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Fluid Modeling with OpenModelica:

Recent improvements and Further Needs

OpenModelica Workshop 2011

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Agenda

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- Recent improvements, that make fluid modeller happy
- Test Case
  - Tube Hydrodynamics
  - Media properties calculation with TTSE
- Benchmark results
  - Compilation performance
  - Simulation performance
  - TTSE performance
- Needed Changes
  - Modelica Media -> TTSE
  - Builtin-Functions and Naming
  - Initialization
- Outlook
- Your Feedback

Major Improvements

With respect to fluid modeling

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- Stream Concept
  - Modelica.Fluid port besides Medium, X, c
- Build system
  - Nightly builds
  - Stability
- Analytic jacobian
- OMEdit
- FMI Implementation on the way

Tube hydrodynamics

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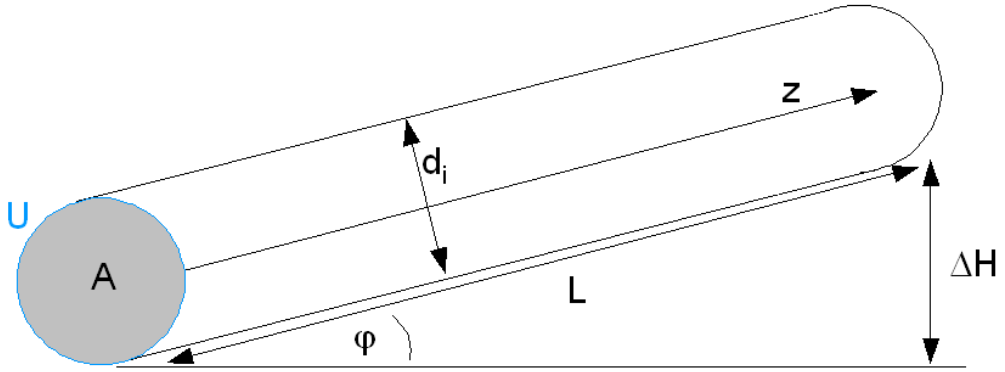
Mass balance

ρ : mass density

$$\frac{\partial}{\partial t}\rho + \frac{\partial}{\partial z}(v\rho) = 0$$



Momentum balance

v : velocity

$$\frac{\partial}{\partial t}(\rho v) + \frac{\partial}{\partial z}(v^2\rho) = -\frac{\partial p}{\partial z} - \rho\left(f_{fric} + f_{hyd}\right)$$

Sources

- Pressure differences
- Friction
- Gravitation

Energy balance

e : specific internal energy

without diffusion

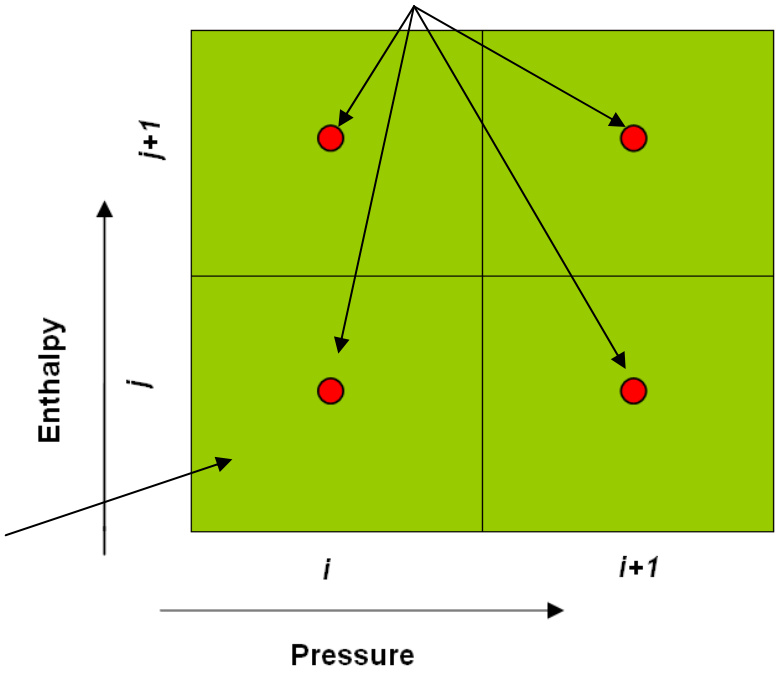
$$\frac{\partial}{\partial t}\left[\rho\left(e + \frac{v^2}{2}\right)\right] + \frac{\partial}{\partial z}\left[v\rho\left(e + \frac{v^2}{2}\right)\right] = \cancel{\lambda \Delta T} - \frac{\partial}{\partial z}(vp) - \rho v f_{hyd} + \frac{U\,\dot{q}_{mf}}{A}$$

