

Proposal for Grid/cloud Service for Parameter Sweep in Modelica

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EGI Champion



What we do

- Institute of Pathological Physiology
 - Interdisciplinary team (~10 people)- physicians, mathematicians, computer scientists, biomedical engineers, painters/graphical designers, ...
 - mathematical modeling of human physiology, Software system for simulation application, Graphical design, Educational portal www.physiome.cz/atlas



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Atlas of Physiology and Pathophysiology

1st FACULTY OF MEDICINE INSTITUTE OF PATHOPHYSIOLOGY, CHARLES UNIVERSITY, LABORATORY OF BIOCYBERNETICS AND COMPUTER AIDED TEACHING head of laboratory: JIŘÍ KOFRÁNEK, M.D., Ph.D.

- info
- regulation
- circulation
- haemostasis
- gas transport
- acid-base
- intern. environment
- cell
- kidney
- respiration
- muscle
- physical laws

info

How to use the Atlas

- Modelling and Simulation
- What is behind the curtain
- Authors
- In progress...

Info

Currently the Atlas is only available in Czech version.

Check out the section in progress for updates.

Proposal

Models in Modelica – standard language for mathematical models,

Simulation workflow: MO file → translated to C++/ EXE → produce result files

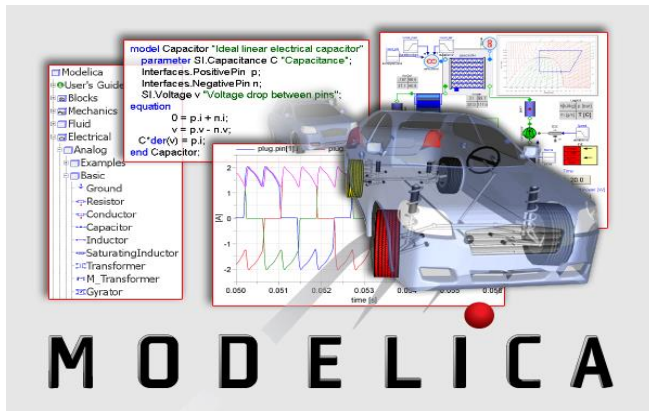
Some parameters (constants in model) are defined by it's normal range

Parameter sweep workflow: range separated to e.g. 10 values, other parameters fixed → 10 simulation per parameter → 24 parameters in models → 240 simulation results

1 Simulation takes about 1 minute → 240 serial simulation takes 240 minutes

- independent, can be parallelized (HPC / HTC) ?

Modelica



Modelica - is an open standard, object-oriented, declarative, multi-domain modeling language for component-oriented modeling of complex systems.

Industry - automotive companies, such as Audi, BMW, Daimler, Ford, Toyota, VW use Modelica to design energy efficient vehicles and/or improved air conditioning systems. Power plant providers, such as ABB, EDF, Siemens use Modelica, as well as many other companies.

Research - projects within Europe spend 75 Mil. € in the years 2007-2015 to further improve Modelica and Modelica related technology. This is performed within the ITEA2 projects EUROSYSLIB, MODELISAR, OPENPROD, and MODRIO

Tools – commercial (3DS Dymola, Wolfram System Modeler, MAPLE, Simulation X), free-opensource (OpenModelica)

