“D6.3.1 – Prototype and Evaluation of efficient Run-time Performance Profiler in OpenModelica”

“Sub WP 6.3: Debugging and performance profiling of system models in operation”

“Work Package 6: Modelling and simulation services”

MODRIO (11004)

Version 1.0

Date 2016-04-21

This document: Evaluation of the Performance Profiler

Authors

Åke Kinnander Siemens TU

Summary

The goal of this task is to investigate and evaluate the performance profiler applied on the development of a boiler model intended for dynamic analysis of Siemens combined cycle power plants.

The conclusion is that the profiler facilitates the work with modeling a lot.

Content

1 Introduction 3

2 Tutorial examination of the profiler 3

2.1 Running profiler with settings "all" 3
2.2 Conclusion 7

Glossary

OM	Open Modelica

1 Introduction

Siemens TU is working with simulation of combined cycle power plants. This task involves the dynamics of water cycling from water to steam and back while streaming in different flow regimes through pipes, valves and volumes, affecting the heat transfer from the flue gases. To handle these rather complicated phenomena including boiling and condensation in and on tubes, accurate dynamic models requires often high computer power and efficient programing and a good balance between accuracy and computational speed in the aspect of simulation purposes. The performance profiler is a tool that informs where in user equations CPU power is spent and gives thereby possibility to evaluate different mathematical methods and make deliberated trading between accuracy and computational speed.

The evaluation is done by applying the profiler on the boiler part of the combined cycle model. This model has previously been run and tested with Dymola and is for this task converted to OM.

2 Tutorial examination of the profiler

2.1 Running profiler with settings "all"

Following model is simulated:

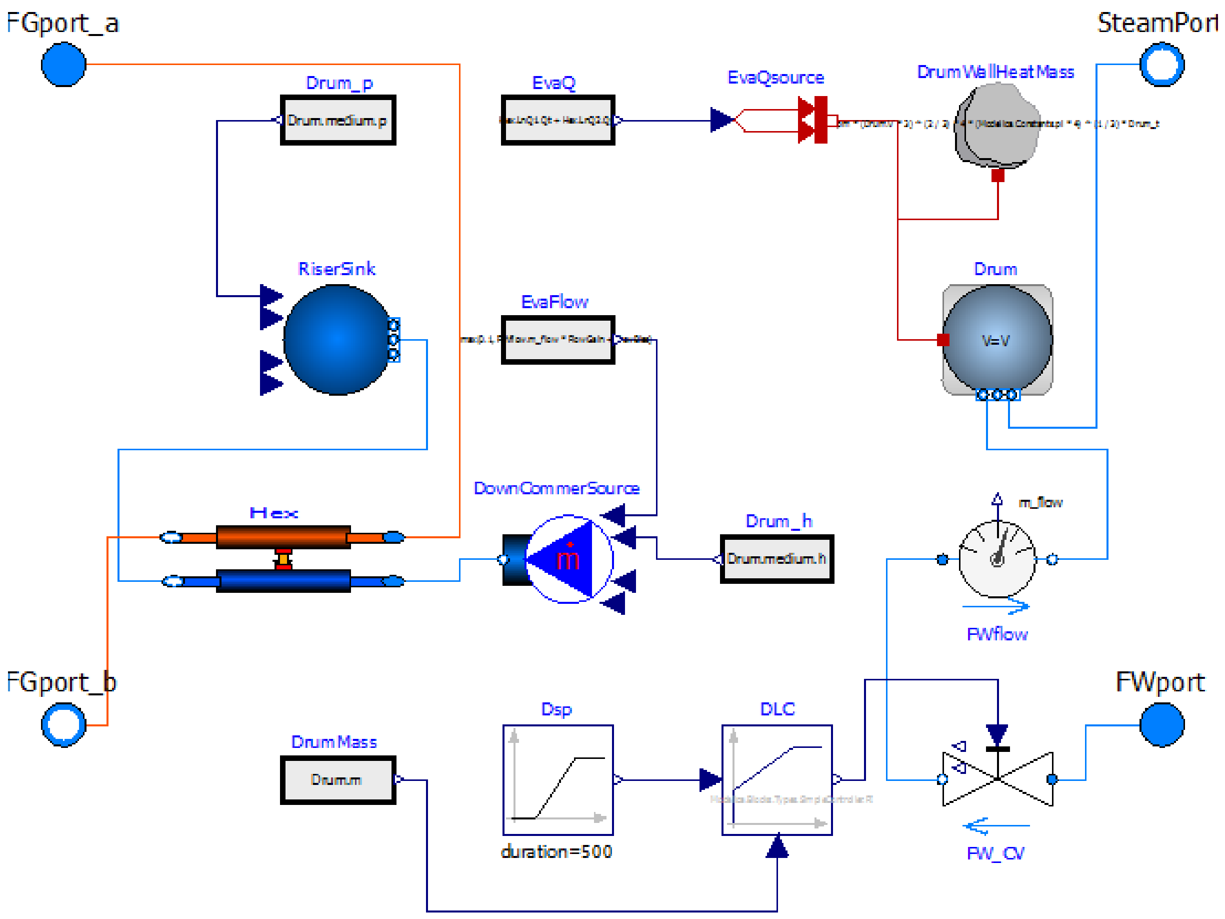
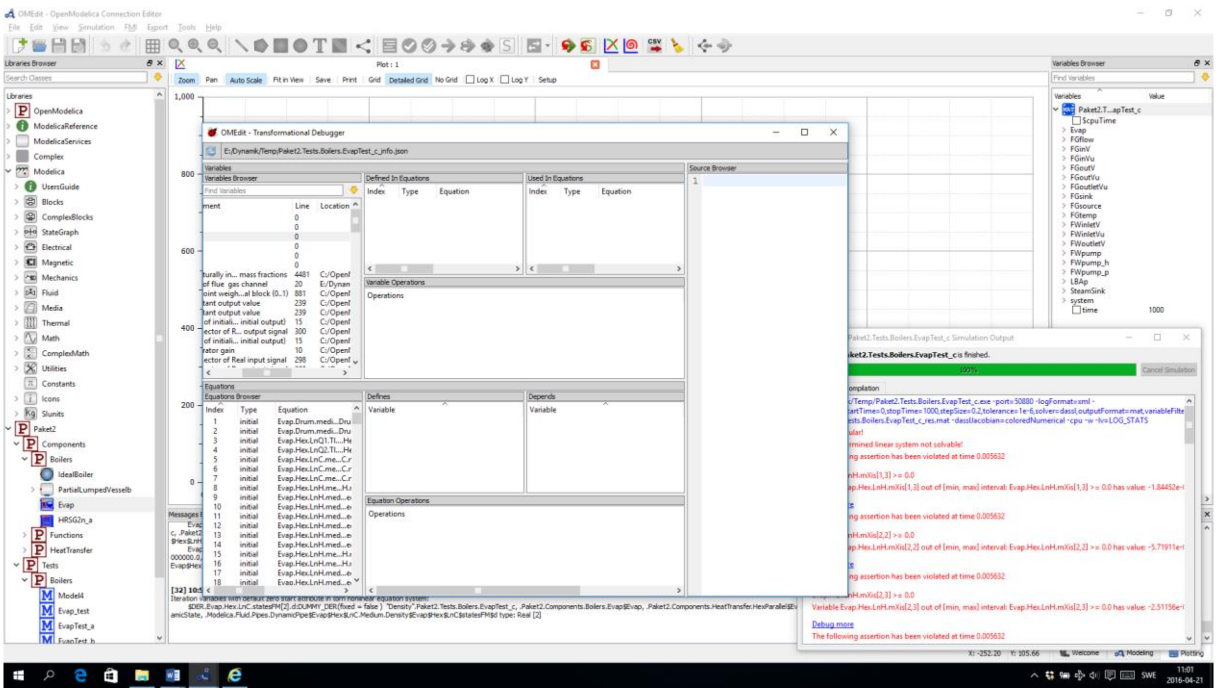