- Heating

Changes needed to Fluid models for OMC

Use TTSE (or any external Media) instead of Modelica.Media

Stored grid/table of water thermodynamic properties $z(x_i,y_j)$ and their partial derivatives calculated with the standard IAPWS-IF95 (scientific use) and with pressure (x) and enthalpy (y) as variables



Properties are calculated on each cell (i,j) with the Taylor Series Expansion:

Call of the function in the TTSE library and derivative computation

$$z = z_{i,j} + (x - x_j)\left(\frac{\partial z}{\partial x}\right)_{i,j} + (x - y_i)\left(\frac{\partial z}{\partial y}\right)_{i,j} + \frac{1}{2}(x - x_j)^2\left(\frac{\partial^2 z}{\partial x^2}\right)_{i,j} + \frac{1}{2}(y - y_i)^2\left(\frac{\partial^2 z}{\partial y^2}\right)_{i,j} + (x - x_j)(y - y_i)\left(\frac{\partial^2 z}{\partial x \partial y}\right)_{i,j}$$

TTSE
Accuracy

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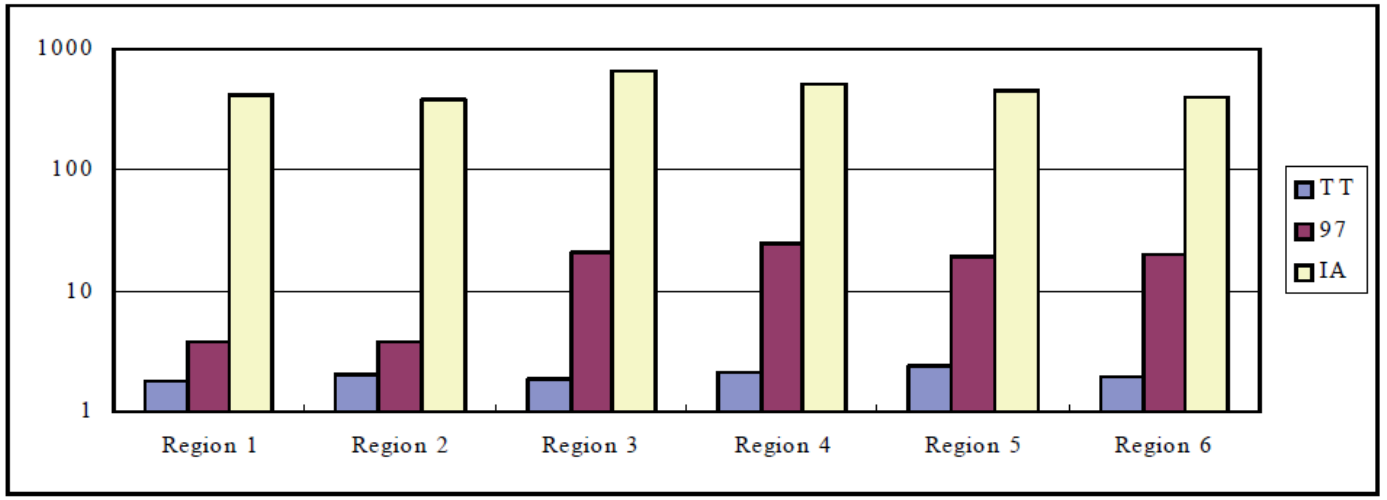
Fast computation time: from half (regions 1 and 2) to one-tenth of the standard IF97