Modelica in Physiology

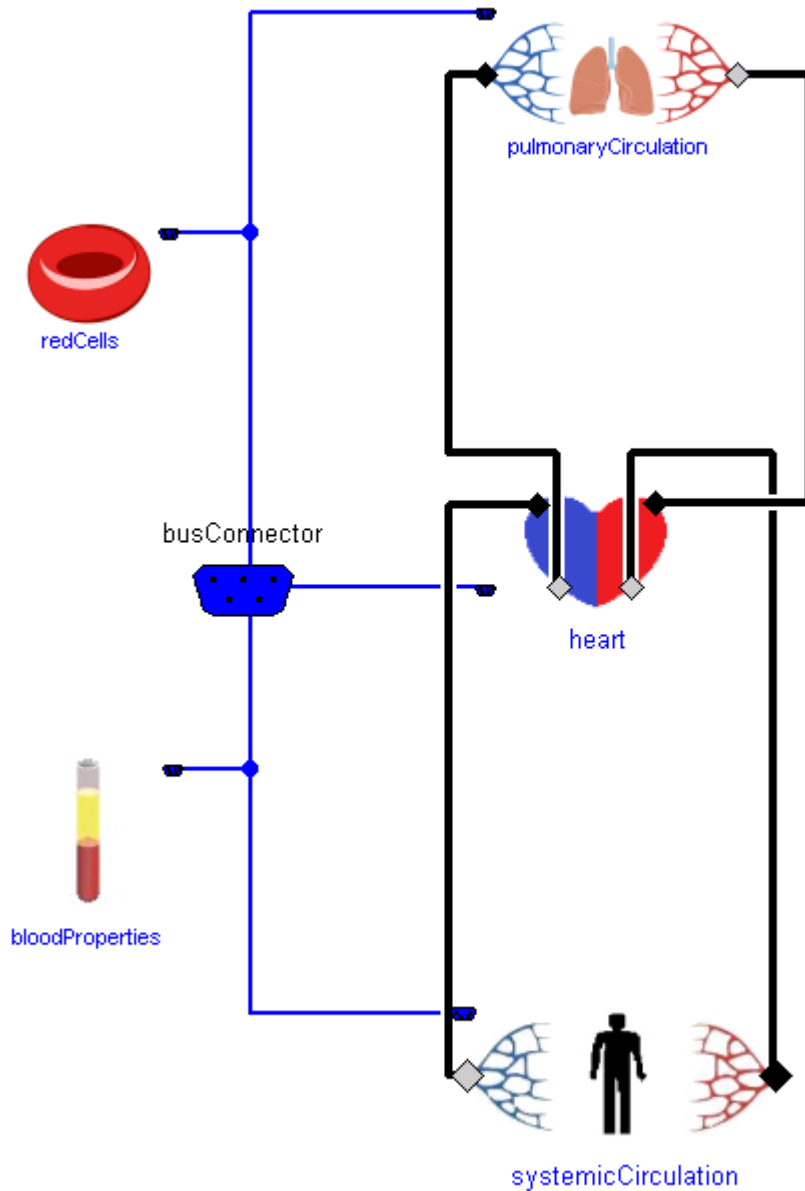
Combination of hydraulic, biochemical, thermofluid, osmotic domain

HumMod - Kofránek, Jiří, Mateják, Marek, Privitzer, Pavol: [HumMod - large scale physiological model in Modelica](#). **8th. International Modelica conference 2011, Dresden, Germany**

