15th Modelica Conference

THE 15TH INTERNATIONAL MODELICA CONFERENCE

AACHEN

09.-11. OCTOBER 2023

RWTH AACHEN UNIVERSITY

Modelica Association

JÜLICH Forschungszentrum

Modelica Association

Modelica Conference
Aachen 2023

TABLE OF CONTENTS

Modelica Association

Modelica Conference
Aachen 2023

CONFERENCE BOARD

PROF. DIRK MÜLLER (Conference Chair)
RWTH Aachen University, Germany

PROF. ANTONELLO MONTI
RWTH Aachen University, Germany

PROF. ANDREA BENIGNI
Forschungszentrum Jülich GmbH, Germany

PROF. MARTIN OTTER
Deutsches Zentrum für Luft- und Raumfahrt, Germany

PROF. FRANCESCO CASELLA
Politecnico di Milano, Italy

ASSISTANT PROF. MARTIN SJÖLUND
Linköping University, Sweden

DR. MICHAEL TILLER
Realis Simulation, U.S.A.

REVIEWERS

Bernhard Bachmann
John Batteh
Albert Benveniste
Christian Bertsch
Volker Beuter
Robert Braun
Leonardo Carreras
Francesco Casella
Yan Chen
Christoph Clauss
Johan de Kleer
Atiyah Elsheikh
Olaf Enge-Rosenblatt
Gianni Ferretti
Leo Gall
Sriram Karthik Gurumurthy
Anton Haumer
Tobias Heins
Dan Henriksson
Dominik Hering
Yutaka Hirano
David Jansen
Martin Kremer
Larissa Kühn
Alessandro Maccarini
Marwa Maghnie
Laura Maier
Martin Moraga
Marc Moritz
Maximilian Mork
Thierry S. Nouidui
Hans Olsson
Martin Otter
Kaustubh Phalak
Adrian Pop
Marcus Karel Richardson
Clemens Schlegel
Elena Shmoylova
Michael Sielemann
Martin Sjölund
Arne Speerforck
Felix Stegemerten
Jan Stock
Wilhelm Tegethoff
Bernhard Thiele
Matthis Thorade
Michael Tiller
Jakub Tobolar
Hubertus Tummescheit
Eziama Ubachukwu
Alfonso Urquia
Christian Vering
Volker Waurich
Michael Wetter
Stefan Wischhusen
Fabian Wüllhorst
Dirk Zimmer

ORGANIZING COMMITTEE

Julia Breuer
Sina Dibos
Kai Droste
Nina Franck
Sriram Karthik Gurumurthy
Vanessa Hendricks
Dominik Hering
Rahul Karuvingal
Martin Kremer
Larissa Kühn
Marwa Maghnie
Dirk Müller
Felix Stegemerten
Rita Streblow
Christian Vering
Fabian Wüllhorst
Moritz Zuschlag

WELCOME

Welcome to the Modelica Conference 2023 in Aachen!

For many years, Modelica has been an important tool at my institute for the calculation of interesting details in technical systems up to the analysis of complex energy systems. The equation-based approach, especially, allows the early integration of Modelica into the education of students. In this way, students can already develop their own models and combine them with existing models from libraries during their studies and in their final theses. This strengthens students' simulation skills and makes an important contribution to ongoing research projects.

Dynamic simulation has also established itself as a development tool in many companies. Simulation-based decisions can be made at a very early stage of product development, and initial optimizations can be implemented even before a first prototype is created. The object-oriented structure of Modelica makes it possible to develop increasingly detailed and more accurate models based on the initial approaches as the depth of development increases and by calibration using the first experimental data. And so, over the product development phases, a concept model becomes a digital twin that can be used in a variety of ways even after development.

Together with my colleagues Antonello Monti and Andrea Benigni and I am pleased to welcome you as pioneers, developers and users of Modelica in Aachen. The variety of application topics at this conference once again demonstrates the flexibility of Modelica and I am excited to see what we will learn together during the conference. I would like to take this opportunity to especially thank all the sponsors, the Modelica Association and the organizing team, led by Dominik Hering!

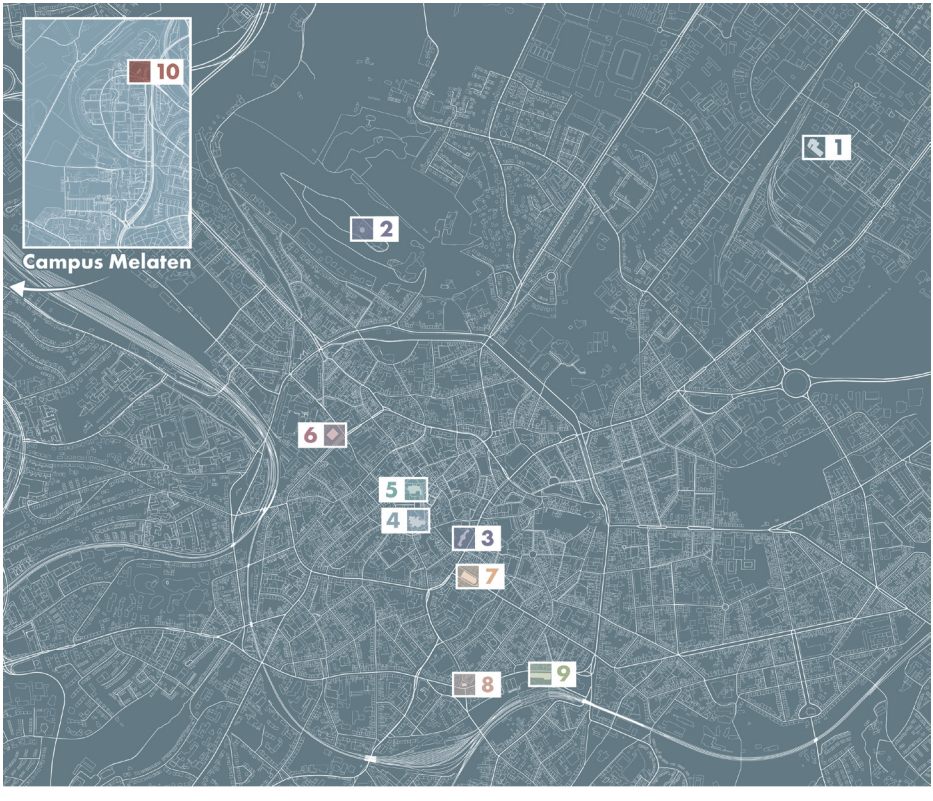
With best regards

UNIV.-PROF DR.-ING. DIRK MÜLLER
Conference Chair

Modelica Association

Modelica Conference
Aachen 2023

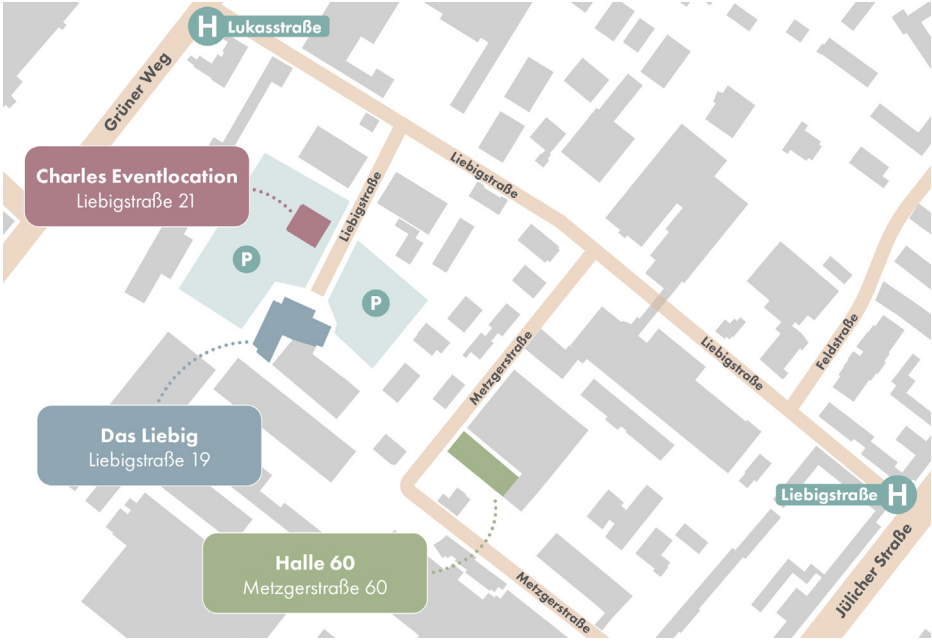
AACHEN



1 - Das Liebig
2 - Lousberg
3 - Elisenbrunnen
4 - Aachen Cathedral
5 - City Hall
6 - Super C
7 - Theatre
8 - Marschiertor
9 - Central Station/Weather Station
10 - RWTH - Energy Research Center

Find more sights and hotels

LOCATION



Das Liebig and *Charles* are the main conference locations where all tutorials, vendor presentations and paper sessions take place. Lunch and dinner will be in *Halle 60*.