Computation time (10^{-6}s/call) for Prandtl number for TTSE (TT), IF97 (97) and IAPWS 95 (IA) (Kiyoshi Miyagawa report)

Simple test case

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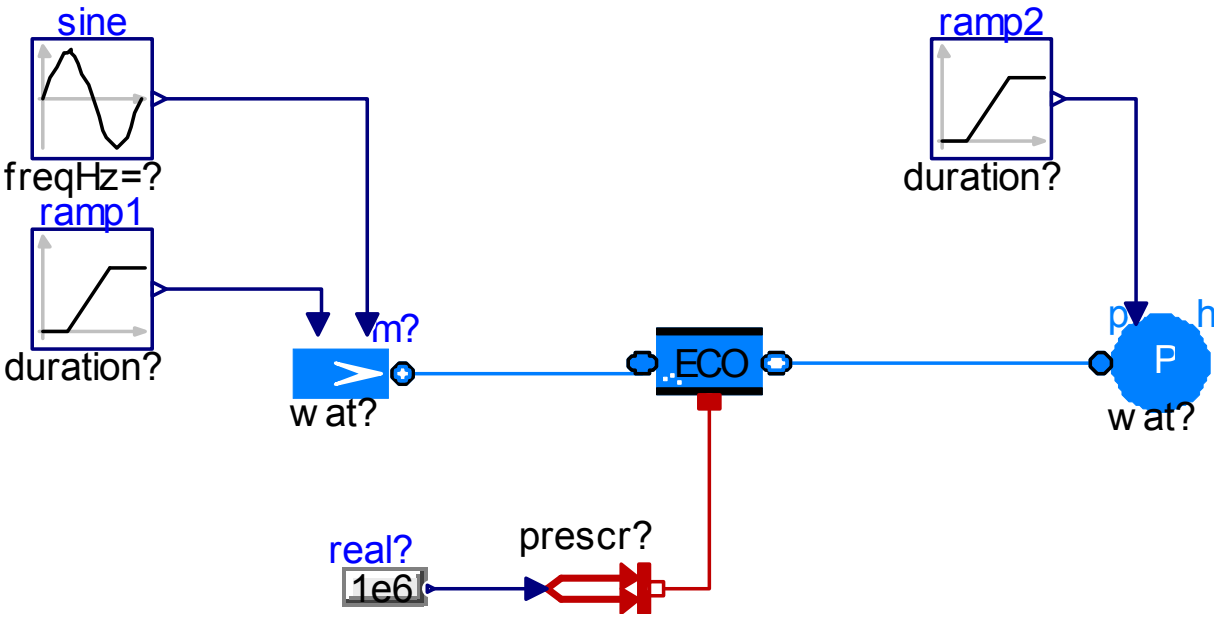

