TECHNISCHE UNIVERSITÄT DRESDEN

Fakultät Maschinenwesen, Professur für Baumaschinen und Fördertechnik

Simulating MultiBody Applications with OpenModelica

– Current Status -

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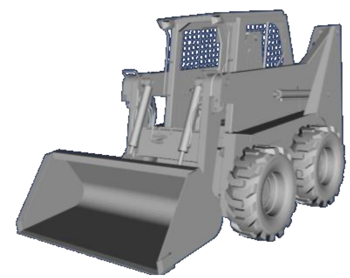
Outline

1. Introduction
2. Feature Status
3. Performance by looking at Examples
    a. Examples
    b. Translation
    c. Compilation
    d. Simulation
4. Possible Future Directions

Applications

Models



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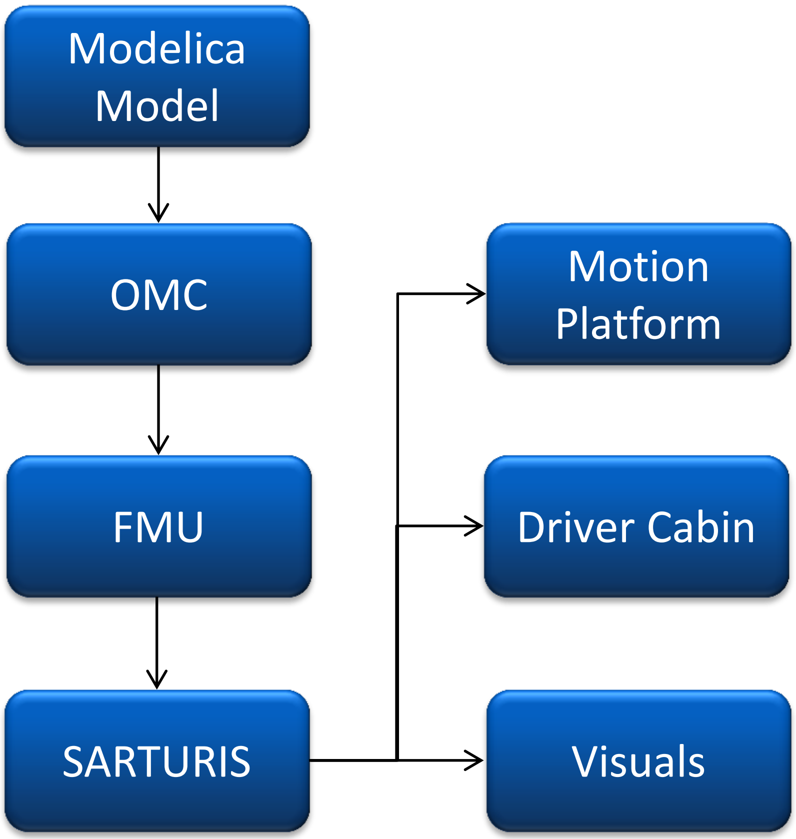
Applications

Simulator

Toolchain



=> Performance is most important to us

Required Features

Handling of Records, Vectors, Matrices	✔
Overconstrained Connection Graph	✔
Annotations: Inline, (__Dymola_)InlineAfterIndexReduction, derivative, noDerivative, Evaluate	✔
Dynamic State Selection	~
Handling of replaceable gravityFunction	✘

Peformance/Comfort Features

Tearing Reducing size of sparse blocks	✔ / ~
Nonlinear Solver (Kinematic Loops)	~
Analytic Jacobians	~
Robust and fast Event Handling	~
Support for large models	~
Visualization	~ / ✘