DIRECTIONS - BY PUBLIC TRANSPORTATION

There are two bus stops close to the conference location with the following lines:
Lukasstraße (4 minute walk): 34
Liebigstraße (9 minute walk): 1,11,21,31,41,52, 70, 220, SB20

FREE PARKING

There are several free car and bike parking spots available.

DAS LIEBIG

INTERNET/WIFI

Name: Liebig Gast
Password: Lieblingsgast!

MONDAY - 09. OCT. 2023

01:00 PM - 01:30 PM	Welcome Speech Room Carbon
01:30 PM - 02:30 PM	Tutorials - Part 1
02:30 PM - 03:00 PM	Coffee Break Room Gold
03:00 PM - 04:30 PM	Tutorials – Part 2
04:30 PM - 05:00 PM	Coffee break Room Gold
05:00 PM - 07:15 PM	Vendor Presentations
07:15 PM - 09:00 PM	Welcome Reception Room Gold

TUESDAY - 10. OCT. 2023

09:00 AM - 09:35 AM	Modelica News Room Carbon
09:35 AM - 10:20 AM	Keynote Dr. Dirk Zimmer Room Carbon
10:20 AM - 10:35 AM	Coffee Break Room Gold
10:35 AM - 12:15 PM	Session 1-A I Session 1-B I Session 1-C I Session 1-D
12:15 PM - 01:45 PM	Lunch Halle 60
01:45 PM - 03:00 PM	FMI User Meeting Room Carbon I Session 2-B I Session 2-C I Session 2-D
03:00 PM - 03:30 PM	Coffee Break with Poster Presentations Room Gold
03:30 PM - 05:10 PM	Industrial User Presentation Room Carbon I Session 3-B I Session 3-C I Session 3-D
08:00 PM - 11:00 PM	Dinner Halle 60

WEDNESDAY - 11. OCT. 2023

08:30 AM - 09:15 AM	Keynote Dr. Bruno Lüdemann Room Carbon
09:15 AM - 09:30 AM	Coffee Break Room Gold
09:30 AM - 10:45 AM	Session 4-A I Session 4-B I Session 4-C I Session 4-D
10:45 AM - 11:15 AM	Coffee Break with Poster Presentations Room Gold
11:15 AM - 12:30 PM	Session 5-A I Session 5-B I Session 5-C I Session 5-D
12:30 PM - 02:00 PM	Lunch Halle 60
02:00 PM - 03:15 PM	Session 6-A I Session 6-B I Session 6-C I Session 6-D
03:15 PM - 03:30 PM	Closing and Rewards Room Carbon

LOCATIONS FOR SESSIONS

SESSION A Room Carbon

SESSION B Room Silver

SESSION C Room Oxygen

SESSION D Charles

ONLINE VERSION OF THE PROGRAMM:

DAY 1 - TUTORIALS

TUTORIAL: eFMI
TIME: Monday, 09/Oct/2023, 1:30 PM - 4:30 PM
LOCATION: Room Carbon
PRESENTER: Christoff Bürger

We demonstrate the current state-of-the-art of available eFMI tooling. Participants will get a very high-level overview of the eFMI workflow and a hands-on experience of it for selected Modelica example models.

They will configure a tooling workflow from acausal physics models in Modelica down to embedded target code and have a chance to investigate the generated eFMUs and their various intermediate model representations.

Besides setting up and experiencing the eFMI workflow, we will also focus on the non-functional quality criteria satisfied by the generated solutions, like traceability within eFMUs, MISRA C:2012 conformance of generated production code and other code quality criteria like static memory allocation and error handling.

TUTORIAL: Simulation-based optimization with CasADi and FMI
TIME: Monday, 09/Oct/2023, 1:30 PM - 4:30 PM
LOCATION: Room Silver
PRESENTER: Joel Andersson, Joris K C Gillis

CasADi is a versatile open-source framework for numerical optimization in general and numerical optimal control in particular. Over the past 10 years, it has been used for numerous applications in academia and industry.

In this tutorial, we provide a hands-on demonstration of the new FMI for Model Exchange interoperability in CasADi. Topics covered include the calculation of validated first and second order derivatives, forward and adjoint sensitivity analysis, finding steadystate solutions, and numerical optimal control.

TUTORIAL: HVAC and controls modeling with the Modelica IBPSA Library
TIME: Monday, 09/Oct/2023, 1:30 PM - 4:30 PM
LOCATION: Room Oxygen
PRESENTER: Michael Wetter

This workshop teaches fundamentals for HVAC and control modeling using the Modelica IBPSA Library – the core of the Modelica AixLib, Buildings, BuildingSystems and IDEAS Libraries – and OpenModelica's OMEdit.

The workshop will give an introduction to OMEdit and present best practices for modeling HVAC and control systems with Modelica for new users. Participants will conduct hands-on exercises using OMEdit and the Modelica IBPSA Library. The workshop will close with an overview of the four libraries that use the Modelica IBPSA Library as their core, i.e., the AixLib, Buildings, BuildingSystems and IDEAS Libraries.

TUTORIAL: FMI Beginner's tutorial
TIME: Monday, 09/Oct/2023, 1:30 PM - 4:30 PM
LOCATION: Room Helium
PRESENTER: Cinzia Bernardeschi, Christian Bertsch, Cláudio Gomes, Torsten Sommer, Maurizio Palmieri

The first part consists of a presentation of the motivation, history, the FMI project, the basic technical idea, the different FMI versions, limitations and the current state of tool support.

In the second part, hands-on exercises are given to gain first experience with creating, checking, coupling and simulating FMUs in different open source and commercial tools. This second part can also viewed as a demonstration where the exercises are done by the presenters, if the software tools are not available.

At the end an outlook is given on further material: other resources such as tutorial modules for more advanced usage of FMI.

TUTORIAL: Modeling complex thermal architectures using the DLR ThermoFluid Stream Library
TIME: Monday, 09/Oct/2023, 1:30 PM - 4:30 PM
LOCATION: Room Neon
PRESENTER: Niels Weber, Dirk Zimmer

The DLR ThermoFluid Stream Library introduces a new computational concept to enable the robust solution of even complex thermodynamic architectures.

In this tutorial we provide you hands-on examples to work with, discuss the theoretical underpinning and present the newest additions to the library.

For library access and tool compatibility, please visit the ThermofluidStream

TUTORIAL: Studying the robustness of a model with FMI and Persalys
TIME: Monday, 09/Oct/2023, 1:30 PM - 4:30 PM
LOCATION: Room Argon
PRESENTER: Angélique Marion

Numerical simulation with physical models enables the computing of quantities of interest from input parameters and variables. These data are often uncertain: sensors are never 100% reliable, and the properties of two products from the same product line can differ due to various tolerances. Then, how is it possible to trust our models?

Persalys is an open source GUI allowing to account for uncertainties in simulation. It is jointly developed by EDF, the French national electric utility company, and Phimeca.