Simple Test Case

How to reduce the burden of getting started

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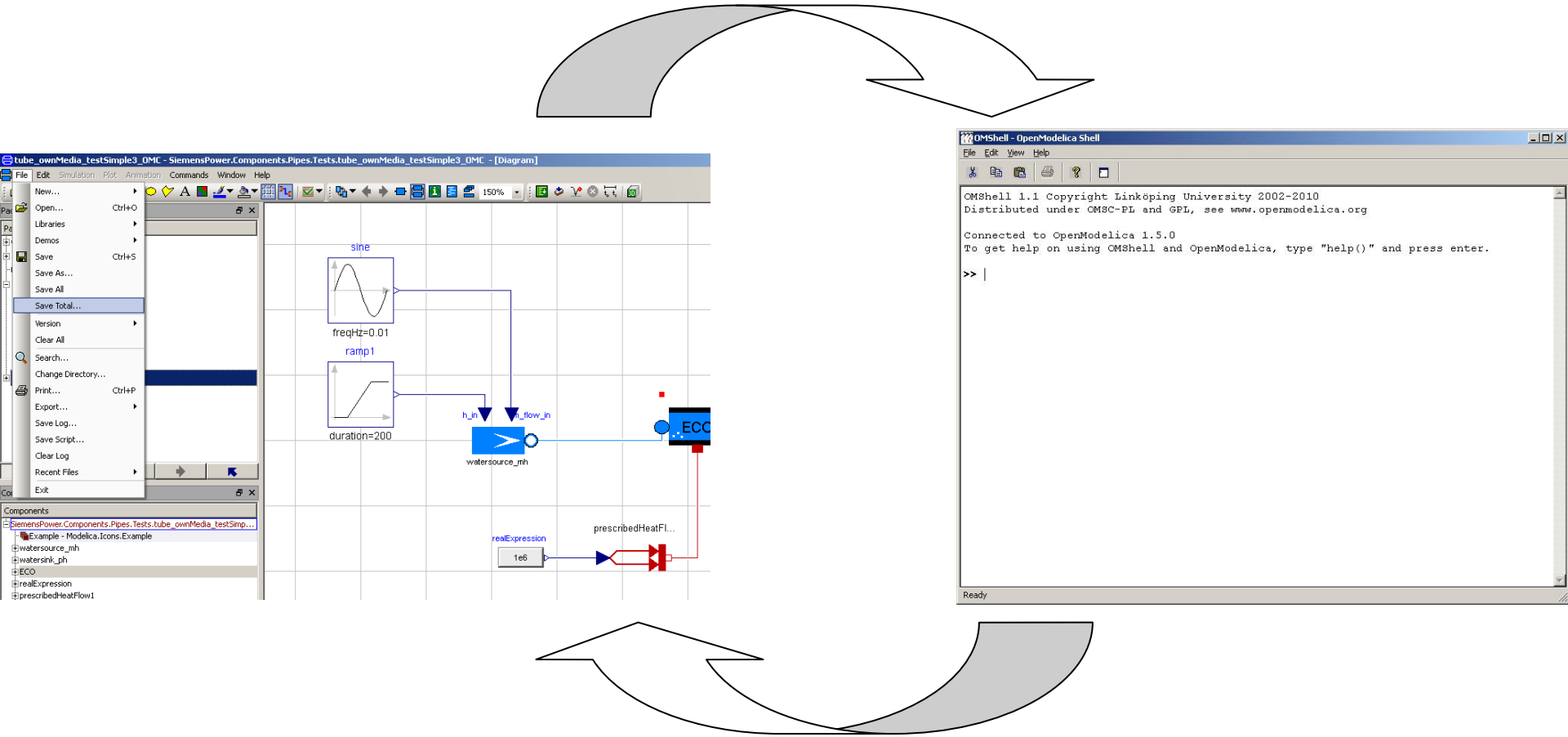