Figure 1 Simple Drum model with evaporator and level (drum mass) controller

The screen looks like this after a successful execution:

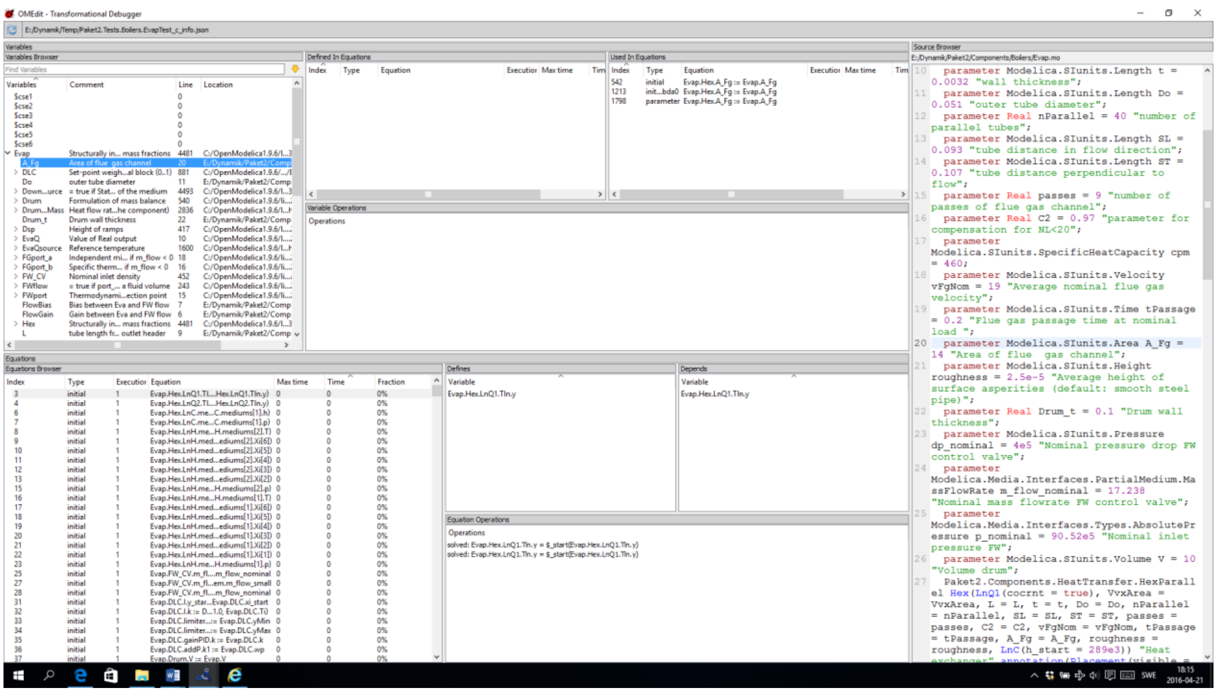


```
Paket2.Tests.Boilers.EvapTest_c Simulation Output
ket2.Tests.Boilers.EvapTest_c is finished.
100%
ompilation
:/Temp/Paket2.Tests.Boilers.EvapTest_c.exe -port=50880 -logFormat=xml -
artTime=0,stopTime=1000,stepSize=0.2,tolerance=1e-6,solver=dassl,outputFormat=mat,variableFilte
ests.Boilers.EvapTest_c_res.mat -dasslJacobian=coloredNumerical -cpu -w -lv=LOG_STATS
ular!
rmined linear system not solvable!
ng assertion has been violated at time 0.005632
nH.mXis[1,3] >= 0.0
ap.Hex.LnH.mXis[1,3] out of [min, max] interval: Evap.Hex.LnH.mXis[1,3] >= 0.0 has value: -1.84452e-
ng assertion has been violated at time 0.005632
nH.mXis[2,2] >= 0.0
ap.Hex.LnH.mXis[2,2] out of [min, max] interval: Evap.Hex.LnH.mXis[2,2] >= 0.0 has value: -5.71911e-
ng assertion has been violated at time 0.005632
nH.mXis[2,3] >= 0.0
Variable Evap.Hex.LnH.mXis[2,3] out of [min, max] interval: Evap.Hex.LnH.mXis[2,3] >= 0.0 has value: -2.51156e-
Debug more
The following assertion has been violated at time 0.005632
```

Figure 2 Output on computer screen after a successful execution with profiler activated (option all selected)

In the foreground is the a window Transformational Debugger that invoked by the selection of « Profiler All » in the simulation setup options for simulation flags. Behind that the « Simulation Output » window, giving the important information that 100% of specified simulation time is successfully reached, but also various warnings in red with an option to debug more. (The output window is better always placed in forefront, to see the progress of the simulation, or alternatively the plot window if it plots the progress continuously or at least frequent). In the background is OMEdit's main window, now displaying the plotting interface.