In this tutorial, we will work together through a case study with a model of a solar collector from the ThermoSysPro library, also developped by EDF. First, we will determine the relative influence of the inputs on the model outputs. In our case the inputs are the sun radiation, angle of the mirror, and outside temperature. The outputs are the heating power delivered by the collector and the temperature of the water that is heated. Then we will perform the central tendancy analysis using the Monte Carlo method.

Finally, we will calculate a failure probability, which in our case is the probability that the water temperature is too low for the heating to be efficient.

TUTORIAL: Techno-economical assessment of industrial infrastructure - optimal design and control to reach net-zero
TIME: Monday, 09/Oct/2023, 1:30 PM - 4:30 PM
LOCATION: Room Xenon
PRESENTER: Daniel Rohde

Dynamic optimization based on CasADi has been around for a number of years and the advantages of this dynamic trajectory-based optimization approach are well understood. However, so far it was always quite inaccessible and hard to integrate into engineering design workflows. With Modelon Impact, we are introducing a fully integrated solution to enable this exciting and powerful technology.

In this tutorial, we will showcase advanced workflows of Modelon Impact – Modelon's cloud-based system simulation platform which is powered by the Optimica Compiler and enables the linking of Modelica with the CasADi dynamic optimization tool chain. Modelon Impact is an easy-to-use tool which provides the ability to not only find the optimal design of your system infrastructure but also delivers the optimal control of the individual components for minimal carbon emissions and cost.

Participants will only require a laptop which has either Google Chrome or Microsoft Edge built on Chromium. Time permitting, we will also provide the participants with an opportunity to test the integrated steady state workflow for rapid sizing of flow components.

TUTORIAL: Introduction to Modeling, Simulation, Debugging, and Interoperability with Modelica and OpenModelica
TIME: Monday, 09/Oct/2023, 1:30 PM - 4:30 PM
LOCATION: Room Copper
PRESENTER: Adrian Pop, Peter Ambjörn Fritzson

This tutorial gives an introduction to the Modelica language, the OpenModelica environment, and an overview of modeling and simulation in a number of application areas.

Moreover, an introduction to debugging Modelica models will be given, and an introduction to interoperability with Julia/Python used for simple control system design. Some advanced features of OpenModelica will be presented, including clocked synchronous support, real-time embedded code generation, FMI export and import, OMPython, OMJulia, etc.

A number of hands-on exercises will be done during the tutorial, both graphical modeling using the Modelica standard library and textual modeling. Bring your laptop for exercises.

DAY 1 - VENDOR PRESENTATIONS

VENDOR PRESENTATION 1

Maplesoft,
Suzhou Tongyuan Software & Control Technology Co., Ltd.
Modelon

TIME: Monday, 09/Oct/2023, 5:00 PM - 7:15 PM
LOCATION: Room Carbon
CHAIR: Dirk Müller

MAPLESOFT: MAPLESIM 2023

MapleSim is a Modelica-based platform that combines system-level modeling and simulation with powerful analytic capabilities. Our goal with MapleSim is to provide engineers with an easy to use tool for design exploration and simulation, and offer options to connect the model with your product development toolchain.

This session will be an overview of some of the unique features of MapleSim, as well as an update on the latest software enhancements.

THE NEXT-GENERATION SCIENTIFIC COMPUTING AND SYSTEM MODELING SIMULATION PLATFORM, MWORKS

After 15 years of development, MWORKS has evolved from a simple Modelica modeling and simulation environment into a next-generation scientific computing and system modeling simulation platform. Based on Modelica, MWORKS.Sysplorer offers a multi-paradigm integrated modeling and simulation environment including physical modeling, block diagram modeling, and state machines.

Built on Julia, MWORKS.Syslab provides an integrated scientific computing development environment. Syslab seamlessly integrates with Sysplorer. Additionally, MWORKS offers cloud versions of Sysplorer and Syslab, known as MoHub. This presentation will first introduce Tongyuan's 15-year journey from Modelica to Julia+Modelica, then delve into the three core software of the MWORKS platform: the scientific computing software Syslab, the system modeling simulation software Sysplorer, and the cloud-based platform MoHub. Lastly, it will showcase typical application cases of MWORKS in industries like aerospace, aviation, and nuclear energy.

MEET MODELON IMPACT – A CLOUD PLATFORM FOR VIRTUALLY DESIGNING, SIMULATING, AND ANALYZING INDUSTRIAL SYSTEMS

What happens when you combine the power of cloud technology with powerful system modeling and simulation? The emergence of cutting-edge MBSE application possibilities for commercial utilization.

In this session, we'll walk through real-world examples of how Modelon Impact goes beyond the traditional use of Modelica-based system simulation tools. We'll also discuss the most recent updates to Modelon's Modelica libraries, Modelon Impact, as well as what users can expect from the platform and its libraries in the near future.

VENDOR PRESENTATION 2

Chiastek
XRG
Wolfram

TIME: Monday, 09/Oct/2023, 5:00 PM - 7:15 PM
LOCATION: Room Silver
CHAIR: Andrea Benigni

CHIASTEK: VALIDATION PLATFORM USING CO-SIMULATION

FMI is a standard for co-simulation communication at system level. The CosiMate software is a platform for co-simulation that allows to instantiate both native system models and/or FMU's. This will help us validating simulation workflow with less effort. In this paper we will present a strategy to set up models owned by internal and external stakeholders using different modelling tools. We will describe how we are achieving the virtual design of Multi-Cylinder SI Engine by instantiation of 3 models from different simulators: Simulink, GTSuite and Amesim.

The system is a multi-cylinder engine, where GT-Suite model is representing the engine, Simulink model a controller and Amesim model a sample converter. We implement a first co-simulation with the original model, then we will export each model as an FMU for co-simulation. The co-simulation platform also allows multi-site distribution and we will discuss how this capability can offer the possibility to run a co-simulation using models located in different places or countries.

Moreover, we will discuss the benefits of native co-simulation to support the validation of FMU's; we will define some prerequisite to export and run an FMU using commercially available simulator then integrate the FMUs into the co-simulation platform; finally, we will underline the advantages of FMUs for co-simulation and distributed co-simulation.

WELCOME TO THE WORLD OF XRG: ADVANCED THERMAL ENERGY SIMULATION AND TOOLS

In this presentation, we will introduce you to our latest advancements and special features in Modelica libraries and tools, showcasing the extremely enhanced capabilities of our Human-Comfort Library, HVAC Library, ClaRaPlus Library and our very efficient Score Excel AddIn enabling simulations for everyone.
Discover how these multi simulation platform solutions empower you to efficiently simulate and model diverse scenarios, optimize thermal behavior, analyze HVAC systems, simulate power plants, and remotely control FMUs or Dymola from the familiar Excel interface. Get ready to elevate your simulation experience with XRG's innovative offerings!

NEW IN SYSTEM MODELER

This presentation will showcase the latest System Modeler features, including streamlined distribution of Modelica libraries, interactive real time interfaces, and Wolfram Language workflows. Furthermore, the latest Modelica libraries from Wolfram will be presented.

VENDOR PRESENTATION 3

JuliaHub
Dassault Systèmes
Claytex

TIME: Monday, 09/Oct/2023, 5:00 PM - 7:15 PM
LOCATION: Room Oxygen
CHAIR: Martin Otter

JULIAHUB VENDOR:

Automating Neural Surrogates for Machine Learning Acceleration of FMUs with JuliaSim DigitalEchoNeural surrogates are machine-learned approximations to existing models that can run >100x faster. However, establishing trust in machine learning workflows is difficult: how does one choose the neural architecture, verify that its results are accurate over the whole space, and do this in a simple testable fashion?

JuliaSim's DigitalEcho is a tool that accomplishes these goals. Its new architecture has methods to adapt the data generation process on the fly in order to improve the surrogate accuracy, generate validation reports for users to understand where using the surrogate would be effective, and integrations for improving warning signals when used in industrial applications.
In this talk we will show how DigitalEchos can be generated directly from FMU-based simulation binaries generated from Modelica models to create faster-running simulations which can be exported back to FMUs for usage in Modelica environments.