Simple Test Case - Benchmark
Comparison of Compile Time

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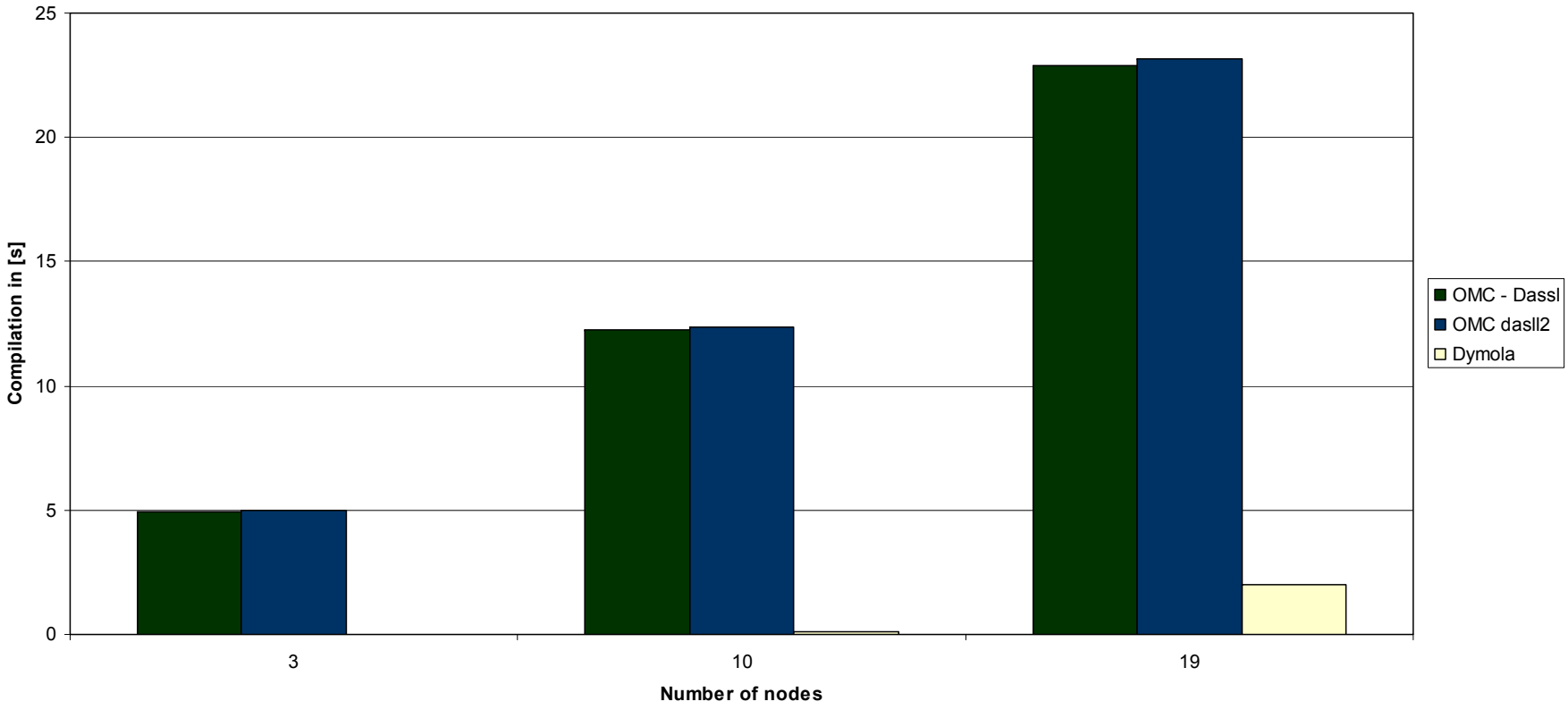

