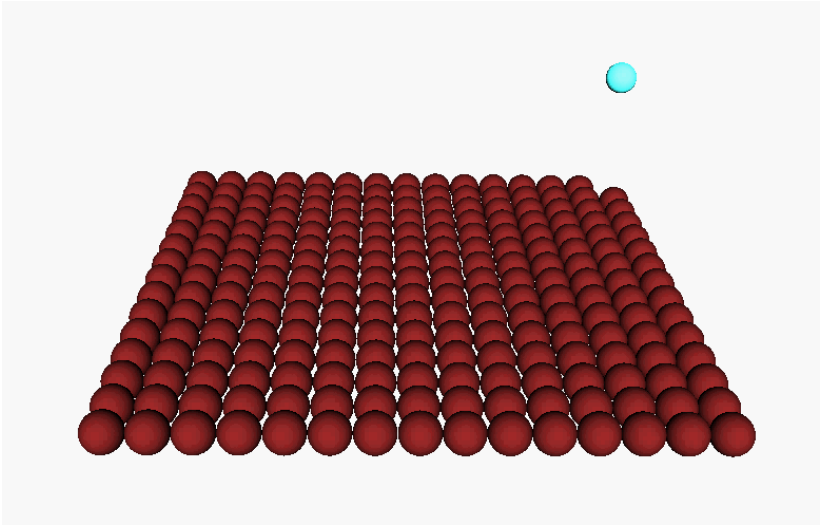
3D animation





Model Visualization

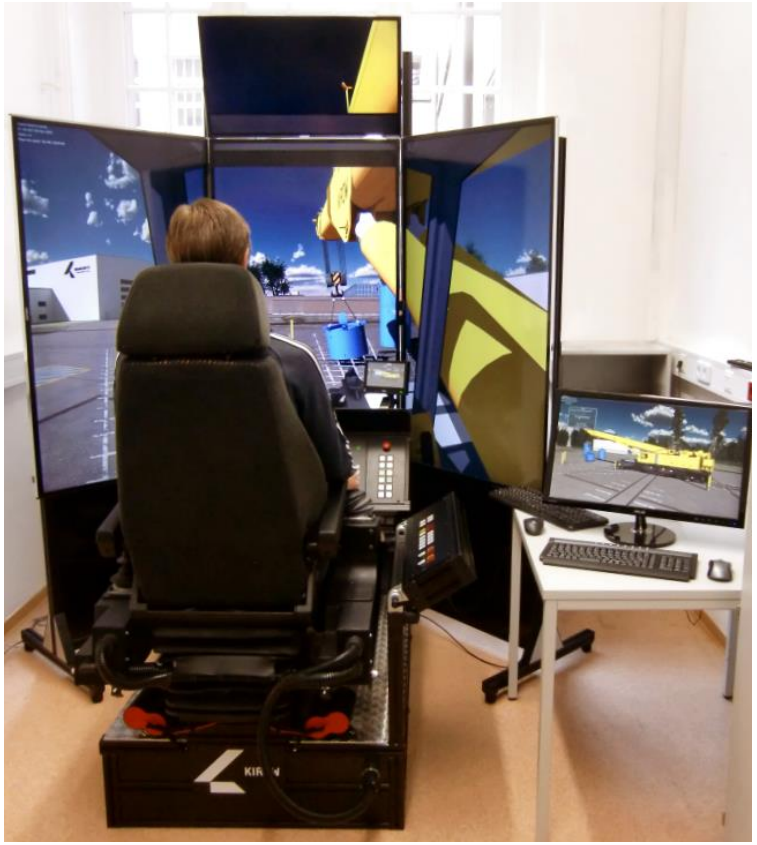
- get an overall understanding of your model behaviour
- model validation
- communicate more data in a faster, more understandable way
- graphic applications (e.g. simulator)



Simulator Development

Get the most realistic behaviour that is still realtime capable.

- evaluation of FMUs for realtime application
- generic simulator setup
- test different FMUs for realtime abbility
  - level of detail
  - optimization, compiler settings
  - parallelization



OMVIS – VISUALIZATION TOOL

Visualization Base Data

Simultaneous animation

- scene update during simulation run
- state-of-the-art for commercial tools
- network communication during simulation

Result file based animation

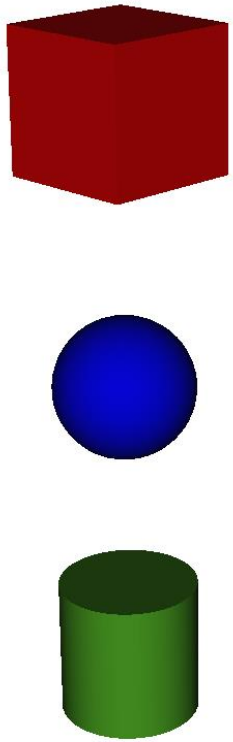
- visualization after completed simulation run
- scene description needed

FMU based animation

- scene description needed
- not specified in standard
- currently no public solution available (?)