DASSAULT SYSTÈMES:
You will discover the latest news and perspectives regarding Dymola and underlying technologies, as well as the portfolio of libraries. Also included: latest standards support and examples of workflows involving native and web clients of the Dassault Systèmes offer.

CLAYTEX
Claytex, a TECHNIA Company, delivers exceptional tools at the cutting edge of vehicle simulation covering every aspect of modelling of all vehicle types, through every stage of development, from concept and durability to real time. With over 25 years of system simulation experience using Dymola and Modelica in the Motorsport and Automotive sectors, we know that no single challenge is the same. So, we apply an adaptable, flexible, and solution-oriented approach, empowering our customers to achieve their technical and business objectives.

AVSandbox, the autonomous vehicle simulation solution developed by Claytex, is built around rFpro and provides physics-based sensor models enabling automotive manufacturers to test, develop and deploy AV solutions into the real world without compromising on safety.

Our simulation tools and services help you create a dynamic development and deployment infrastructure that unleashes the potential of AV and ADAS programmes. The power of AVSandbox, with its millimetre accurate digital twins, high fidelity vehicle dynamics and real-world, physics-based sensor modelling, brings you the precision, flexibility, and scope to test every conceivable parameter in fully deterministic, repeatable, and highly accurate scenarios – Helping to transform your vision from concept to commercialisation.

NOTES

DAY 2 - KEYNOTE
DR. DIRK ZIMMER

KEYNOTE: Dealing with complex models and how to use the idealization of physics to our advantage
TIME: Tuesday, 10/Oct/2023, 9:35 AM - 10:20 AM
LOCATION: Room Carbon

The complexity of models can be assessed in different ways. We can look at the complexity in terms of computational time it takes for simulation. We can also look at the complexity in terms of the underlying program size.

There is a trade-off between these two forms and it is often unclear where the optimum is. How we perform this trade-off is determined by the way we choose to idealize the underlying physical system.

To become better modelers, we will hence revisit the familiar schemes of idealization and then investigate a new approach that is favorable for many applications and offers new opportunities for code generation.

DR. DIRK ZIMMER
DLR e.V.

DAY 2 - SESSION 1

SESSION 1-A: Large-scale system modelling 1
TIME: Tuesday, 10/Oct/2023, 10:35 AM - 12:15 PM
LOCATION: Room Carbon
CHAIR: Dirk Müller

MOPYREGTEST: A PYTHON PACKAGE FOR CONTINUOUS INTEGRATION-FRIENDLY REGRESSION TESTING OF MODELICA LIBRARIES

Philipp Emanuel Stelzig
(simercator GmbH, Germany)

SIMULATION MODEL AS A SERVICE (SMAAS): A CONCEPT FOR INTEGRATED DEPLOYMENT, EXECUTION AND TRACKING OF SYSTEM SIMULATION MODELS

Philipp Emanuel Stelzig, Benjamin Rodenberg
(simercator GmbH, Germany)

CONTROL DEVELOPMENT AND SIZING ANALYSIS FOR A 5TH GENERATION DISTRICT HEATING AND COOLING NETWORK USING MODELICA

Ettore Zanetti, David Blum, Michael Wetter
(Lawrence Berkeley National Laboratory, United States of America)

MARCO: AN EXPERIMENTAL HIGH-PERFORMANCE COMPILER FOR LARGE-SCALE MODELICA MODELS

Giovanni Agosta[1], Francesco Casella[1], Daniele Cattaneo[1], Stefano Cherubin[2], Alberto Leva[1], Michele Scuttari[1], Federico Terraneo[1]
([1]Politecnico di Milano, Italy; [2]Edinburgh Napier University)

SESSION 1-B: Discrete modeling techniques – FEM, CFD, DEM (Discrete Element Method) 1
TIME: Tuesday, 10/Oct/2023, 10:35 AM - 12:15 PM
LOCATION: Room Silver
CHAIR: Martin Otter

OBJECT-ORIENTED MODELLING OF FLEXIBLE CABLES BASED ON ABSOLUTE NODAL COORDINATE FORMULATION

Jianchen Wu[1], Baokun Zhang[1], Dedong Liang[1], Yujie Guo[2], Lu Chen[1], Ji Ding[1], Fanli Zhou[1]
([1]Suzhou Tongyuan Software&Control Technology Co., Ltd., China; [2]College of Aerospace Engineering, Nanjing University of Aeronautics and Astronautics, China)

DEVELOPMENT OF A NOVEL QUASI-2D PEM ELECTROLYZER MODEL IN MODELICA

Ansgar Reimann[1], Paul Kohlenbach[2], Lars Röntzsch[3]
([1]Fraunhofer IEG, Germany; [2]BHT Berlin, Germany; [3]BTU Cottbus, Germany)

MODELICA ASSOCIATION STANDARDS AND SURROGATE MODELING TO ENABLE MULTI-FIDELITY SIMULATIONS

Olle Lindqvist[1], Robert Hällqvist[2,4], Raghu Chaitanya Munjulury[3,4]
([1]FCS Verification & Validation, Saab Aeronautics, Sweden; [2]System Simulation and Concept Development, Saab Aeronautics, Sweden;[3]Technical Management & Maintenance, Saab Aeronautics, Sweden; [4]Division of Fluid and Mechatronic Systems (FLUMES), Linköping University, Sweden)

DISTRIBUTED PARAMETER PNEUMATICS

Felix Fischer, Katharina Schmitz
(ifas, RWTH Aachen University, Germany)

SESSION 1-C: Applications of Modelica for optimization and optimal control 1
TIME: Tuesday, 10/Oct/2023, 10:35 AM - 12:15 PM
LOCATION: Room Oxygen
CHAIR: John Batteh

A RENEWABLE HEAT PLANT MODELICA LIBRARY FOR DYNAMIC OPTIMIZATION WITH OPTIMICA

Thomas Colin De Verdiere[1,2], Sylvain Serra[2], Sabine Sochard[2], Pierre Garcia[1], Pierre Delmas[1], Jean-Michel Renaume[2]
([1]Newheat, France; [2]Universite de Pau et des Pays de l'Adour, E2S UPPA, LaTEP, Pau, France)

EFFICIENT GLOBAL MULTI PARAMETER CALIBRATION FOR COMPLEX SYSTEM MODELS USING MACHINE-LEARNING SURROGATES

Julius Aka[1,2], Johannes Brunnemann[1], Svenne Freund[2], Arne Speerforck[2]
([1]XRG Simulation GmbH, Germany; [2]Hamburg University of Technology, Hamburg)

FAST CHARGE ALGORITHM DEVELOPMENT FOR BATTERY PACKS UNDER ELECTROCHEMICAL AND THERMAL CONSTRAINTS WITH JMODELICA.ORG

Alberto Romero, Johannes Angerer (Kreisel Electric, Austria)

COMPARATIVE STUDY AND VALIDATION OF PHOTOVOLTAIC MODEL FORMULATIONS FOR THE IBPSA MODELICA LIBRARY BASED ON ROOFTOP MEASUREMENT DATA

Laura Maier[1], Christoph Nytsch-Geusen[2], Kushagra Mathur[2], Michael Wetter[3], Dirk Müller[1]
([1]Institute for Energy Efficient Buildings and Indoor Climate, E.ON Energy Research Center, RWTH Aachen University; [2]Institute for Architecture and Urban Planning, Berlin University of the Arts; [3]Lawrence Berkeley National Laboratory, Berkeley, California)

SESSION 1-D: Mechatronics and robotics 1
TIME: Tuesday, 10/Oct/2023, 10:35 AM - 12:15 PM
LOCATION: Charles
CHAIR: Wangda Zuo

PAVING THE WAY FOR HYBRID TWINS USING NEURAL FUNCTIONAL MOCK-UP UNITS

Tobias Thummerer[1], Artem Kolesnikov[2], Julia Gundermann[2], Denis Ritz[3], Lars Mikelsons[1]
([1]University of Augsburg, Germany; [2]ESI Germany GmbH, Dresden, Germany; [3]Technische Universität Dresden, Germany)