Current Status

Necessary features implemented

Workaround for gravityFunction

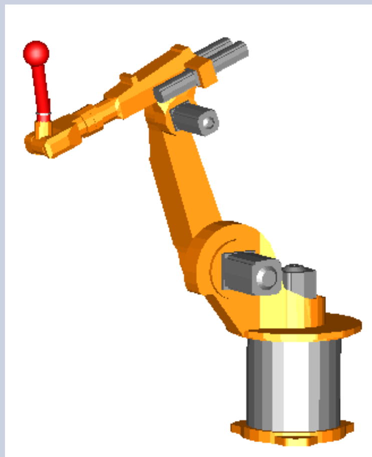
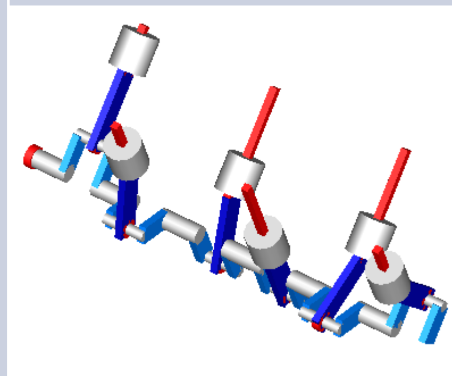
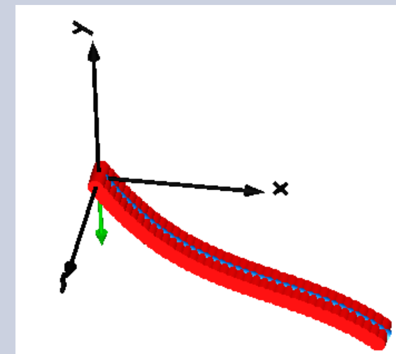
⇒ Multibody should work

⇒ One test from MSL 3.2.1 fails:
Elementary.UserDefinedGravityField

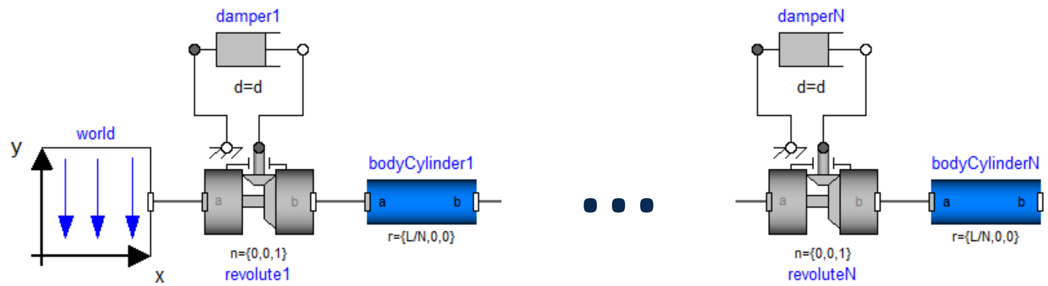
Performance/Comfort functions not finished

Let us see how they perform

Examples

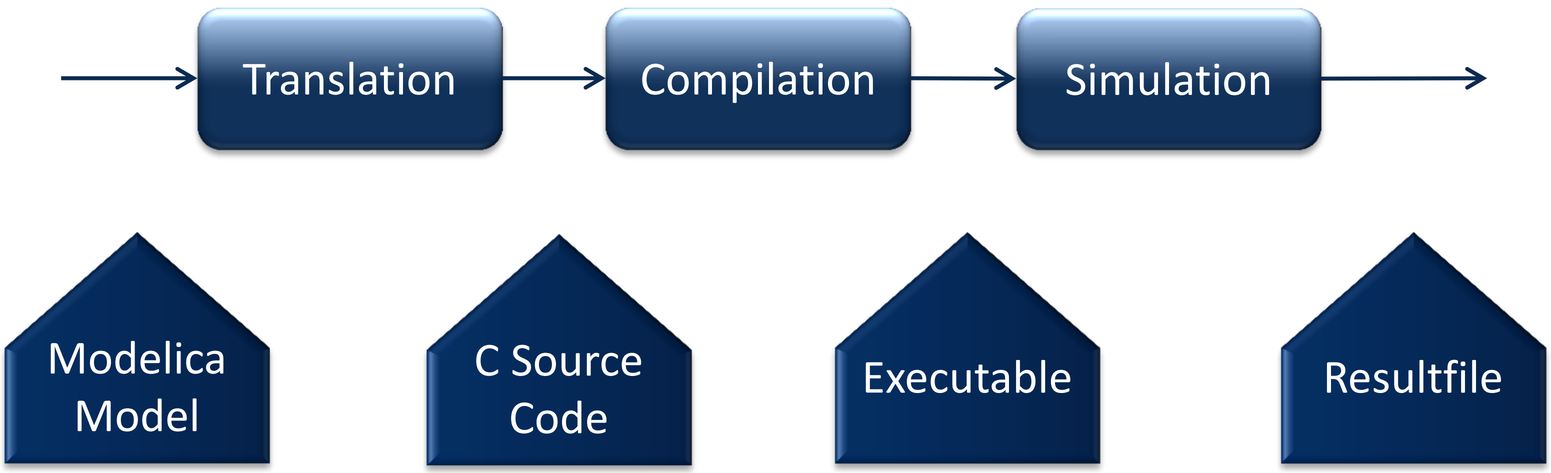
	RobotR3	EngineV6	Pendulum N
Picture			
#Vars	4921	12491	≈ 242 N
#States	36	4	2 N
#NIs	0	6	0
Linear	137 -> 6	322 -> 31	≈ 12 N -> N