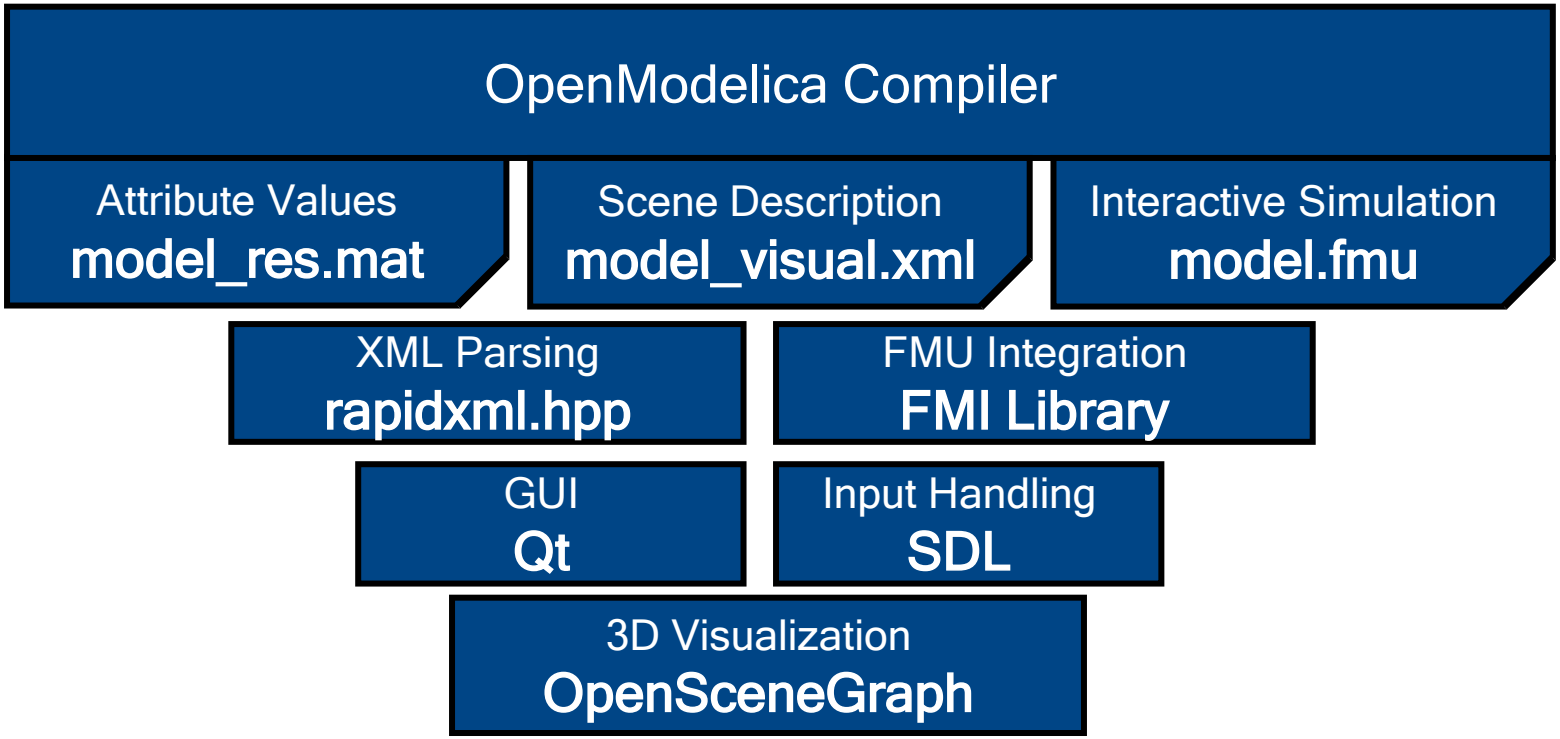
Scene Description

```
<visualization>
  <shape>
    <ident>world.x_label.cylinders[1]</ident>
    <type>cylinder</type>
    <r>
      <cref>world.x_label.r_abs[1]</cref>
      <cref>world.x_label.r_abs[2]</cref>
      <cref>world.x_label.r_abs[3]</cref>
      …
    </r>
    <length>
      <exp>0.05303300858899107</exp>
    </length>
  </shape>
…
```