A closer look at the Transformational Debugger window gives following :



OMEdit - Transformational Debugger

E:/Dynamik/Temp/Paket2.Tests.Boilers.EvapTest_c_info.json

Variables

Variables Browser

Find Variables

Variables	Comment	Line	Location
$cse1		0	
$cse2		0	
$cse3		0	
$cse4		0	
$cse5		0	
$cse6		0	
Evap	Structurally in... mass fractions	4481	C:/OpenModelica1.9.6/l...3
A_Fg	Area of flue gas channel	20	E:/Dynamik/Paket2/Comp
DLC	Set-point weigh...al block (0..1)	881	C:/OpenModelica1.9.6/.../E
Do	outer tube diameter	11	E:/Dynamik/Paket2/Comp
Down...urce	= true if Stat... of the medium	4493	C:/OpenModelica1.9.6/l...3
Drum	Formulation of mass balance	540	C:/OpenModelica1.9.6/li...
Drum...Mass	Heat flow rat...he component)	2836	C:/OpenModelica1.9.6/l...h
Drum_t	Drum wall thickness	22	E:/Dynamik/Paket2/Comp
Dsp	Height of ramps	417	C:/OpenModelica1.9.6/l....
EvaQ	Value of Real output	10	C:/OpenModelica1.9.6/l....
EvaQsource	Reference temperature	1600	C:/OpenModelica1.9.6/l...h
FGport_a	Independent mi... if m_flow < 0	18	C:/OpenModelica1.9.6/li...
FGport_b	Specific therm... if m_flow < 0	16	C:/OpenModelica1.9.6/li...
FW_CV	Nominal inlet density	452	C:/OpenModelica1.9.6/li...
FWflow	= true if port_... a fluid volume	243	C:/OpenModelica1.9.6/li...
FWport	Thermodynami...ection point	15	C:/OpenModelica1.9.6/li...
FlowBias	Bias between Eva and FW flow	7	E:/Dynamik/Paket2/Comp
FlowGain	Gain between Eva and FW flow	6	E:/Dynamik/Paket2/Comp
Hex	Structurally in... mass fractions	4481	C:/OpenModelica1.9.6/l...3
L	tube length fr... outlet header	9	E:/Dynamik/Paket2/Comp

Defined In Equations

Index	Type	Equation	Executior	Max time	Tim

Used In Equations

Index	Type	Equation	Executior	Max time	Tim
542	initial	Evap.Hex.A_Fg := Evap.A_Fg			
1213	init...bda0	Evap.Hex.A_Fg := Evap.A_Fg			
1798	parameter	Evap.Hex.A_Fg := Evap.A_Fg			

Variable Operations

Operations

Source Browser

E:/Dynamik/Paket2/Components/Boilers/Evap.mo

```
  parameter Modelica.SIunits.Length t =
0.0032 "wall thickness";
  parameter Modelica.SIunits.Length Do =
0.051 "outer tube diameter";
  parameter Real nParallel = 40 "number of
parallel tubes";
  parameter Modelica.SIunits.Length SL =
0.093 "tube distance in flow direction";
  parameter Modelica.SIunits.Length ST =
0.107 "tube distance perpendicular to
flow";
  parameter Real passes = 9 "number of
passes of flue gas channel";
  parameter Real C2 = 0.97 "parameter for
compensation for NL<20";
  parameter
Modelica.SIunits.SpecificHeatCapacity cpm
= 460;
  parameter Modelica.SIunits.Velocity
vFgNom = 19 "Average nominal flue gas
velocity";
  parameter Modelica.SIunits.Time tPassage
= 0.2 "Flue gas passage time at nominal
load ";
  parameter Modelica.SIunits.Area A_Fg =
14 "Area of flue  gas channel";
  parameter Modelica.SIunits.Height
roughness = 2.5e-5 "Average height of
surface asperities (default: smooth steel
pipe)";
  parameter Real Drum_t = 0.1 "Drum wall
thickness";
  parameter Modelica.SIunits.Pressure
dp_nominal = 4e5 "Nominal pressure drop FW
control valve";
  parameter
Modelica.Media.Interfaces.PartialMedium.Ma
ssFlowRate m_flow_nominal = 17.238
"Nominal mass flowrate FW control valve";
  parameter
Modelica.Media.Interfaces.Types.AbsolutePr
essure p_nominal = 90.52e5 "Nominal inlet
pressure FW";
  parameter Modelica.SIunits.Volume V = 10
"Volume drum";
  Paket2.Components.HeatTransfer.HexParall
el Hex(LnQ1(cocrnt = true), VvxArea =
VvxArea, L = L, t = t, Do = Do, nParallel
= nParallel, SL = SL, ST = ST, passes =
passes, C2 = C2, vFgNom = vFgNom, tPassage
= tPassage, A_Fg = A_Fg, roughness =
roughness, LnC(h_start = 289e3)) "Heat
```