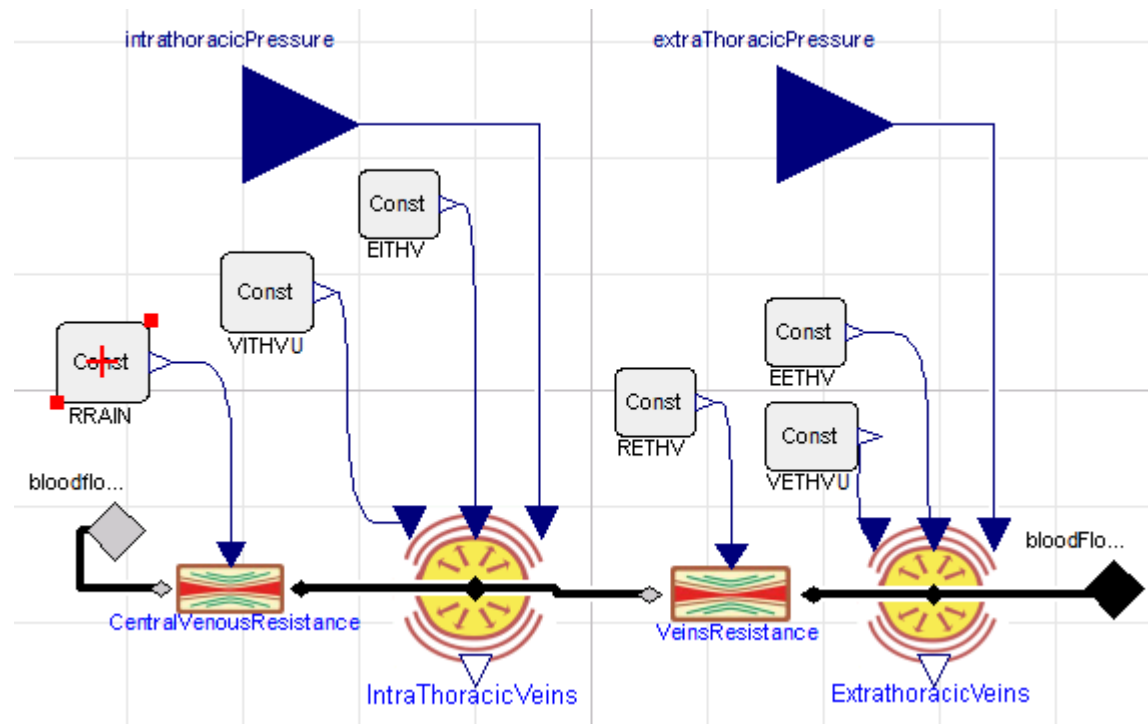
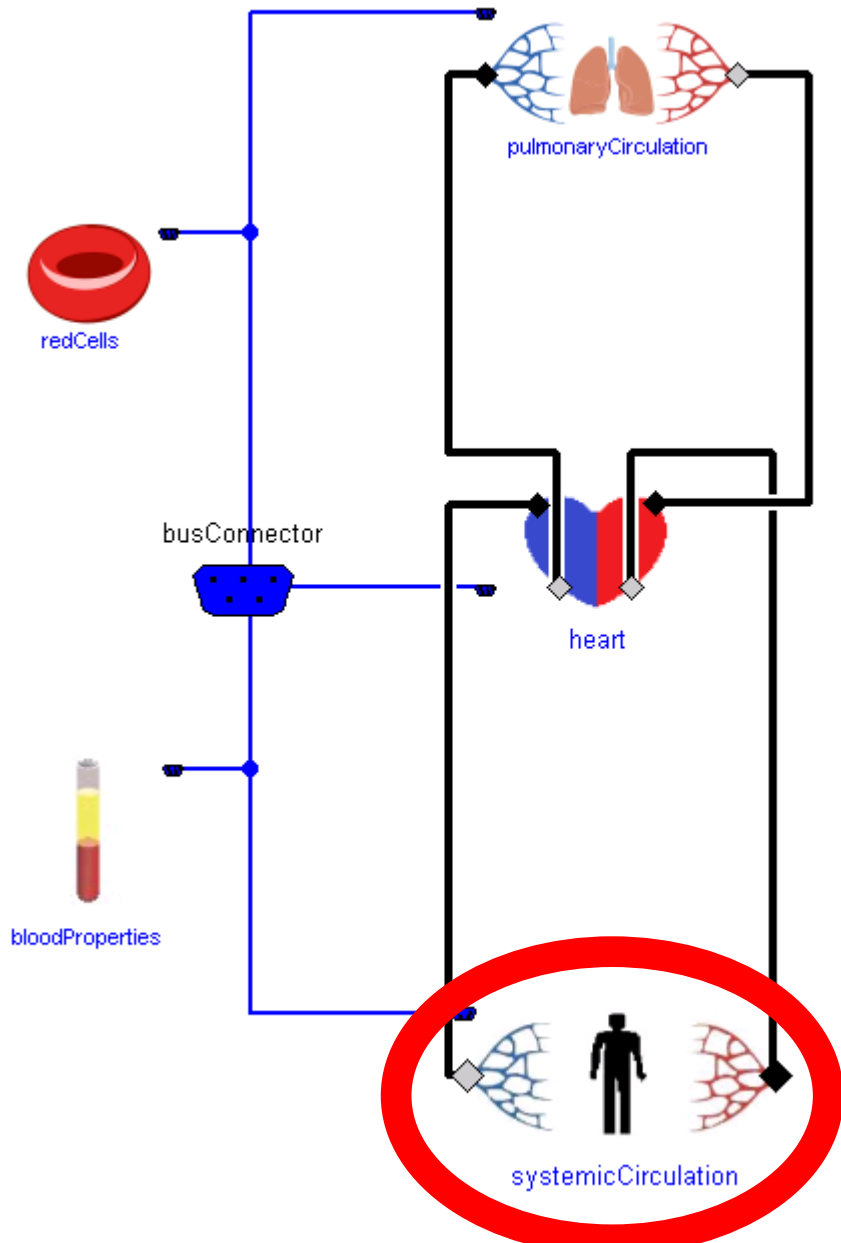
Physiolibrary – free library for modeling physiology, www.physiolibrary.org, 1st price Modelica Free Library Award, 10th International Modelica Conference, March 12, 2014, Lund, Sweden