Pendulum with N bodies

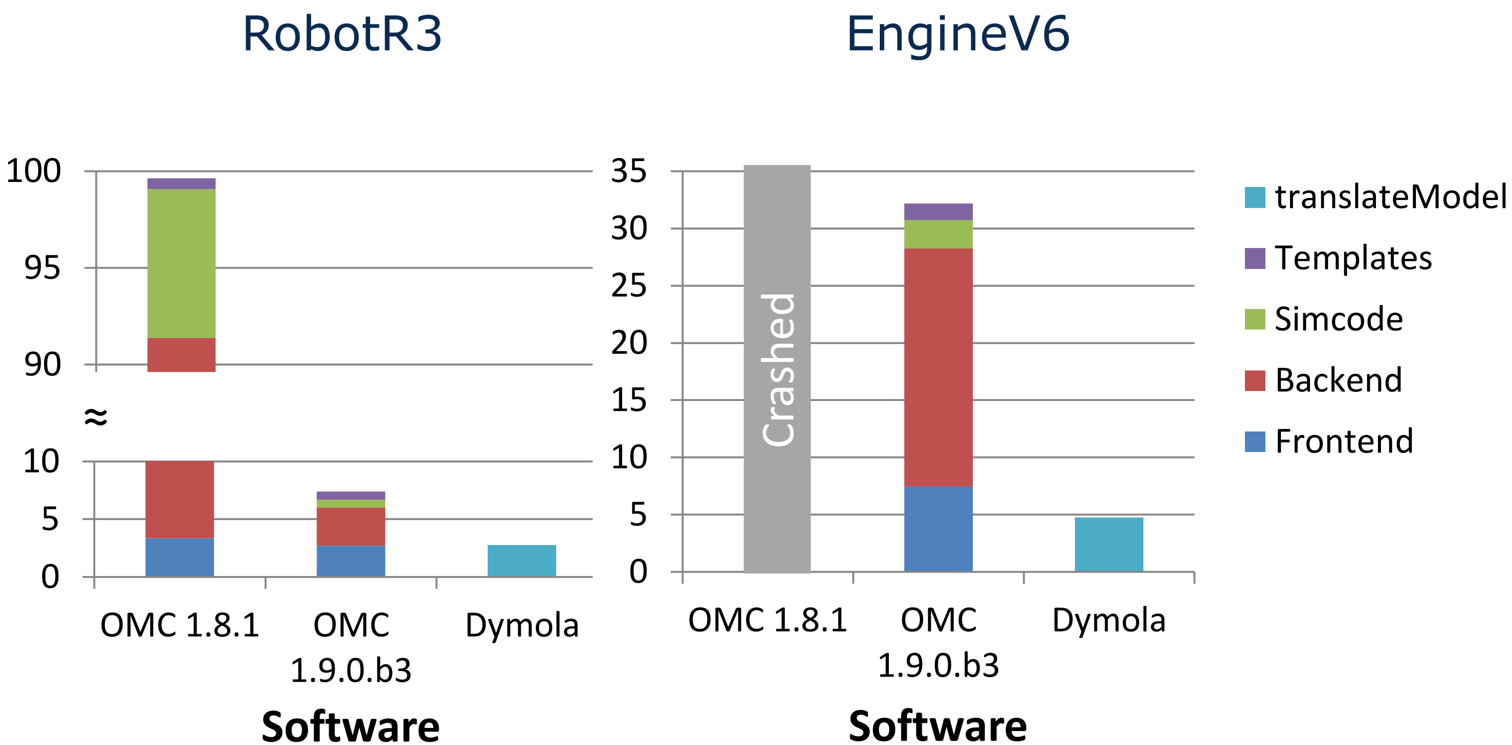



```
model Pendulum_N
  constant Integer N = 2;
  inner World world;
  Revolute revolute[N];
  BodyCylinder bodyCylinder[N];
  Damper damper[N];
equation
  connect(world.frame_b, revolute[1].frame_a);
  connect(revolute.frame_b, bodyCylinder.frame_a);
  connect(damper.flange_a, revolute.support);
  connect(damper.flange_b, revolute.axis);
  connect(bodyCylinder[1:N-1].frame_b, revolute[2:N].frame_a);
end Pendulum_N;
```