MODELING AND SIMULATION OF DYNAMICALLY CONSTRAINED OBJECTS FOR LIMITED STRUCTURALLY VARIABLE SYSTEMS IN MODELICA

Robert Reiser, Matthias J. Reiner
(German Aerospace Center (DLR), Germany)

A GRAPH-BASED META-DATA MODEL FOR DEVOPS: EXTENSIONS TO SSP AND SYSML2 AND A REVIEW ON THE DCP STANDARD

Stefan H. Reiterer, Clemens Schiffer, Mario Schwaiger
(Virtual Vehicle Research, Austria)

INTRODUCING DIALECTIC MECHANICS

Dirk Zimmer, Carsten Oldemeyer
(German Aerospace Center (DLR), Germany)

DAY 2 - FMI USER MEETING

FMI USER MEETING PRESENTATIONS

TIME: Tuesday, 10/Oct/2023, 1:45 PM - 3:00 PM
LOCATION: Room Carbon
CHAIR: Christian Bertsch

BUILDING BLOCKS FOR SIMULATION BASED COOPERATION BETWEEN PARTNERS

Hans-Martin Heinkel[1], Pierre Mai[2]
([1]Robert Bosch GmbH,Germany; [2]PMSF)

This presentation first shows the challenges of Simulation based Cooperation between Partners like, traceability, cooperation in a network of partners with heterogeneous environments. Then some solution building blocks are presented.

First the Credible Simulation Process Framework as a basis for traceability. Then the MIC Core Specification for Model Metadata and its application is presented. The usage of Modelica standards like FMI, SSP, SSP-traceability in a cooperation is shown by an example.

LINKING DESIGN REQUIREMENTS TO FMUS TO CREATE LOTAR COMPLIANT MBSE MODELS

Clément Coïc[1], Mark Williams[2], Juan Carlos Mendo[3], Jose Maria Alvarez-Rodriguez[4], Marcus Karel Richardson[3]
([1]Modelon, Germany; [2]PDES, Inc and INCOSE, USA; [3]The Boeing Company, USA; [4]Department of Computer Science and Engineering, Carlos III University of Madrid, Spain)

Long Time Archiving and Retrieval (LOTAR) of models is key to using the full capabilities of model-Based System Engineering (mBSE) in a system design lifecycle. LOTAR supports model exchange, reuse and the long-term preservation of data representing our valuable product designs and knowledge.

The PDES-LOTAR MBSE workgroup is writing the EN/NAS 9300-Part 5xx specifications to standardize the associated process, across the aerospace industry. These technologies are developed and adapted to each specific MBSE modeling domain, including: product, part, and functional architectures; developing and verifying design requirements; analytical and behavior modeling; and linking data across multiple models.

For the purpose of creating simulation models, the group recommends using the Modelica, FMI (Functional Mockup Interface) and SSP (System Structure and Parameterization) standards. The LOTAR process requires the integration of industrial data, vendor software tool implementations, and data standards.

For the purpose of this example, the archive process was greatly enhanced by developing a tool-agnostic model using the Modelon Impact software. The initiative to create the international standard relies on developing prototypes that couple the engineering process with industrial data in a repeatable workflow of procedures.

The recommendations proposed in this report were developed as one of those prototypes with the intent of significantly improving future LOTAR implementations and promoting the adoption of these standards across multiple industries.

DAY 2 - SESSION 2

SESSION 2-B: Symbolic algorithms and numerical methods for model transformation and simulation 1
TIME: Tuesday, 10/Oct/2023, 1:45 PM - 3:00 PM
LOCATION: Room Silver
CHAIR: Benoît Caillaud

PSEUDO ARRAY CAUSALIZATION

Karim Abdelhak[1], Francesco Casella[2], Bernhard Bachmann[1]
([1]University of Applied Sciences Bielefeld, Germany; [2]Politecnico di Milano)

UNDERSTANDING AND IMPROVING MODEL PERFORMANCE AT SMALL MASS FLOW RATES IN FLUID SYSTEM MODELS

Robert Flesch, Annika Kuhlmann, Johannes Brunnemann, Eiden Jörg
(XRG Simulation GmbH, Germany)

HYBRID DATA DRIVEN/THERMAL SIMULATION MODEL FOR COMFORT ASSESSMENT

Romain Barbedienne[1], Sara Yasmine Ouerk[1], Mouadh Yagoubi[1], Hassan Bouia[2], Aurélie Kaemmerlen[2], Benoit Charrier[2]
([1]IRT-SystemX, France; [2]EDF, France)

SESSION 2-C: Thermodynamic and energy systems applications 1
TIME: Tuesday, 10/Oct/2023, 1:45 PM - 3:00 PM
LOCATION: Room Oxygen
CHAIR: Christopher Laughman

THERMALSYSTEMSCONTROLLIBRARY: A MODELICA LIBRARY FOR DEVELOPING CONTROL STRATEGIES OF INDUSTRIAL ENERGY SYSTEMS

Fabian Borst, Michael Georg Frank, Lukas Theisinger, Matthias Weigold (PTW TU Darmstadt, Germany)

HVAC AND CONTROL TEMPLATES FOR THE MODELICA BUILDINGS LIBRARY

Michael Wetter[1], Antoine Gautier[2], Jianjun Hu[1], Hubertus Tummescheit[3] ([1]Lawrence Berkeley National Laboratory, United States of America; [2]Solamen SAS, Beaupreau en Mauges, France; [3]Modelon Inc, United States of America)

MODELING AND SIMULATION OF THE HYDROGEN VALUE CHAIN WITH THERMOSYSPRO AND MODELICA

Sebastian Vallejo Jimenez[1], Luis Corona Mesa-Molesv, Damien Faille[2], Dina Irofti[2]
([1]ENSTA Paris; [2]EDF R&D)

SESSION 2-D: Real-time and hardware-in-the-loop simulation 1
TIME: Tuesday, 10/Oct/2023, 1:45 PM - 3:00 PM
LOCATION: Charles
CHAIR: Sriram Karthik Gurumurthy

DIALECTIC MECHANICS: EXTENSION FOR REAL-TIME SIMULATION

Carsten Oldemeyer, Dirk Zimmer
(Deutsches Zentrum für Luft- und Raumfahrt(DLR), Germany)

TESTING THE VERIFICATION AND VALIDATION CAPABILITY OF A DCP BASED INTERFACE FOR DISTRIBUTED REAL-TIME APPLICATIONS

Mikel Segura[1], Alejandro J. Calderón[1], Tomaso Poggi[2], Rafael Barcena[3]
([1]Ikerlan, Spain; [2]Mondragon Unibertsitatea, Spain; [3]University of the Basque Country, Spain)

A COUPLED LUMPED PARAMETERS-REDUCED ORDER MODELS APPROACH FOR NEAR REAL-TIME APPLICATIONS INVOLVING CFD

Andrea Lorenzo Lario, Gabriele Ottino
(Dofware S.r.l., Italy)

DAY 2 - INDUSTRIAL USER PRESENTATIONS

INDUSTRIAL USER PRESENTATION

TIME: Tuesday, 10/Oct/2023, 3:30 PM - 5:10 PM
LOCATION: Room Carbon
CHAIR: Andrea Benigni

BALANCE OF PLANT SIMULATION FOR ELECTROLYZERS

Yann Pellny[1], Berina Delalić-Gurda[1], Jacob Arnoldi[2], Max Ellerich[2], Manuel Gräber[1]
([1]TLK Energy GmbH, Germany; [2]NEUMAN & ESSER, Germany)

EXPERIENCES DURING THE DEVELOPMENT OF A MODELICA LIBRARY IN AN INDUSTRIAL CONTEXT ON THE EXAMPLE OF THE REXROTH SIMULATION LIBRARY BRSL

Sven Bätzing, Rüdiger Kampfmann, Nils Menager, Niklas Worschech
(Bosch Rexroth AG, Lohr a. Main, Germany)

PHYSICAL MODELLING IN TRANSPORT AUTOMATION

Edo Drenth
(Volvo Autonomous Solutions AB, Sweden)