Example – model of cardiovascular system



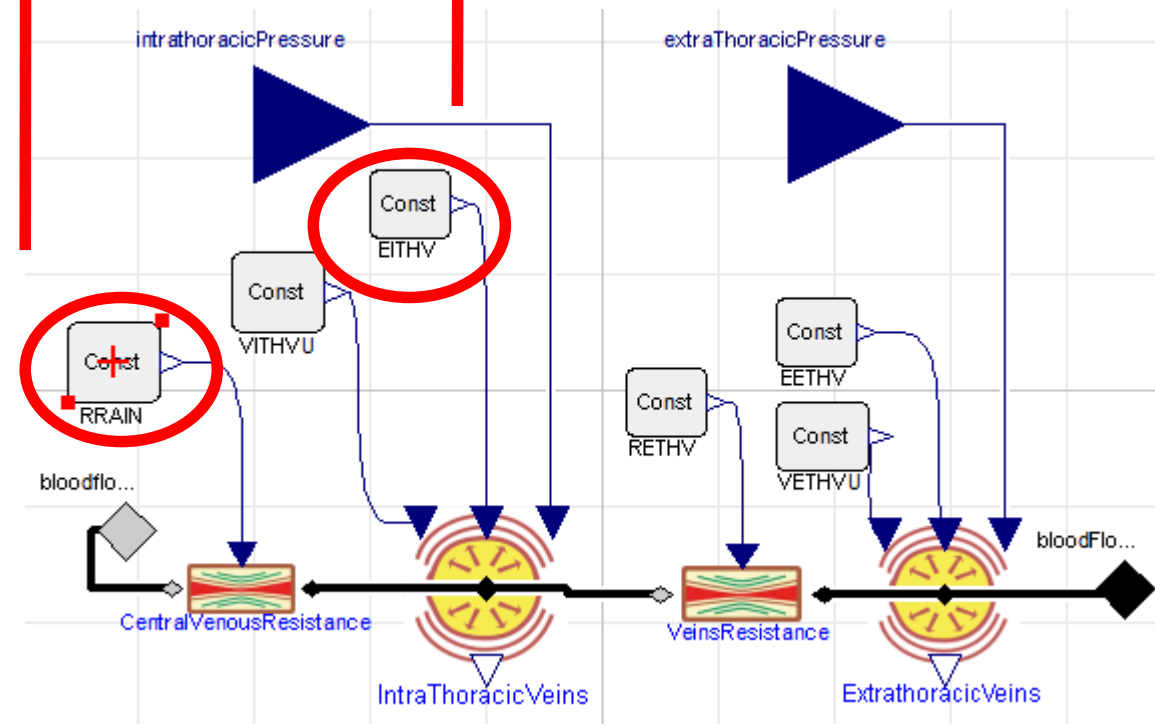
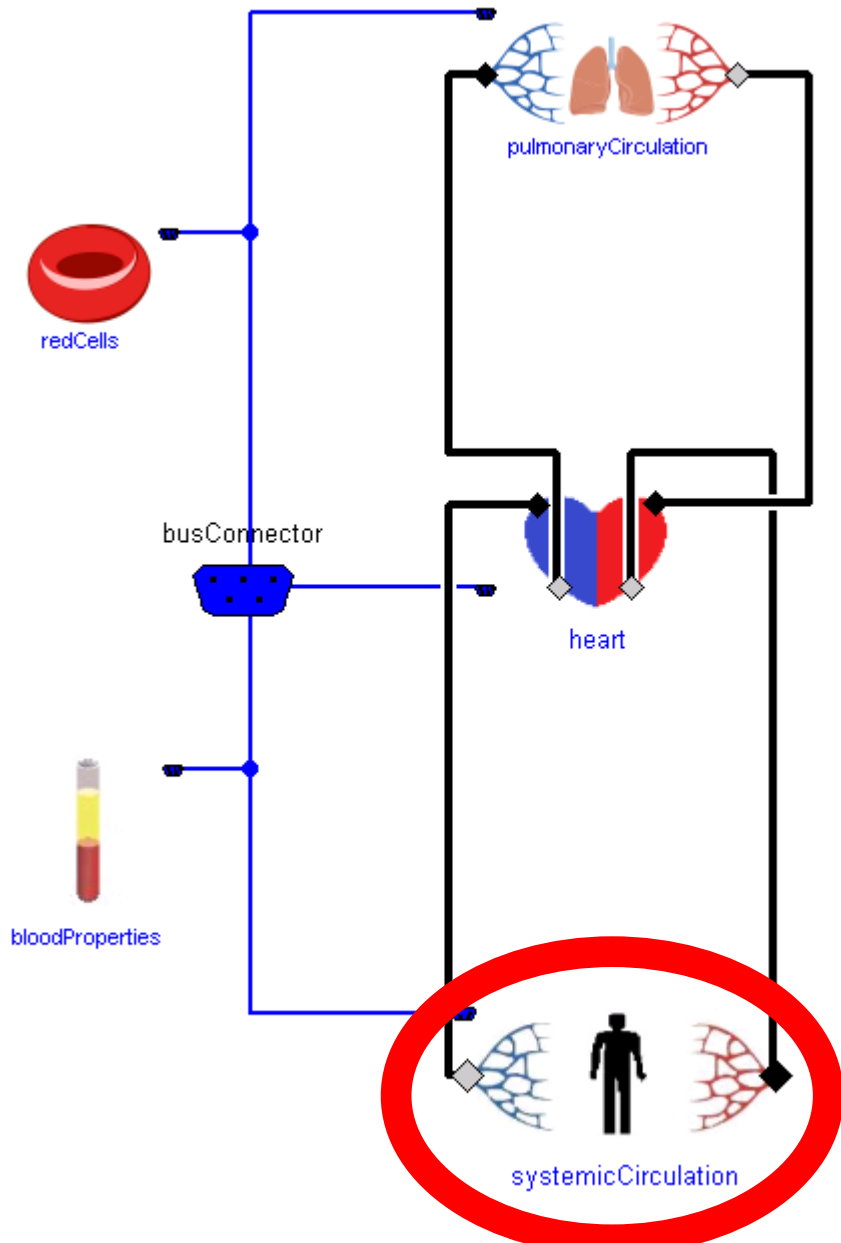
Example Model