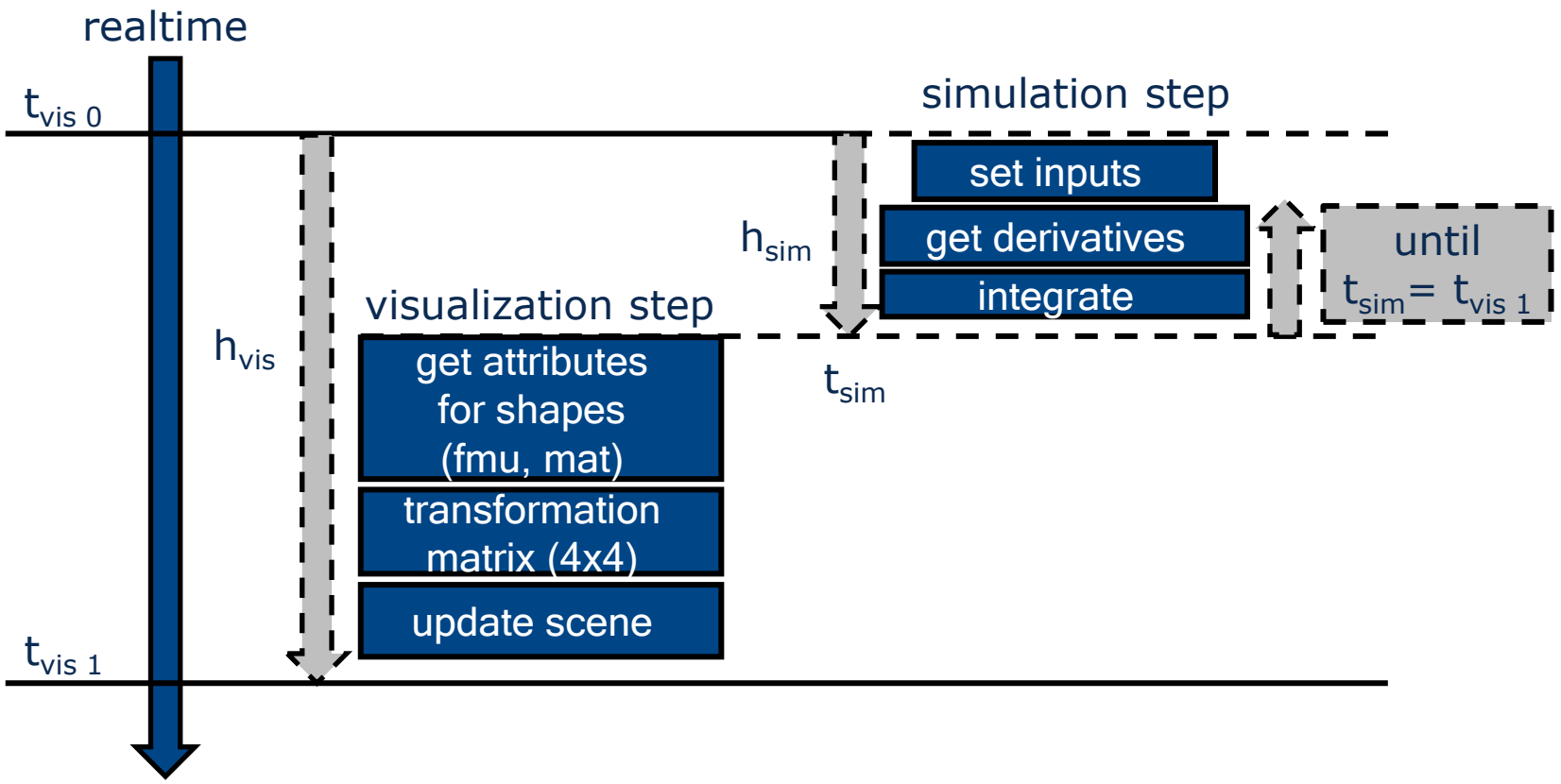


Shapes from:
`Modelica.Mechanics.MultiBody.Visualizers.Advanced.Shape`

Structure


OpenModelica Compiler
Attribute Values
model_res.mat
Scene Description
model_visual.xml
Interactive Simulation
model.fmu
XML Parsing
rapidxml.hpp
FMU Integration
FMI Library
GUI
Qt
Input Handling
SDL
3D Visualization
OpenSceneGraph

Workflow


realtime
$t_{vis\ 0}$
$t_{vis\ 1}$
h_{vis}
simulation step
h_{sim}
set inputs
get derivatives
integrate
until
$t_{sim} = t_{vis\ 1}$
t_{sim}
visualization step
get attributes for shapes (fmu, mat)
transformation matrix (4x4)
update scene

INTERACTIVE SIMULATOR

Realtime Criteria

- simulation of a time range Δt has to be faster than realtime Δt

→ deterministic execution time of system computation and time integration:
  - no event iteration (or fixed number of iterations)
  - no nonlinear systems (or fixed number of iterations)
  - no implicit time integration methods (or fixed number of iterations)
  - no order or step size control (fixed step size)

In practice:

everything is allowed as long as the real time criteria is fulfilled

Encounter Realtime Requirements

model adaptation:

- linearization, stiffness, complexity reduction

system computation:

- tearing, reshuffling, partial function evaluation, common-sub-expression-elimination, backend-evaluation of linear torn systems
- evaluation of parameters, compute outputs only
- parallelization

time integration:

- multirate, multimode, inline integration

hardware

Excavator model

Summary

- Implementation of a visualization tool
- either result file visualization or fmu-based, interactive visualization
- scene description XML file, generated by OpenModelica Compiler
- generic simulator set up to evaluate FMUs for interactive simulators

Outlook

- further enhancement of OMC to perform automated realtime optimizations
  (multirate integration with static partitioning)
- extend OMVis for missing functionalities
  (missing geometric primitives, modelica visualization lib?)
- FMU visualization standard ?

Thank you for your attention.

Volker Waurich
volker.waurich@tu-dresden.de