DAY 2 - POSTER PRESENTATIONS

POSTER PRESENTATION
TIME: Tuesday, 10/Oct/2023, 3:00 PM - 3:30 PM
Wednesday, 11/Oct/2023, 10:45 AM - 11:15 AM
LOCATION: Room Gold

CALIBRATION WORKFLOW FOR MECHANICAL AND THERMAL APPLICATIONS

Tim Willert[1], Peter Sundström[2]
([1]Modelon K.K., Japan; [2]Modelon AB, Sweden)

SSP IN A MODELICA ENVIRONMENT

Dag Brück
(Dassault Systèmes AB, Sweden)

AN FMI- AND SSP-BASED MODEL INTEGRATION METHODOLOGY FOR A DIGITAL TWIN PLATFORM OF A HOLISTIC RAILWAY INFRASTRUCTURE SYSTEM

Ozan Kugu[1], Shiyang Zhou1, Rebecca Nowak[2], Gabor Müller[3], Stefan Harald Reiterer[3], Alexander Meierhofer[3], Stefan Lachinger[4], Lukas Wurth[1], Manfred Grafinger[1]
([1]Technische Universität Wien, 1060 Vienna, Austria; [2]VRVis Zentrum für Virtual Reality und Visualisierung Forschungs-GmbH, 1220 Vienna, Austria; [3]Virtual Vehicle Research GmbH, 8010 Graz, Austria; [4]AIT - Austrian Institute of Technology GmbH, 1210 Vienna, Austria)

PNRG – A LIBRARY FOR MODELING VARIABLE STRUCTURE ENERGY GRIDS IN MODELICA USING ENERGETIC PETRI NETS

Christian Gutsche[1,2], Zizhe Wang[1,2,] Sebastian Götz[2], Volodymyr Prokopets[2], Uwe Aßmann[2]
([1]Boysen-TU Dresden-Research Training Group; [2]Chair of Software Technology, Technische Universität Dresden, Dresden, Germany Christian Gutsche[1,2], Zizhe Wang[1,2], Sebastian Götz[2], Volodymyr Prokopets[2], Uwe Aßmann[2])

ENERGY EFFICIENCY MEASURES FOR EXISTING FACTORY BUILDINGS

Xenia Kirschstein, Anja Schaffarczyk, Miriam Schuster, Nadja Bishara
(Institute of Structural Mechanics and Design, Technical University of Darmstadt, Germany)

HYBRID POWER SYSTEMS SIMULATION AND OPTIMIZATION UTILIZING SSP AND FMI

Dai Araki[1], Magnus Sandell[2]
([1]Toshiba Digital Solutions Corporation; [2]Toshiba Europe Ltd)

SIMULATION OF VEHICLE HEADLAMP LEVELLING SYSTEMS

Filip Cieslar[1], Martin Düsing[2]
([1]HELLA GmbH & Co. KGaA,, Czech Republic; [2]HELLA GmbH & Co. KGaA,, Germany)

PIECEWISE-STEADY-STATE MODELICA SIMULATIONS FOR THE CONCEPTUAL DESIGN PHASE OF INDUSTRIAL PROCESSES

Raphael Agner, Jonas Grand, Andrin Duss, Beat Wellig
(Lucerne University of Applied Sciences and Arts, Switzerland)

HOME ENERGY DYNAMICS: A MODELICA MODELLING TOOLKIT FOR IDENTIFYING PATHWAYS TO DECARBONISE UK DWELLINGS

Ilaria Salerno[1], Carl Holland[1], Bunmi Adefajo[1], Alessandro Picarelli[2] ([1]Energy System Catapult Ltd., United Kingdom; [2]Claytex, Technia, United Kingdom)

MODELING AND CONTROL DESIGN OF AN EDUCATIONAL MAGNETIC LEVITATION SYSTEM

Anton Haumer
(Ostbayerische Technische Hochschule Regensburg, Germany)

COUPLING OF THERMAL AND ELECTRICAL SYSTEMS FOR THE SIMULATION OF ECS ARCHITECTURES

Nicolás Ablanque[1], Sriram Gurumurthy[2], Santiago Torras[1], Antonello Monti[2], Joaquim Rigola[1], Carles Oliet[1]
([1]Heat and Mass Transfer Technological Center (CTTC), Universitat Politècnica Catalunya (UPC), Spain; [2]ACS, EONERC, RWTH Aachen University, Germany)

A PENALTY FUNCTION-BASED MODELICA LIBRARY FOR MULTI-BODY CONTACT COLLISION

Ziheng Zhu, Hualong Zhao, Xueqi Ma, Yuhui Liu, Lu Chen, Fanli Zhou
(SUZHOU TONGYUAN SOFT.&CTRL. TECH.CO.LTD, China)

AUTOMATIC OPTIMIZATION OF ENERGY SUPPLY SYSTEMS IN BUILDINGS AND CITY QUARTERS BASED ON MODELICA MODELS

Torsten Schwan[1], David Feige[2], Leonhard Wenzel[1], Charlotte Voelckner[1], Martin Leuschke[1]
([1]EA Systems Dresden GmbH, Germany; [2]HKL Ingenieurgesellschaft mbH)

DAY 2 - SESSION 3

SESSION 3-B: Symbolic algorithms and numerical methods for model transformation and simulation 2
TIME: Tuesday, 10/Oct/2023, 3:30 PM - 5:10 PM
LOCATION: Room Silver
CHAIR: Adrian Pop

ACCELERATING THE SIMULATION OF EQUATION-BASED MODELS BY REPLACING NON-LINEAR ALGEBRAIC LOOPS WITH ERROR-CONTROLLED MACHINE LEARNING SURROGATES
Andreas Heuermann[1], Philip Hannebohm[1], Matthias Schäfer[2], Bernhard Bachmann[1]
([1]Hochschule Bielefeld - University of Applied Sciences and Arts, Germany; [2]LTX Simulation GmbH, Germany)

OBJECT-ORIENTED FORMULATION AND SIMULATION OF MODELS USING LINEAR IMPLICIT EQUILIBRIUM DYNAMICS
Dirk Zimmer (German Aerospace Center, Germany)

EXPLOITING MODELICA AND THE OPENIPSL FOR UNIVERSITY CAMPUS MICROGRID MODEL DEVELOPMENT
Fernando Fachini[1], Srijita Bhattacharjee[1], Miguel Aguilera[2], Luigi Vanfretti[1], Giuseppe Laera[1], Tetiana Bogodorova[1], Ardeshir Moftakhari[3], Michael Huylo[4], Atila Novoselac[4]
([1]Rensselaer Polytechnic Institute, United States of America; [2]OPAL-RT Technologies,; [3]Pennsylvania State University; [4]University of Texas at Austin)

TOWARDS THE SEPARATE COMPILATION OF MODELICA: MODULARITY AND INTERFACES FOR THE INDEX REDUCTION OF INCOMPLETE DAE SYSTEMS
Albert Benveniste, Benoît Caillaud, Mathias Malandain, Joan Thibault
(Inria centre at Rennes University)

SESSION 3-C: Applications of Modelica for optimization and optimal control 2
TIME: Tuesday, 10/Oct/2023, 3:30 PM - 5:10 PM
LOCATION: Room Oxygen
CHAIR: Francesco Casella

PARAMETER ESTIMATION OF MODELICA BUILDING MODELS USING CASADI

Carlos Durán Cañas[1], Javier Arroyo[1], Joris Gillis[1,2], Lieve Helsen[1,3]
([1]Department of Mechanical Engineering, KU Leuven, Heverlee, Belgium; [2] Flanders Make@KU Leuven; [3] EnergyVille, ThorPark, Waterschei, Belgium)

PRESENTATION, VALIDATION AND APPLICATION OF THE ENERGYPROCESS LIBRARY

Francois Nepveu[1], Sylvain Mathonniere[2], Nicolas Lamaison[2], Gael Enee[1]
([1]CEA, CEA Pays de la Loire, 44343 Bouguenais cedex, France; [2]Univ. Grenoble Alpes, CEA, Liten, Campus Ines, 73375 Le Bourget du Lac, France)