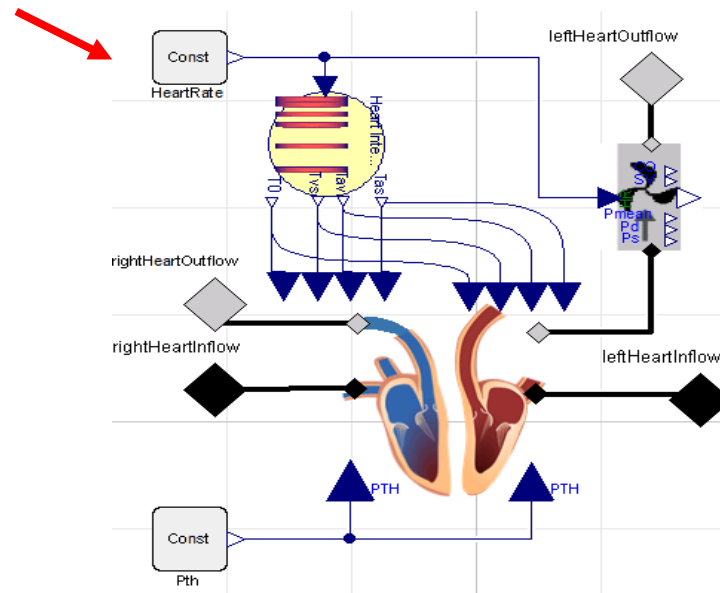
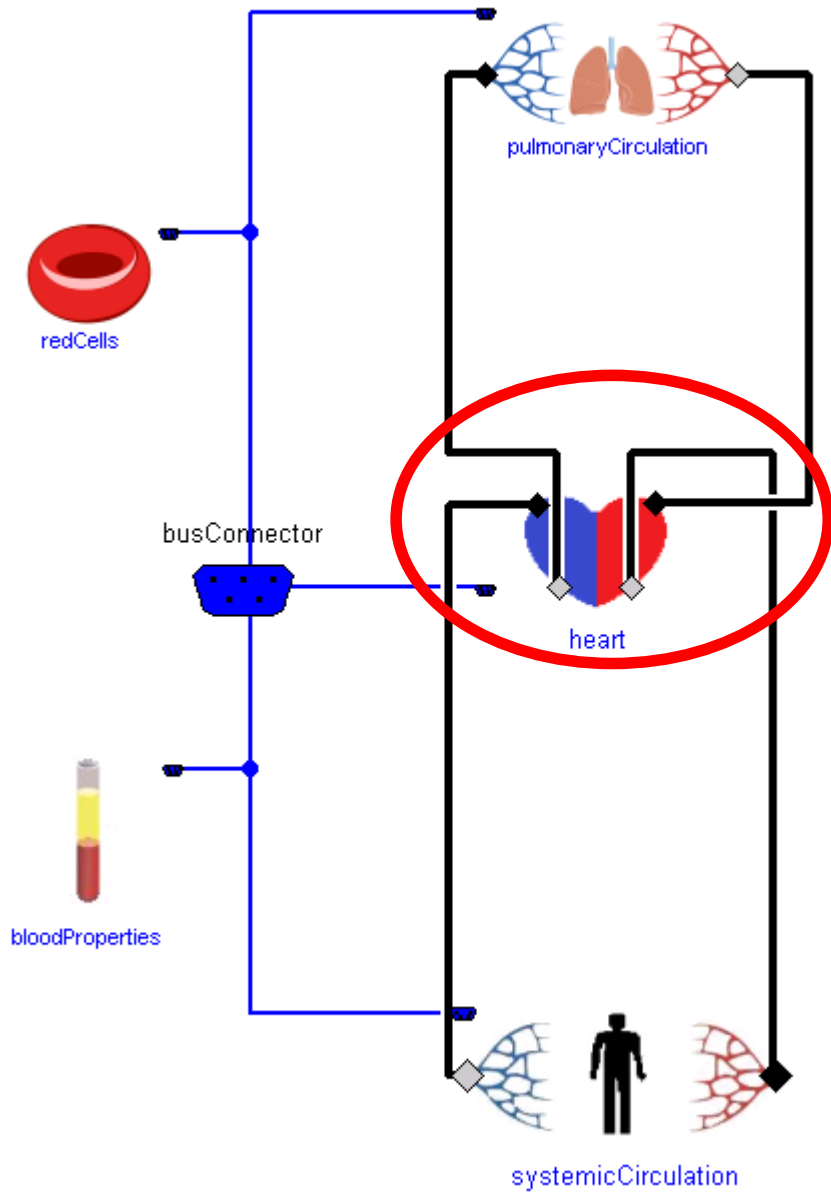
Example Model