Equations

Equations Browser

Index	Type	Executior	Equation	Max time	Time	Fraction
3	initial	1	Evap.Hex.LnQ1.Tl....Hex.LnQ1.Tln.y)	0	0	0%
4	initial	1	Evap.Hex.LnQ2.Tl....Hex.LnQ2.Tln.y)	0	0	0%
6	initial	1	Evap.Hex.LnC.me...C.mediums[1].h)	0	0	0%
7	initial	1	Evap.Hex.LnC.me...C.mediums[1].p)	0	0	0%
8	initial	1	Evap.Hex.LnH.me...H.mediums[2].T)	0	0	0%
9	initial	1	Evap.Hex.LnH.med...ediums[2].Xi[6])	0	0	0%
10	initial	1	Evap.Hex.LnH.med...ediums[2].Xi[5])	0	0	0%
11	initial	1	Evap.Hex.LnH.med...ediums[2].Xi[4])	0	0	0%
12	initial	1	Evap.Hex.LnH.med...ediums[2].Xi[3])	0	0	0%
13	initial	1	Evap.Hex.LnH.med...ediums[2].Xi[2])	0	0	0%
15	initial	1	Evap.Hex.LnH.me...H.mediums[2].p)	0	0	0%
16	initial	1	Evap.Hex.LnH.me...H.mediums[1].T)	0	0	0%
17	initial	1	Evap.Hex.LnH.med...ediums[1].Xi[6])	0	0	0%
18	initial	1	Evap.Hex.LnH.med...ediums[1].Xi[5])	0	0	0%
19	initial	1	Evap.Hex.LnH.med...ediums[1].Xi[4])	0	0	0%
20	initial	1	Evap.Hex.LnH.med...ediums[1].Xi[3])	0	0	0%
21	initial	1	Evap.Hex.LnH.med...ediums[1].Xi[2])	0	0	0%
22	initial	1	Evap.Hex.LnH.med...ediums[1].Xi[1])	0	0	0%
23	initial	1	Evap.Hex.LnH.me...H.mediums[1].p)	0	0	0%
25	initial	1	Evap.FW_CV.m_fl....m_flow_nominal	0	0	0%
27	initial	1	Evap.FW_CV.m_fl...em.m_flow_small	0	0	0%
28	initial	1	Evap.FW_CV.m_fl....m_flow_nominal	0	0	0%
31	initial	1	Evap.DLC.I.y_star...Evap.DLC.xi_start	0	0	0%
32	initial	1	Evap.DLC.I.k := D...1.0, Evap.DLC.Ti)	0	0	0%
33	initial	1	Evap.DLC.limiter...:= Evap.DLC.yMin	0	0	0%
34	initial	1	Evap.DLC.limiter...:= Evap.DLC.yMax	0	0	0%
35	initial	1	Evap.DLC.gainPID.k := Evap.DLC.k	0	0	0%
36	initial	1	Evap.DLC.addP.k1 := Evap.DLC.wp	0	0	0%
37	initial	1	Evap.Drum.V := Evap.V	0	0	0%

Defines

Variable
Evap.Hex.LnQ1.Tln.y

Depends

Variable
Evap.Hex.LnQ1.Tln.y

Equation Operations

Operations

```
solved: Evap.Hex.LnQ1.Tln.y = $_start(Evap.Hex.LnQ1.Tln.y)
solved: Evap.Hex.LnQ1.Tln.y = $_start(Evap.Hex.LnQ1.Tln.y)
```

SWE 18:15 2016-04-21

Figure 3 Transformational Debugger

To the left it has two browsers, one for variables and one for equations. Clicking on a variable will show :

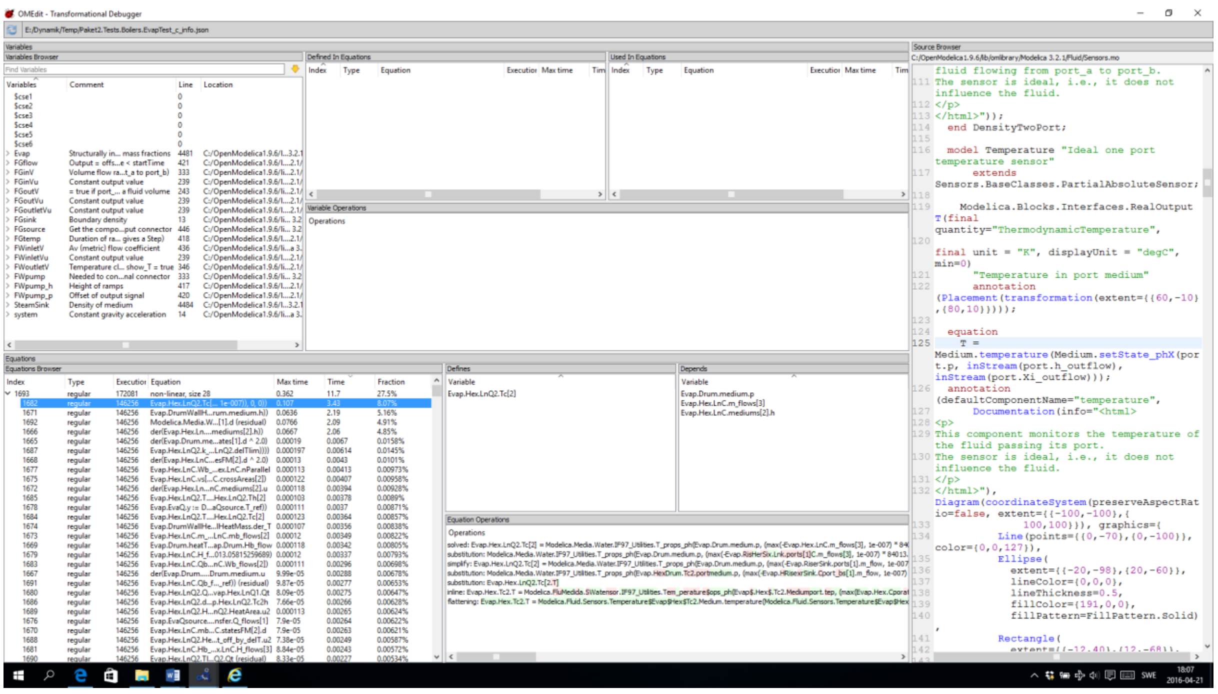
1. where it is defined
2. where it is used
3. operations made.
4. the source code line that defines the variable value will be highlighted (source browser to the right)

All lines are truncated to allow all windows above to be seen. Expanding windows and scrolling displays all hidden text. I.e. there is an instant knowledge where a variable is used, which helps a lot to analyze consequences of a change.