IMPORT AND EXPORT OF FUNCTIONAL MOCKUP UNITS IN CASADI

Joel Andersson (Jae Andersson Consulting LLC, United States of America)

APPLICATION OF THE OPENMODELICA-MATLAB INTERFACE TO INTEGRATED SIMULATION AND SUCCESSIVE LINEARIZATION BASED MODEL PREDICTIVE CONTROL

Mohammad Hadi Alizadeh[1], Ali M. Sahlodin[1], Arunkumar Palanisamy[2], Francesco Casella[3], Peter Fritzson[2]
([1]Amirkabir University of Technology (Tehran Polytechnique), Iran, Islamic Republic of; [2]Department of Computer and Information Science (IDA), Linköping University, Sweden; [3]Dipartimento di Elettronica, Informazione e Bioingegneria, Politecnico di Milano, Italy)

SESSION 3-D: Thermodynamic and energy systems applications 2
TIME: Tuesday, 10/Oct/2023, 3:30 PM - 5:10 PM
LOCATION: Charles
CHAIR: Michael Wetter

A LIBRARY TO SIMULATE PROCESSES IN THE FACTORY HALL

Julia Gundermann, Torsten Blochwitz
(ESI Germany GmbH, Germany)

DYNAMIC MODELING AND EXPERIMENTAL VALIDATION OF DISHWASHER WITH HEAT PUMP SYSTEM

Erdoğan Mert Şeren, Mutlu İpek
(Arçelik Global, Turkiye)

LARGETESMODELINGTOOLKIT: A MODELICA LIBRARY FOR LARGE-SCALE THERMAL ENERGY STORAGE MODELING AND SIMULATION

Michael Reisenbichler-S.[1,2], Franz Wotawa[2], Keith O'Donovan[1,3], Carles Ribas Tugores[1], Franz Hengel[1]
([1]AEE - Institute for Sustainable Technologies, Austria; [2]Institute of Software Technology, Graz University of Technology, Austria; [3]Modelon Deutschland GmbH, Germany)

ON THE CHARACTERISTICS OF ONE-DIMENSIONAL COMPRESSIBLE FLOW

Hongtao Qiao[1], Takashi Kobayashi[2], Christopher Laughman[1], Scott Bortoff[1]
([1] Mitsubishi Electric Research Labs, United States of America; [2]Mitsubishi Electric Corporation)

DAY 3 - KEYNOTE
DR. BRUNO LÜDEMANN

KEYNOTE: Relevance of Dynamic Simulation of complex systems in Building Technology - review and outlook
TIME: Wednesday, 11/Oct/2023, 8:30 AM - 9:15 AM
LOCATION: Room Carbon

In the last three decades, simulations have been used more and more as a matter of course to answer a wide variety of questions for the planning and construction of buildings and technical building systems.

ROM Technik, as a large construction company for technical equipment of buildings, has been using these possibilities intensively for its own projects for over 30 years and is actively involved in the development and integration of simulation tools into the overall construction process.

From the lecturer's many years of practice as research assistant and at ROM R&D, examples will be shown to illustrate the growing importance and acceptance of simulations in practice and to present the deeper anchoring in the digital construction process that is currently being strived for the future.

DR. BRUNO LÜDEMANN
ROM-Technik GmbH & Co. KG

DAY 3 - SESSION 4

SESSION 4-A: New features of the Modelica language and of FMI 1
TIME: Wednesday, 11/Oct/2023, 9:30 AM - 10:45 AM
LOCATION: Room Carbon
CHAIR: Luigi Vanfretti

MODELICA 3.6 - CHANGES, BENEFITS AND IMPLEMENTATION

Hans Olsson (Dassault Systèmes, Sweden)

MODELICA MODELS IN SSP

Dag Brück (Dassault Systèmes AB, Sweden)

BEYOND FMI - TOWARDS NEW APPLICATIONS WITH LAYERED STANDARDS

Christian Bertsch[1], Matthias Blesken[2], Torsten Blochwitz[3], Andreas Junghanns[4], Benedikt Menne[2], Pierre R. Mai[5], Kevin Reim[2], Klaus Schuch[6], Torsten Sommer[7], Markus Süvern[2], Patrick Täuber[2] ([1]Robert Bosch GmbH, Germany; [2]dSpace GmbH, Germany; [3]ESI Group, Germany; [4]Synopsys, Germany; [5]PMSF IT Consuling; [6]AVL List GmbH, Austria; [7]Dassault Systems, Germany)

SESSION 4-B: Thermodynamic and energy systems applications 3
TIME: Wednesday, 11/Oct/2023, 9:30 AM - 10:45 AM
LOCATION: Room Silver
CHAIR: Hubertus Tummescheit

CONVECTION OF CHEMICALS AND OTHER SUBSTANCES WITH THERMOSYSPRO

Giorgio Simonini, Arnaud Duval, Sarah Hocine-Rastic, Mathilde Praud (EDF, France)

HEAT CONSUMER MODEL FOR ROBUST AND FAST SIMULATIONS OF DISTRICT HEATING NETWORKS

Johannes Zipplies, Janybek Orozaliev, Klaus Vajen
(University of Kassel, Department of Solar and Systems Engineering, Germany)

LOW-ORDER AQUIFER THERMAL ENERGY STORAGE MODEL FOR GEOTHERMAL SYSTEM SIMULATION

Alessandro Maccarini[1], Michael Wetter[2], Davide Varesano[3], Martin Bloemendal[4], Alireza Afshari[1], Angelo Zarrella[3]
([1]Department of the Built Environment, Aalborg University, Denmark; [2]Building Technology and Urban Systems Division, Lawrence Berkeley National Laboratory, USA; [3]Department of Industrial Engineering, University of Padova, Italy; Department of Water Management, [4]Delft University of Technology, and KWR water research, The Netherlands)

SESSION 4-C: Other industrial applications, such as electric drives, power systems, aerospace, etc. 1
TIME: Wednesday, 11/Oct/2023, 9:30 AM - 10:45 AM
LOCATION: Room Oxygen
CHAIR: Anton Haumer

USING THE DLR THERMOFLUID STREAM LIBRARY FOR THERMAL MANAGEMENT OF FUEL CELL SYSTEMS IN AVIATION

Niels Weber[1], Camiel Cartignij[2], Dirk Zimmer[1]
([1]German Aerospace Center (DLR), Germany; [2]Eindhoven University of Technology, Netherlands)

A MODELICA LIBRARY TO ADD CONTACT DYNAMICS AND TERRAMECHANICS TO MULTI-BODY MECHANICS

Fabian Buse, Antoine Pignède, Stefan Barthelmes (DLR, Germany)

SUPPORTING INFINITELY FAST PROCESSES IN CONTINUOUS SYSTEM MODELING

John Kristofer Tinnerholm[1], Francesco Casella[2], Adrian Pop[1]
([1]Department of Computer and Information Science (IDA), Linköping University, Sweden; [2]Dipartimento di Elettronica, Informazione e Bioingegneria, Politecnico di Milano, Italy)

SESSION 4-D: Medicine and biology applications 1
TIME: Wednesday, 11/Oct/2023, 9:30 AM - 10:45 AM
LOCATION: Charles
CHAIR: Peter Ambjörn Fritzson

CREATING CARDIOVASCULAR AND RESPIRATORY MODELS USING PHYSIOLIBRARY 3.0

Marek Mateják[1,2]
([1]Charles University inPrague, Czech Republic; [2] Institute for Clinical and Experimental Medicine, Czech Republic)

DESIGN IDEAS BEHIND BIOPROCESS LIBRARY FOR MODELICA

Jan Peter Axelsson
(Vascaia AB, Sweden)

BODYLIGHT.JS 2.0 - WEB COMPONENTS FOR FMU SIMULATION, VISUALISATION AND ANIMATION IN STANDARD WEB BROWSER

Tomas Kulhanek[1,2] , Arnost Mladek[2], Jiri Kofranek[1,2] , Filip Jezek[2,3]
([1]Creative Connections, Czechia; [2]Charles University, Prague, Czechia; [3]University of Michigan, Ann Arbor, USA)