RRAIN – resistance of vena cava = $0.003 \text{ mmHg} \cdot \text{s/ml}$
Range $0.0001 - 0.1 \text{ mmHg} \cdot \text{s/ml}$

EITHV – elastance of vena cava = 0.0182 mmHg/ml
Range $0.001 - 0.2 \text{ mmHg/ml}$

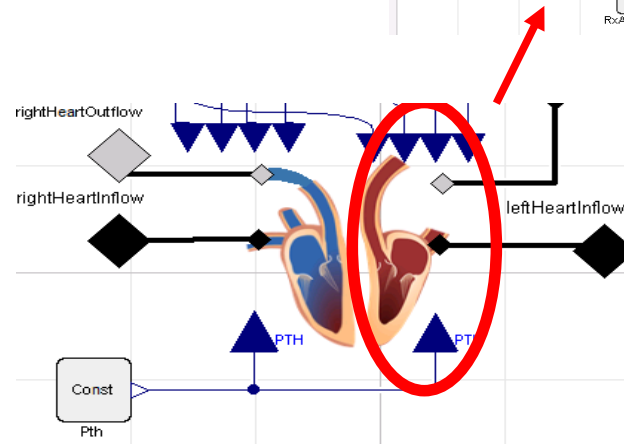
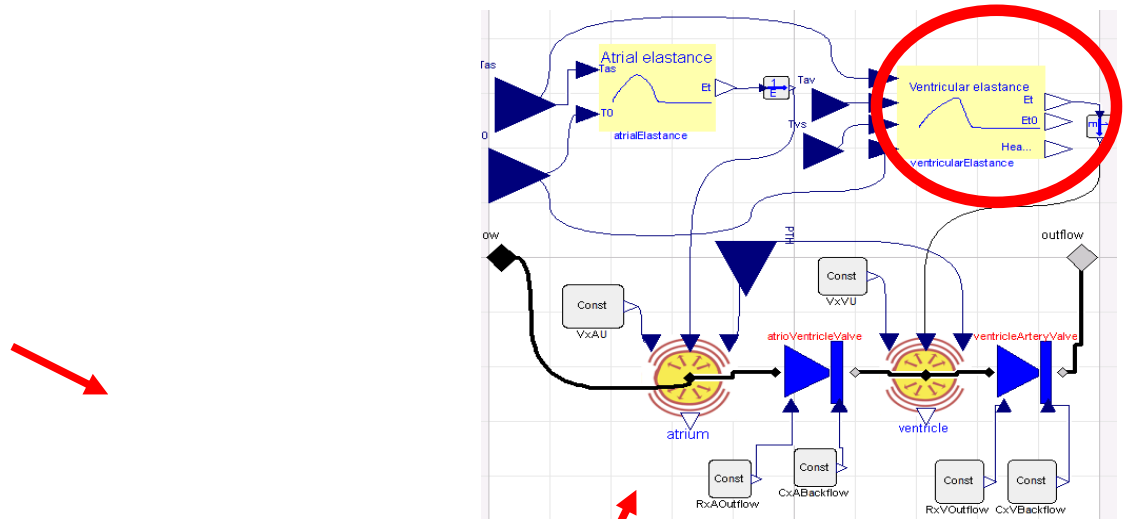
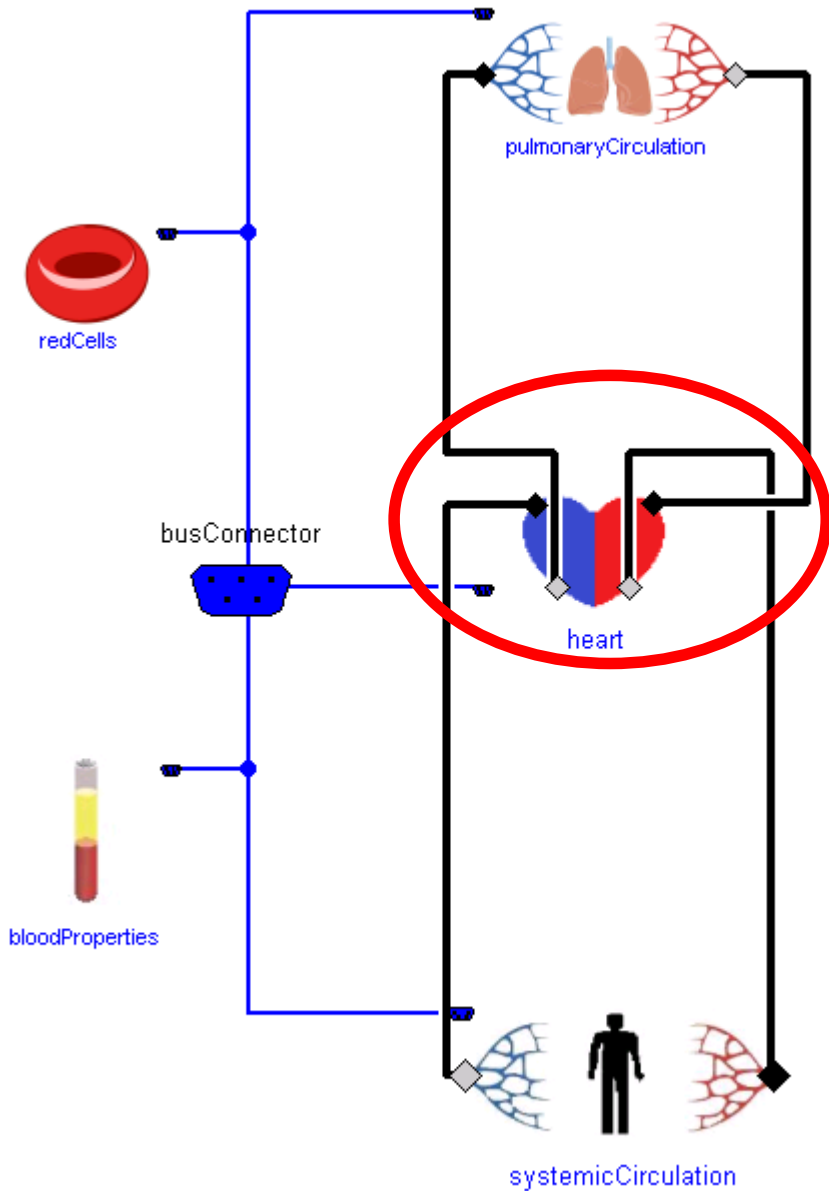