The index presented gives the link to the equations used and presented in the equation browser. A clicking on a line in that browser gives

1. which variable the equation defines
2. what variables it depends upon
3. what operations that are made for the equation
4. where in the source code the equation is written

The equation browser gives the link between the C-code equation solved and the source code in the .mo files. This browser also displays columns for execution times, number of executions and total execution time, both as fraction of total simulation time and in seconds. Sorting by fraction or time gives the equation in order of time consumed.



OMEdit - Transformational Debugger

E:/Dynamik/Temp/Paket2.Tests.Boilers.EvapTest_c_info.json

Variables

Variables Browser

Variables	Comment	Line	Location
$cse1		0	
$cse2		0	
$cse3		0	
$cse4		0	
$cse5		0	
$cse6		0	
Evap	Structurally in... mass fractions	4481	C:/OpenModelica1.9.6/l...3.2.1
FGflow	Output = offs...e < startTime	421	C:/OpenModelica1.9.6/l....2.1/
FGinV	Volume flow ra...t_a to port_b)	333	C:/OpenModelica1.9.6/li...2.1/
FGinVu	Constant output value	239	C:/OpenModelica1.9.6/l....2.1/
FGoutV	= true if port_... a fluid volume	243	C:/OpenModelica1.9.6/li...2.1/
FGoutVu	Constant output value	239	C:/OpenModelica1.9.6/l....2.1/
FGoutletVu	Constant output value	239	C:/OpenModelica1.9.6/l....2.1/
FGsink	Boundary density	13	C:/OpenModelica1.9.6/li... 3.2
FGsource	Get the compo...put connector	446	C:/OpenModelica1.9.6/li... 3.2
FGtemp	Duration of ra... gives a Step)	418	C:/OpenModelica1.9.6/l....2.1/
FWinletV	Av (metric) flow coefficient	436	C:/OpenModelica1.9.6/li...a 3.
FWinletVu	Constant output value	239	C:/OpenModelica1.9.6/l....2.1/
FWoutletV	Temperature cl... show_T = true	346	C:/OpenModelica1.9.6/li...2.1/
FWpump	Needed to con...nal connector	333	C:/OpenModelica1.9.6/li... 3.2
FWpump_h	Height of ramps	417	C:/OpenModelica1.9.6/l....2.1/
FWpump_p	Offset of output signal	420	C:/OpenModelica1.9.6/l....2.1/
SteamSink	Density of medium	4484	C:/OpenModelica1.9.6/l...3.2.1
system	Constant gravity acceleration	14	C:/OpenModelica1.9.6/li...a 3.

Defined In Equations

Index	Type	Equation	Executio	Max time	Tim

Used In Equations

Index	Type	Equation	Executio	Max time	Tim

Variable Operations

Operations

Equations

Equations Browser

Index	Type	Executior	Equation	Max time	Time	Fraction
1693	regular	172081	non-linear, size 28	0.362	11.7	27.5%
1682	regular	146256	Evap.Hex.LnQ2.Tc[... 1e-007)), 0, 0))	0.107	3.43	8.07%
1671	regular	146256	Evap.DrumWallH...rum.medium.h))	0.0636	2.19	5.16%
1692	regular	146256	Modelica.Media.W...[1].d (residual)	0.0766	2.09	4.91%
1666	regular	146256	der(Evap.Hex.Ln....mediums[2].h))	0.0667	2.06	4.85%
1665	regular	146256	der(Evap.Drum.me...ates[1].d ^ 2.0)	0.00019	0.0067	0.0158%
1687	regular	146256	Evap.Hex.LnQ2.k_...LnQ2.delTlim))))	0.000197	0.00614	0.0145%
1668	regular	146256	der(Evap.Hex.LnC...esFM[2].d ^ 2.0)	0.00013	0.0043	0.0101%
1677	regular	146256	Evap.Hex.LnC.Wb_...ex.LnC.nParallel	0.000113	0.00413	0.00973%
1675	regular	146256	Evap.Hex.LnC.vs[...C.crossAreas[2])	0.000122	0.00407	0.00958%
1672	regular	146256	der(Evap.Hex.Ln...nC.mediums[2].u	0.000118	0.00394	0.00928%
1685	regular	146256	Evap.Hex.LnQ2.T....Hex.LnQ2.Th[2]	0.000103	0.00378	0.0089%
1678	regular	146256	Evap.EvaQ.y := D...aQsource.T_ref))	0.000111	0.0037	0.00871%
1684	regular	146256	Evap.Hex.LnQ2.T....Hex.LnQ2.Tc[2]	0.000123	0.00364	0.00857%
1674	regular	146256	Evap.DrumWallHe...lHeatMass.der_T	0.000107	0.00356	0.00838%
1673	regular	146256	Evap.Hex.LnC.m_...LnC.mb_flows[2]	0.00012	0.00349	0.00822%
1669	regular	146256	Evap.Drum.heatT...ap.Drum.Hb_flow	0.000118	0.00342	0.00805%
1679	regular	146256	Evap.Hex.LnC.H_f...013.05815259689)	0.00012	0.00337	0.00793%
1683	regular	146256	Evap.Hex.LnC.Qb...nC.Wb_flows[2])	0.000111	0.00296	0.00698%
1667	regular	146256	der(Evap.Drum.....Drum.medium.u	9.99e-05	0.00288	0.00678%
1691	regular	146256	Evap.Hex.LnC.Qb_f...._ref)) (residual)	9.87e-05	0.00277	0.00653%
1680	regular	146256	Evap.Hex.LnQ2.Q...vap.Hex.LnQ1.Qt	8.09e-05	0.00275	0.00647%
1686	regular	146256	Evap.Hex.LnQ2.d...p.Hex.LnQ2.Tc2h	7.66e-05	0.00266	0.00628%
1689	regular	146256	Evap.Hex.LnQ2.H...nQ2.HeatArea.u2	0.000113	0.00265	0.00624%
1676	regular	146256	Evap.EvaQsource....nsfer.Q_flows[1]	7.9e-05	0.00264	0.00622%
1670	regular	146256	Evap.Hex.LnC.mb...C.statesFM[2].d	7.9e-05	0.00263	0.00621%
1688	regular	146256	Evap.Hex.LnQ2.He...t_off_by_delT.u2	7.38e-05	0.00249	0.00587%
1681	regular	146256	Evap.Hex.LnC.Hb_...x.LnC.H_flows[3]	8.84e-05	0.00243	0.00572%
1690	regular	146256	Evap.Hex.LnQ2.Tl...Q2.Qt (residual)	8.33e-05	0.00227	0.00534%