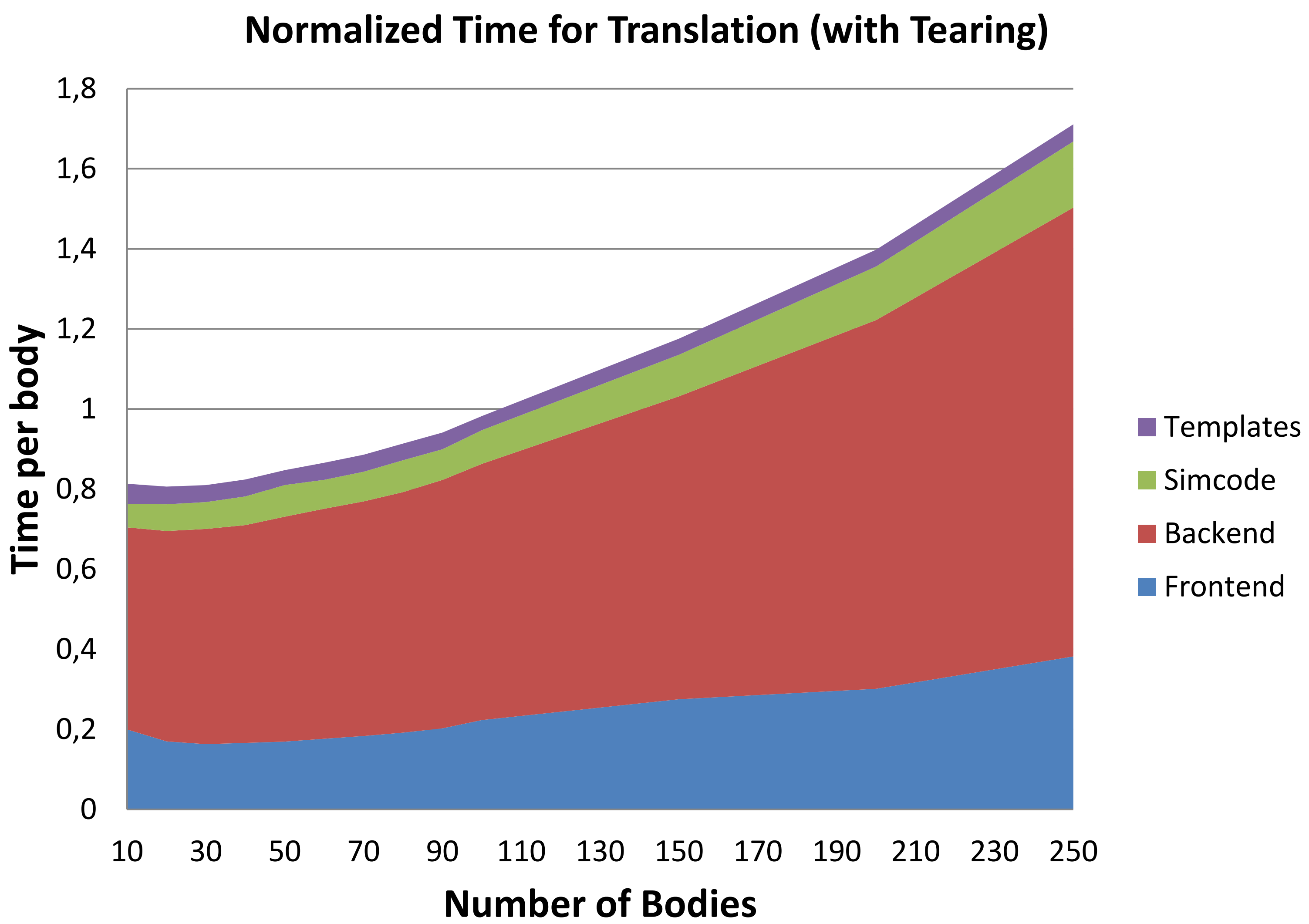
Division into three steps



Translation



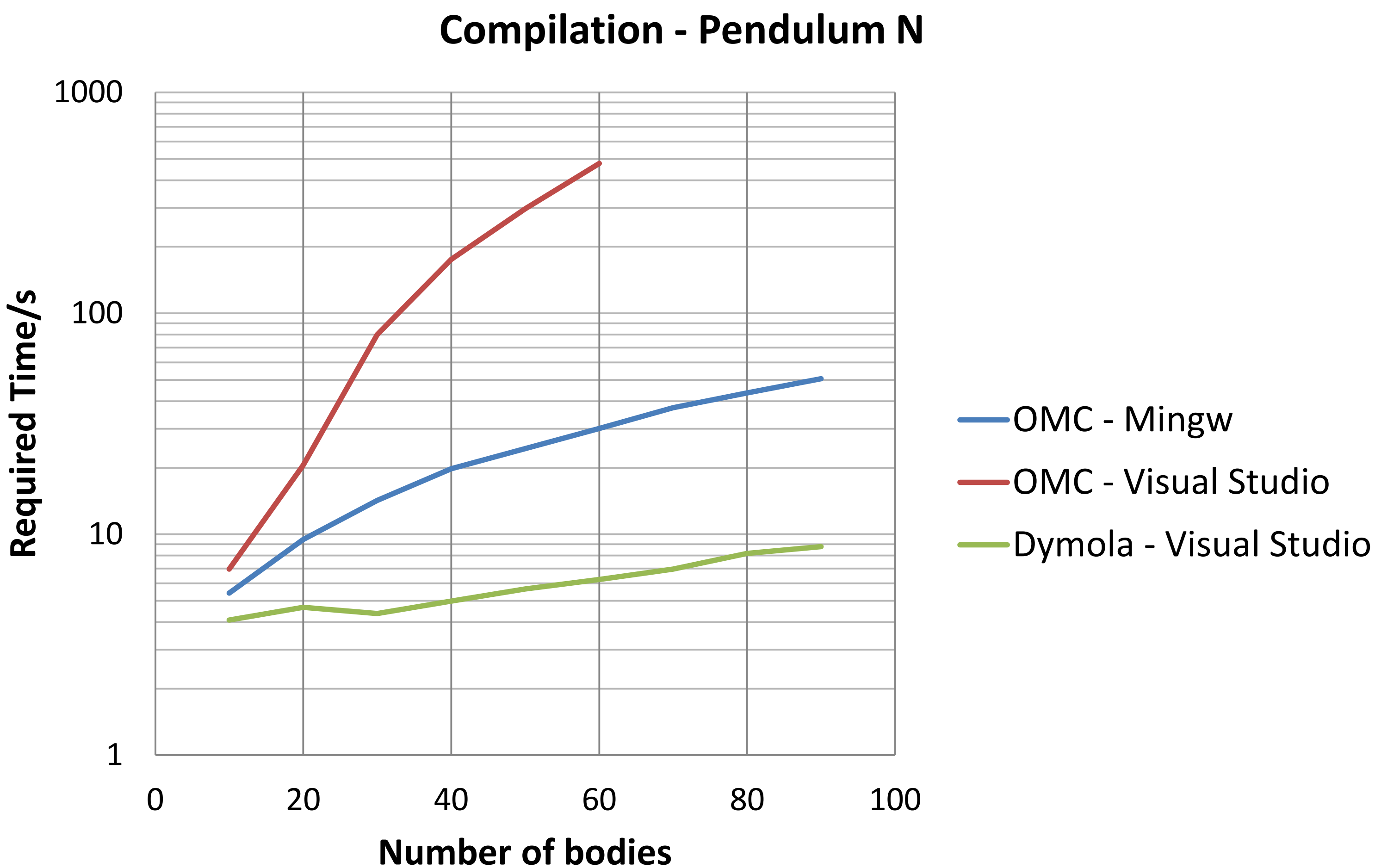
Translation



Translation

- Translation lies within factor 10 of Dymola
- Translation scales with $O(N^2)$
- Problems have been identified
  and are being fixed