Example Model



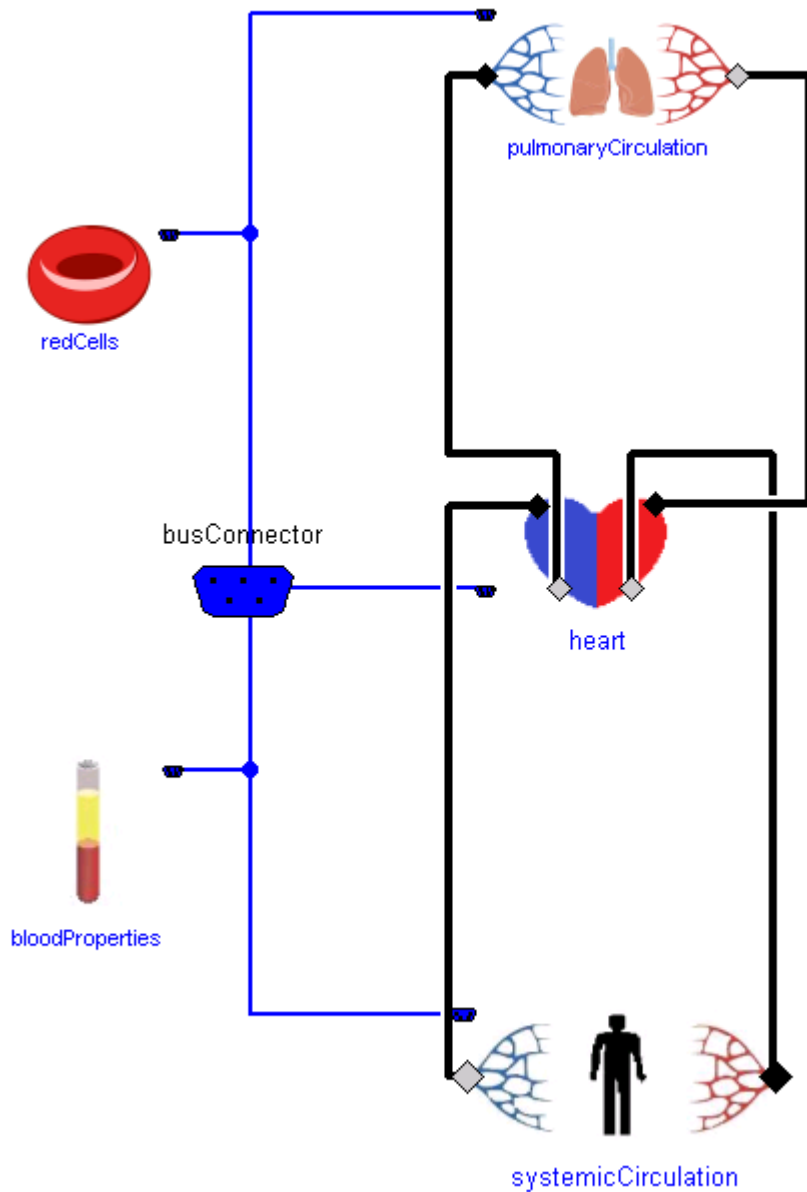
Example Model

Ventricular Elastance $E_{MAX} = 4 \text{ mmHg/ml}$
Physiological range $0.4 - 10 \text{ mmHg/ml}$



Example Model

Parameter sweep:
Sensitive analysis, Validation of mathematical models - comparison with real patients, comparison with experiments



What we have done

System for parameter identification

- Compute parameters that cannot be measured from patient
- Dependent simulation – genetic algorithm, cloud computing
- Model -> Executable (commercial Dymola tool)
- .NET web service, REST API to simulate model
- Web portal with genetic algorithm driving the simulation
- Kulhánek T., Identification of model parameters in cloud deployed simulation service, **EGI TF 2013**, Madrid Spain, presentation & poster
- Planned presentation on Life Sciences Workshop @ EGI CF 2014 Helsinki

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- Reduce computation from hours(days) to minutes, Monte carlo simulation of combinations 10^{24}
- Modelica compilation to FMI or executable - OpenModelica compiler (www.openmodelica.org)
- FMI control layer in C/C++ - <https://github.com/modelon/FMILibrary>
- FMI HTTP REST control layer in .NET - <https://github.com/TomasKulhanek/Physio.FmiRestService>
- Utilize existing grid/cloud workflow
- Test cases - HumMod Modelica Edition (<http://www.physiome.cz/hummod>) or Burkhoff-Kofranek, Meurs-Kulhanek models of Cardiovascular system.