Simple Test Case - Benchmark
Comparison of Simulation Time

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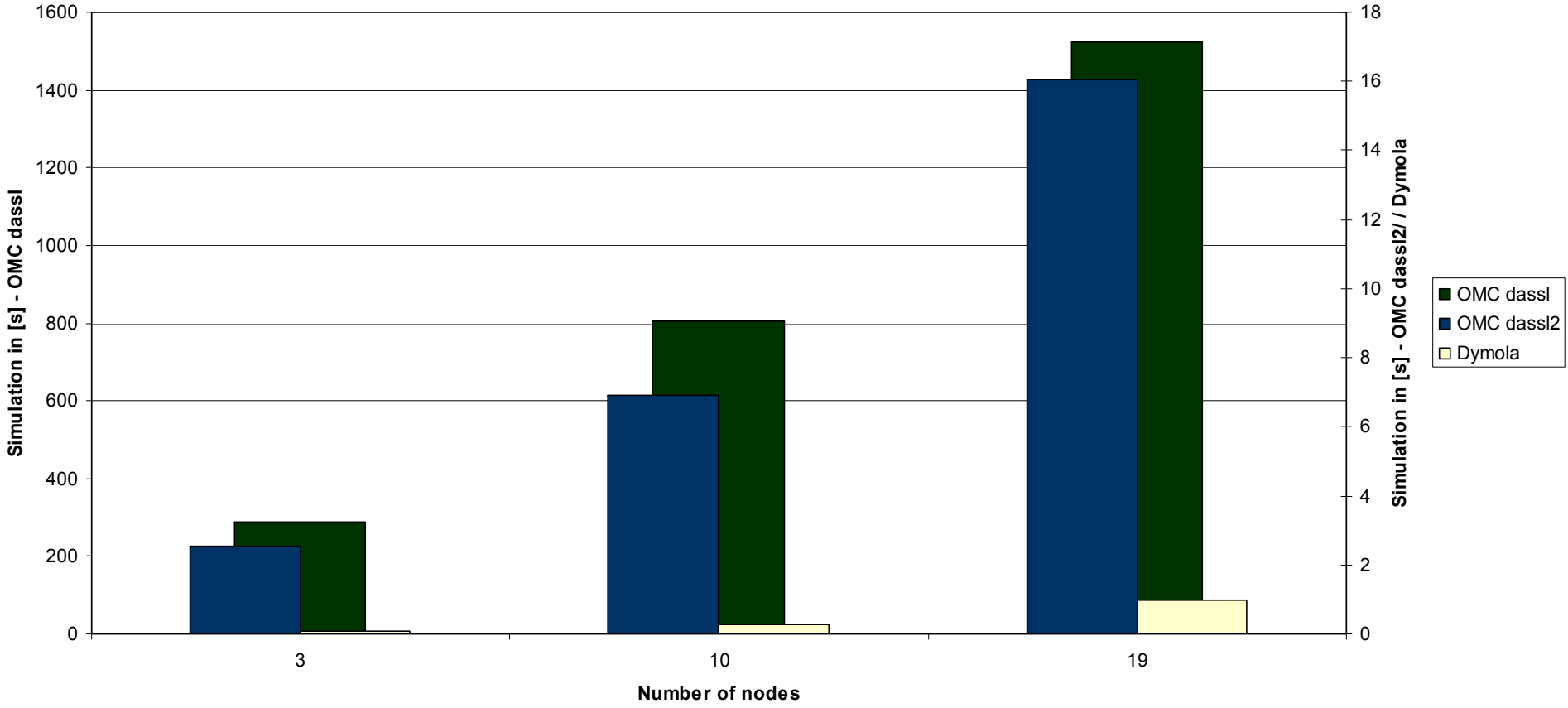

Needed changes

Modelica Media -> TTSE

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DymolaModelica	OmcModelica

replaceable package Medium =
Modelica.Media.Water.WaterIF97_ph
constrainedby
Modelica.Media.Interfaces.PartialMedium;
 	
Medium.BaseProperties h2o[N];
 	
h2o.h = h;
h2o.d = rho;
...
	T[j] =
	SiemensPower.Media.TTSE.OMC.T_ph(p, h[j]);
	rho[j] =
	SiemensPower.Media.TTSE.OMC.Rho_ph(p, h[j]);
	drdp[j] =
	SiemensPower.Media.TTSE.OMC.Rho_ph_dp(p, h[j]);
	drdh[j] =
	SiemensPower.Media.TTSE.OMC.Rho_ph_dh(p, h[j]);

Needed changes

Initial Equations

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DymolaModelica	OmcModelica

initial equation
 	
if (steady_enthalpy_inflow and steady_state and
dynamicSimulation) then
der(h[1])=0;
end if;
if (steady_state and dynamicSimulation) then
for j in 2:N loop
der(h[j]) = 0;
end for;
end if;	

Outlook

With respect to fluid modeling

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- Performance, Performance, Performance.
- Initialization support.
- Status and error messages, debugging support.
- OMEdit: Stability and Performance.

Your Feedback

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Thank you for your attention!

Needed Changes

Minor issues

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- Builtin-functions
- Naming