Compilation



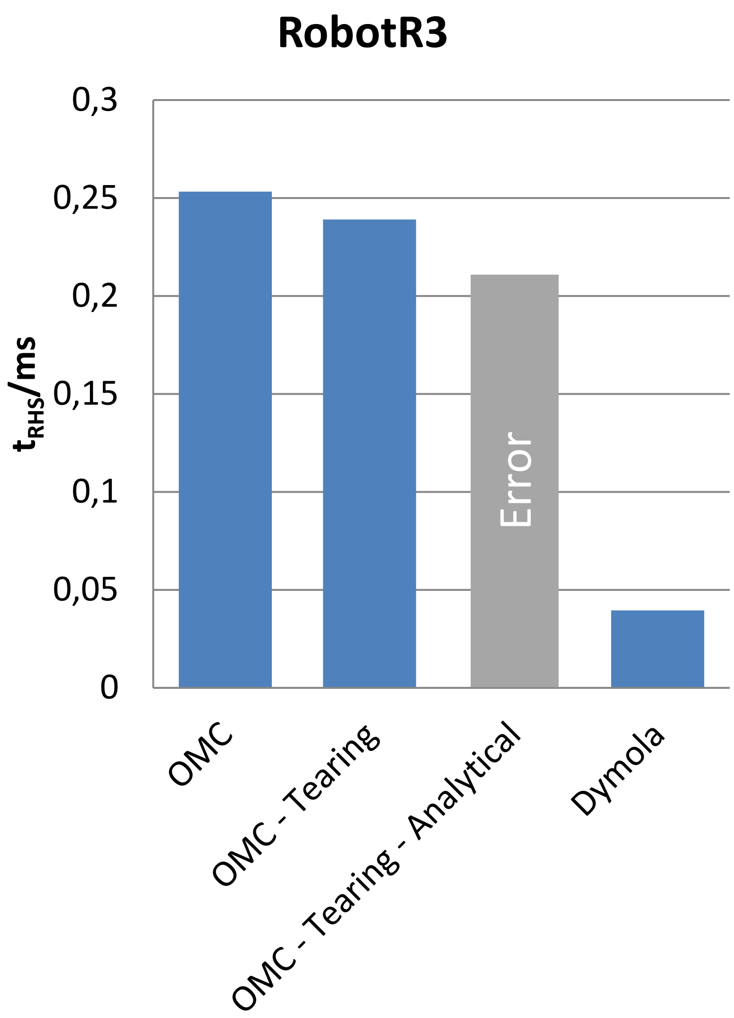
Compilation

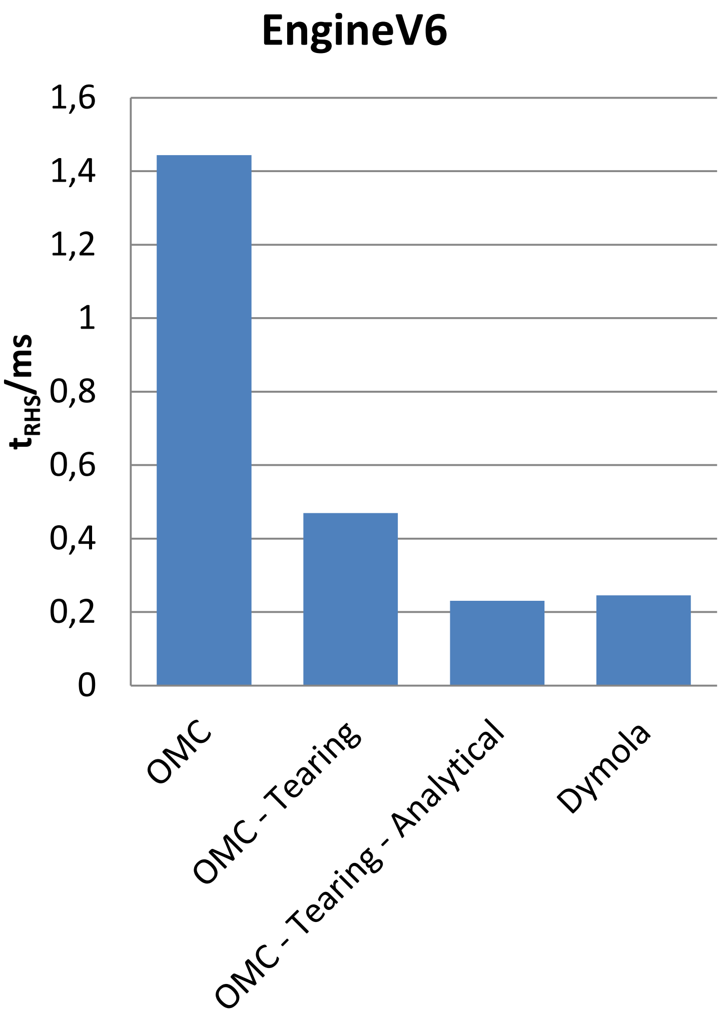
- Compilation as long as translation
- Compilation limits model size
- gcc faster than Visual Studio
- much slower than Dymola