Defines

Variable
Evap.Hex.LnQ2.Tc[2]

Depends

Variable
Evap.Drum.medium.p
Evap.Hex.LnC.m_flows[3]
Evap.Hex.LnC.mediums[2].h

Equation Operations

```
Operations
solved: Evap.Hex.LnQ2.Tc[2] = Modelica.Media.Water.IF97_Utilities.T_props_ph(Evap.Drum.medium.p, (max(-Evap.Hex.LnC.m_flows[3], 1e-007) * 84
substitution: Modelica.Media.Water.IF97_Utilities.T_props_ph(Evap.Drum.medium.p, (max(-Evap.RisHerSix.Lnk.ports[1]C.m_flows[3], 1e-007) * 84013.
simplify: Evap.Hex.LnQ2.Tc[2] = Modelica.Media.Water.IF97_Utilities.T_props_ph(Evap.Drum.medium.p, (max(-Evap.RiserSink.ports[1].m_flow, 1e-007
substitution: Modelica.Media.Water.IF97_Utilities.T_props_ph(Evap.HexDrum.Tc2.portmedium.p, (max(-Evap.HRisexrSink.Cport_bs[1].m_flow, 1e-007)
substitution: Evap.Hex.LnQ2.Tc[2.T]
inline: Evap.Hex.Tc2.T = Modelica.FluMedida.SWatensor.IF97_Utilities.Tem_perature$ops_ph(Evap$.Hex$.Tc2.Mediumport.tep, (max(Evap.Hex.Cporat
flattening: Evap.Hex.Tc2.T = Modelica.Fluid.Sensors.Temperature$Evap$Hex$Tc2.Medium.temperature(Modelica.Fluid.Sensors.Temperature$Evap$Hex
```

Source Browser

C:/OpenModelica1.9.6/lib/omlibrary/Modelica 3.2.1/Fluid/Sensors.mo

```
fluid flowing from port_a to port_b.
The sensor is ideal, i.e., it does not
influence the fluid.
</p>
</html>"));
  end DensityTwoPort;

  model Temperature "Ideal one port
temperature sensor"
      extends
Sensors.BaseClasses.PartialAbsoluteSensor;

    Modelica.Blocks.Interfaces.RealOutput
T(final
quantity="ThermodynamicTemperature",

final unit = "K", displayUnit = "degC",
min=0)
      "Temperature in port medium"
      annotation
(Placement(transformation(extent={{60,-10}
,{80,10}})));

  equation
    T =
Medium.temperature(Medium.setState_phX(por
t.p, inStream(port.h_outflow),
inStream(port.Xi_outflow)));
  annotation
(defaultComponentName="temperature",
      Documentation(info="<html>
<p>
This component monitors the temperature of
the fluid passing its port.
The sensor is ideal, i.e., it does not
influence the fluid.
</p>
</html>"),
Diagram(coordinateSystem(preserveAspectRat
io=false, extent={{-100,-100},{
            100,100}}), graphics={
          Line(points={{0,-70},{0,-100}},
color={0,0,127}),
          Ellipse(
            extent={{-20,-98},{20,-60}},
            lineColor={0,0,0},
            lineThickness=0.5,
            fillColor={191,0,0},
            fillPattern=FillPattern.Solid)
,
          Rectangle(
            extent={{-12,40},{12,-68}},
```

SWE 18:07 2016-04-21

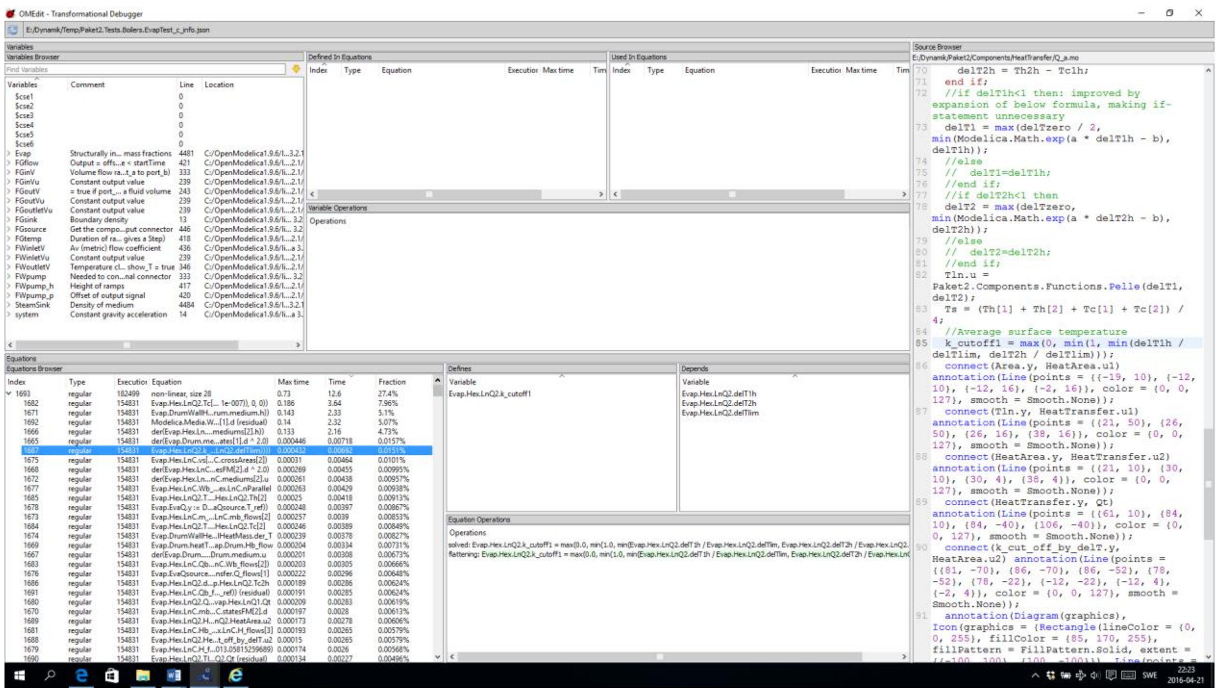
Figure 4 Investigation of heaviest equation after sorting by Time