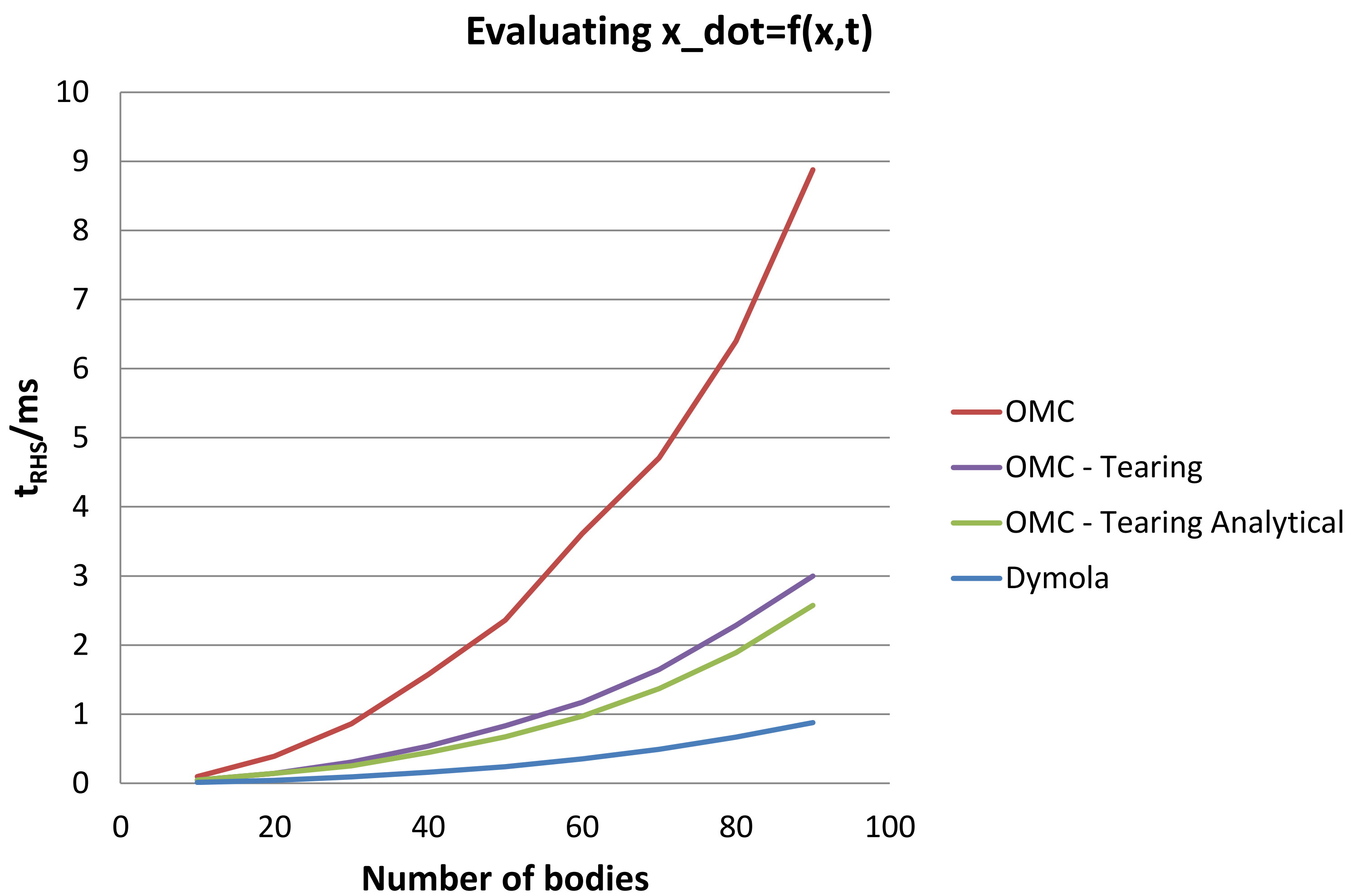
Tearing

- Deactivated by default for linear systems
    - +d=doLinearTearing
- Always treated as nonlinear system
    - => Numerical Jacobian
- Much faster/more robust with symbolic Jacobian
    - +d=doLinearTearing,NLSanalyticJacobian

Simulation


RobotR3
0,3
0,25
0,2
0,15
0,1
0,05
0
t_{RHS}/ms
Error
OMC
OMC - Tearing
OMC - Tearing - Analytical
Dymola


EngineV6
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
t_{RHS}/ms
OMC
OMC - Tearing
OMC - Tearing - Analytical
Dymola


Evaluating x_dot=f(x,t)
10
9
8
7
6
5
4
3
2
1
0
0
20
40
60
80
100
t_{RHS}/ms
Number of bodies
OMC
OMC - Tearing
OMC - Tearing Analytical
Dymola

EngineV6 ($\mathbf{f}(t,\mathbf{x})$ equally fast)

	OMC	Dymola
Simulation time[s]	9,72	5,18
steps	8081	7912
events	544	335
F-Evaluations	12273	24548
Jacobians	3338	3215

Not everything is counted!
Event detection has to be improved

Pendulum with 40 bodies ($\mathbf{f}(t, \mathbf{x})$ 3x slower)

	OMC	Dymola
Simulation time[s]	0,951	0,421
steps	257	240
events	0	0
F-Evaluations	364	1837
Jacobians	14	17

Possible Future Directions

Short term goals: Finishing
- Dynamic State Selection
- Tearing
- Analytic Jacobians

Mid term goal:
- Visualization
- Clean up OpenModelica-Trac

Long term goal:

A complete redesign of the generated code should be considered

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Thank you

»Wissen schafft Brücken.«

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