The profiler gives that Index 1693, that defines the derivative of the enthalpy and pressure of the drum together with the derivative of the enthalpy of the outlet volume of the evaporator pipes (..LnC[2]), is by far the equation that takes most of the CPU power, 27.5 % while next equation takes 5 % (not shown in figure above). As there are three variables defined by this equation no equation is pointed out in the mo file (shown in Source Browser is a previous clicked index – a clearing of that window should be considered when selected variables and equations not corresponds to a line in the source code) nor are any dependencies shown.

Index 1693 is constituted of 28 other variables (size 28) and clicking on 1693 reveals indexes from 1665 to 1692 (28 equations). Those are the used equations by the solver and clicking on any of them shows the corresponding source code, and what variables the equation is dependent upon and the operations made.

The conclusion from this is that the Drum is the heaviest part of the model, and improvements of its equations should have the best chance of improving performance and shortening the simulation time.

Exploring the 28 equations reveals only one that is set up by the user (amongst the equations spending 85 % of the calculation time). The rest are equations from the Modelica Fluid library. To see the impact, by that equation on the performance, one of its the parameters where changed. The equation has a parameter delTlim that is limiting the heat transfer calculation preventing that the temperature differences becomes equal, thereby causing a simulation crash. Increasing delTlim value from 0.1 to 0.5 °C, which deteriorates the accuracy of the heat transfer calculation, gives that equations with index 1693 makes a minor reduction to 27.4 % from 27.5 % of the total time, but the simulation time (major part of the total time) is anyway reduced from 30.0 to 28.5 s (not shown).



OMEdit - Transformational Debugger

E:/Dynamik/Temp/Paket2.Tests.Boilers.EvapTest_c_info.json

Variables Browser

Variables	Comment	Line	Location
$cse1		0	
$cse2		0	
$cse3		0	
$cse4		0	
$cse5		0	
$cse6		0	
Evap	Structurally in... mass fractions	4481	C:/OpenModelica1.9.6/l...3.2.1
FGflow	Output = offs...e < startTime	421	C:/OpenModelica1.9.6/l....2.1/
FGinV	Volume flow ra...t_a to port_b)	333	C:/OpenModelica1.9.6/li...2.1/
FGinVu	Constant output value	239	C:/OpenModelica1.9.6/l....2.1/
FGoutV	= true if port_... a fluid volume	243	C:/OpenModelica1.9.6/li...2.1/
FGoutVu	Constant output value	239	C:/OpenModelica1.9.6/l....2.1/
FGoutletVu	Constant output value	239	C:/OpenModelica1.9.6/l....2.1/
FGsink	Boundary density	13	C:/OpenModelica1.9.6/li... 3.2
FGsource	Get the compo...put connector	446	C:/OpenModelica1.9.6/li... 3.2
FGtemp	Duration of ra... gives a Step)	418	C:/OpenModelica1.9.6/l....2.1/
FWinletV	Av (metric) flow coefficient	436	C:/OpenModelica1.9.6/li...a 3.
FWinletVu	Constant output value	239	C:/OpenModelica1.9.6/l....2.1/
FWoutletV	Temperature cl... show_T = true	346	C:/OpenModelica1.9.6/li...2.1/
FWpump	Needed to con...nal connector	333	C:/OpenModelica1.9.6/li... 3.2
FWpump_h	Height of ramps	417	C:/OpenModelica1.9.6/l....2.1/
FWpump_p	Offset of output signal	420	C:/OpenModelica1.9.6/l....2.1/
SteamSink	Density of medium	4484	C:/OpenModelica1.9.6/l...3.2.1
system	Constant gravity acceleration	14	C:/OpenModelica1.9.6/li...a 3.

Equations Browser

Index	Type	Execution	Equation	Max time	Time	Fraction
1693	regular	182499	non-linear, size 28	0.73	12.6	27.4%
1682	regular	154831	Evap.Hex.LnQ2.Tc[... 1e-007)), 0, 0))	0.186	3.64	7.96%
1671	regular	154831	Evap.DrumWallH...rum.medium.h))	0.143	2.33	5.1%
1692	regular	154831	Modelica.Media.W...[1].d (residual)	0.14	2.32	5.07%
1666	regular	154831	der(Evap.Hex.Ln....mediums[2].h))	0.133	2.16	4.73%
1665	regular	154831	der(Evap.Drum.me...ates[1].d ^ 2.0)	0.000446	0.00718	0.0157%
1687	regular	154831	Evap.Hex.LnQ2.k_...LnQ2.delTlim))))	0.000432	0.00692	0.0151%
1675	regular	154831	Evap.Hex.LnC.vs[...C.crossAreas[2])	0.00031	0.00464	0.0101%
1668	regular	154831	der(Evap.Hex.LnC...esFM[2].d ^ 2.0)	0.000269	0.00455	0.00995%
1672	regular	154831	der(Evap.Hex.Ln...nC.mediums[2].u	0.000261	0.00438	0.00957%
1677	regular	154831	Evap.Hex.LnC.Wb_...ex.LnC.nParallel	0.000263	0.00429	0.00938%
1685	regular	154831	Evap.Hex.LnQ2.T....Hex.LnQ2.Th[2]	0.00025	0.00418	0.00913%
1678	regular	154831	Evap.EvaQ.y := D...aQsource.T_ref))	0.000248	0.00397	0.00867%
1673	regular	154831	Evap.Hex.LnC.m_...LnC.mb_flows[2]	0.000257	0.0039	0.00853%
1684	regular	154831	Evap.Hex.LnQ2.T....Hex.LnQ2.Tc[2]	0.000246	0.00389	0.00849%
1674	regular	154831	Evap.DrumWallHe...lHeatMass.der_T	0.000239	0.00378	0.00827%
1669	regular	154831	Evap.Drum.heatT...ap.Drum.Hb_flow	0.000204	0.00334	0.00731%
1667	regular	154831	der(Evap.Drum.....Drum.medium.u	0.000201	0.00308	0.00673%
1683	regular	154831	Evap.Hex.LnC.Qb...nC.Wb_flows[2])	0.000203	0.00305	0.00666%
1676	regular	154831	Evap.EvaQsource....nsfer.Q_flows[1]	0.000222	0.00296	0.00648%
1686	regular	154831	Evap.Hex.LnQ2.d...p.Hex.LnQ2.Tc2h	0.000189	0.00286	0.00624%
1691	regular	154831	Evap.Hex.LnC.Qb_f..._ref)) (residual)	0.000191	0.00285	0.00624%
1680	regular	154831	Evap.Hex.LnQ2.Q....vap.Hex.LnQ1.Qt	0.000209	0.00283	0.00619%
1670	regular	154831	Evap.Hex.LnC.mb...C.statesFM[2].d	0.000197	0.0028	0.00613%
1689	regular	154831	Evap.Hex.LnQ2.H....nQ2.HeatArea.u2	0.000173	0.00278	0.00606%
1681	regular	154831	Evap.Hex.LnC.Hb_...x.LnC.H_flows[3]	0.000193	0.00265	0.00579%
1688	regular	154831	Evap.Hex.LnQ2.He...t_off_by_delT.u2	0.00015	0.00265	0.00579%
1679	regular	154831	Evap.Hex.LnC.H_f...013.05815259689)	0.000174	0.0026	0.00568%
1690	regular	154831	Evap.Hex.LnQ2.Tl...Q2.Qt (residual)	0.000134	0.00227	0.00496%

Defines

Variable
Evap.Hex.LnQ2.k_cutoff1

Depends

Variable
Evap.Hex.LnQ2.delT1h
Evap.Hex.LnQ2.delT2h
Evap.Hex.LnQ2.delTlim

Equation Operations

```
solved: Evap.Hex.LnQ2.k_cutoff1 = max(0.0, min(1.0, min(Evap.Hex.LnQ2.delT1h / Evap.Hex.LnQ2.delTlim, Evap.Hex.LnQ2.delT2h / Evap.Hex.LnQ2.
flattening: Evap.Hex.LnQ2.k_cutoff1 = max(0.0, min(1.0, min(Evap.Hex.LnQ2.delT1h / Evap.Hex.LnQ2.delTlim, Evap.Hex.LnQ2.delT2h / Evap.Hex.LnQ
```

Source Browser

E:/Dynamik/Paket2/Components/HeatTransfer/Q_a.mo

```
    delT2h = Th2h - Tc1h;
  end if;
  //if delT1h<1 then: improved by expansion of below formula, making if-statement unnecessary
  delT1 = max(delTzero / 2, min(Modelica.Math.exp(a * delT1h - b), delT1h));
  //else
  //  delT1=delT1h;
  //end if;
  //if delT2h<1 then
  delT2 = max(delTzero, min(Modelica.Math.exp(a * delT2h - b), delT2h));
  //else
  //  delT2=delT2h;
  //end if;
  Tln.u = Paket2.Components.Functions.Pelle(delT1, delT2);
  Ts = (Th[1] + Th[2] + Tc[1] + Tc[2]) / 4;
  //Average surface temperature
  k_cutoff1 = max(0, min(1, min(delT1h / delTlim, delT2h / delTlim)));
  connect(Area.y, HeatArea.u1) annotation(Line(points = {{-19, 10}, {-12, 10}, {-12, 16}, {-2, 16}}, color = {0, 0, 127}, smooth = Smooth.None));
  connect(Tln.y, HeatTransfer.u1) annotation(Line(points = {{21, 50}, {26, 50}, {26, 16}, {38, 16}}, color = {0, 0, 127}, smooth = Smooth.None));
  connect(HeatArea.y, HeatTransfer.u2) annotation(Line(points = {{21, 10}, {30, 10}, {30, 4}, {38, 4}}, color = {0, 0, 127}, smooth = Smooth.None));
  connect(HeatTransfer.y, Qt) annotation(Line(points = {{61, 10}, {84, 10}, {84, -40}, {106, -40}}, color = {0, 0, 127}, smooth = Smooth.None));
  connect(k_cut_off_by_delT.y, HeatArea.u2) annotation(Line(points = {{81, -70}, {86, -70}, {86, -52}, {78, -52}, {78, -22}, {-12, -22}, {-12, 4}, {-2, 4}}, color = {0, 0, 127}, smooth = Smooth.None));
  annotation(Diagram(graphics), Icon(graphics = {Rectangle(lineColor = {0, 0, 255}, fillColor = {85, 170, 255}, fillPattern = FillPattern.Solid, extent =
```

Figure 5 Profiler output after a minor adjustment

From that the user could conclude that changing delTlim, which rather drastically deteriorates the accuracy of the heat transfer, the resulting improvement on the performance for index 1693 is negligible, but the change any way influences the total time a bit more substantial.

2.2 Conclusion

One could conclude that the profiler is a very important tool for model optimization as you could easily see the link between a slow execution and the equations used. Compared to the alternative method where you only have the CPU curve together with plots of all other variables to guide you in the process of finding a good spot to improve, the profiler makes the process of performance optimization radically shorter.