DAY 3 - SESSION 5

SESSION 5-A: New features of the Modelica language and of FMI 2
TIME: Wednesday, 11/Oct/2023, 11:15 AM - 12:30 PM
LOCATION: Room Carbon
CHAIR: Christian Bertsch

DESIGN PROPOSAL OF A STANDARDIZED BASE MODELICA LANGUAGE

Gerd Kurzbach[1], Oliver Lenord[2], Hans Olsson[3], Martin Sjölund[4], Henrik Tidefelt[5]
([1]ESI Germany GmbH, Germany; [2]Robert Bosch GmbH, Germany; [3]Dassault Systèmes, Sweden; [4]Department of Computer and Information Science (IDA), Linköping University, Sweden; [5]Wolfram MathCore, Sweden)

A PRECICE-FMI RUNNER TO COUPLE FMUS TO PDE-BASED SIMULATIONS

Leonard Willeke, David Schneider, Benjamin Uekermann
(University of Stuttgart, Germany)

SECURE EXCHANGE OF BLACK-BOX SIMULATION MODELS USING FMI IN THE INDUSTRIAL CONTEXT

Christian Wolf[1], Miriam Schleipen[1], Georg Frey[2]
([1]EKS InTec GmbH, Germany; [2]Chair of Automation and Energy Systems, Saarland University, Germany)

SESSION 5-B: Experimental language designs and implementations related to Modelica 1
TIME: Wednesday, 11/Oct/2023, 11:15 AM - 12:30 PM
LOCATION: Room Silver
CHAIR: Dirk Zimmer

THE COMMON REQUIREMENT MODELING LANGUAGE

Daniel Bouskela[1], Lena Buffoni[2], Audrey Jardin[1], Vince Molnair[3], Adrian Pop[2], Armin Zavada[4] ([1]Electrecite de France, France; [2]Linköping University, Sweden; [3]Budapest University of Technology and Economics, Hungary; [4]IncQuery Labs cPlc., Hungary)

VARIABLE STRUCTURE SYSTEM SIMULATION VIA PREDEFINED ACAUSAL COMPONENTS

Andrea Neumayr, Martin Otter (German Aerospace Center, Germany)

MOCITEMPGEN: MODELICA CONTINUOUS INTEGRATION TEMPLATE GENERATOR

David Jansen, Fabian Wüllhorst, Sven Hinrichs, Dirk Müller (RWTH Aachen University, E.ON Energy Research Center, Institute for Energy Efficient Buildings and Indoor Climate, Germany)

SESSION 5-C: Other industrial applications, such as electric drives, power systems, aerospace, etc. 2
TIME: Wednesday, 11/Oct/2023, 11:15 AM - 12:30 PM
LOCATION: Room Oxygen
CHAIR: Marcus Karel Richardson

STEADY STATE AND DYNAMIC SIMULATION OF A SMALL-SCALE HOLLOW FIBER MEMBRANE HUMIDIFIER

Markus Pollak[1], Manuel Kutz[2], Christian Schulze[2], Wilhelm Tegethoff[1,2], Jürgen Köhler[1]
([1]Institut für Thermodynamik, Technische Universität Braunschweig, Germany; [2]TLK-Thermo GmbH, Germany)

MODELING COMPONENTS OF A TURBINE-GENERATOR SYSTEM FOR SUB-SYNCHRONOUS OSCILLATION STUDIES WITH MODELICA

Eric Segerstrom[1], Luigi Vanfretti[2], Chetan Mishra[3], Kevin D. Jones[3]
([1]University of Vermont; [2]Rensselaer Polytechnic Institute, United States of America; [3]Dominion Energy)

DRONELIBRARY: MULTI-DOMAIN DRONE MODELING IN MODELICA

Meaghan Podlaski[1], Luigi Vanfretti[2], Dietmar Winkler[3]
([1]GE Research; [2]Rensselaer Polytechnic Institute; [3]University of South-Eastern Norway)

SESSION 5-D: Thermodynamic and energy systems applications 4
TIME: Wednesday, 11/Oct/2023, 11:15 AM - 12:30 PM
LOCATION: Charles
CHAIR: Laura Maier

OPTIMAL SCHEDULING OF IES CONSIDERING THERMAL TRANSMISSION DELAY BASED ON MODELICA AND JULIA

Yong Qiu, Jin Wang, Shubin Zhang, Yuan He, Haiming Zhang, Ji Ding, Fanli Zhou
(Suzhou Tongyuan Software & Control Technology Co. , Ltd, China, People's Republic of)

SIMULATION STUDY OF FLOW INSTABILITY IN PARALLEL MULTI-CHANNEL SYSTEMS BASED ON MODELICA

qiushi Tong[1], xing LV[1], Kangjie Deng[2], Xiaokang Zeng[2], JI Ding[1], Fanli Zhou[1]
([1]Suzhou Tongyuan Software & Control Technology Co. , Ltd, China, People's Republic of; [2]CNNC Key Laboratory on Nuclear Reactor Thermal Hydraulics Technology Nuclear Power Institute of China)

INTEGRATION OF HEAT FLOW THROUGH BORDERS BETWEEN ADJACENT ZONES IN AIXLIB'S REDUCED-ORDER MODEL

Philip Groesdonk[1,2], David Jansen[3], Jacob Estevam Schmiedt[1], Bernhard Hoffschmidt[1,2]
([1]Institute for Solar Research, German Aerospace Center (DLR), Germany; [2]Chair of Solar Components, RWTH Aachen University, Germany; [3]Institute for Energy Efficient Buildings and Indoor Climate, RWTH Aachen University, Germany)

DAY 3 - SESSION 6

SESSION 6-A: Thermodynamic and energy systems applications 5
TIME: Wednesday, 11/Oct/2023, 2:00 PM - 3:15 PM
LOCATION: Room Carbon
CHAIR: Dominik Hering

5TH GENERATION DISTRICT HEATING AND COOLING MODELICA MODELS FOR PROSUMER INTERACTION ANALYSIS

Orestis Angelidis[1], Daniel Zinsmeister[2], Anastasia Ioannou[1], Daniel Friedrich[3], Alan Thomson[4], Gioia Falcone[1]
([1]University of Glasgow, United Kingdom; [2]Technical University of Munich, Germany; [3]The University of Edinburgh, United Kingdom; [4]Ramboll, United Kingdom)

HEAT EXCHANGER SURROGATES FOR A VAPOR COMPRESSION SYSTEM

Nasrulloh Ratu Bagus Satrio Loka[1], Nicolás Ablanque Mejía[2], Santiago Torras Ortiz[2], Sriram Karthik Gurumurthy[3], Antonello Monti[3], Joaquim Rigola[2], Carles Oliet[2], Ivo Couckuyt[1], Tom Dhaene[1]
([1]INTEC, Ghent University - IMEC, Belgium; [2]Universitat Politècnica de Catalunya - Barcelona Tech (UPC), Heat and Mass Transfer Technological Center (CTTC), Spain; [3]ACS, EONERC, RWTH Aachen University, Germany)

ELECTRODE BOILER MODEL FOR ANCILLARY SERVICE SIMULATION

Rene Just Nielsen, Thomas Egsgaard Pedersen
(Added Values P/S, Denmark)

SESSION 6-B: Multi-engineering modeling and simulation with free and commercial Modelica libraries
TIME: Wednesday, 11/Oct/2023, 2:00 PM - 3:15 PM
LOCATION: Room Silver
CHAIR: Francesco Casella

STATUS OF THE CLARA LIBRARY: DETAILED TRANSIENT SIMULATION OF COMPLEX ENERGY SYSTEMS

Ales Vojacek, Johannes Brunnemann, Tim Hanke, Thomas Marx-Schubach, Jörg Eiden
(XRG Simulation GmbH, Germany)

OPEN-SOURCE MODELS FOR SAND-BASED THERMAL ENERGY STORAGE IN HEATING APPLICATIONS

Kathryn Hinkelman[1], David Milner[2], Wangda Zuo[1,3]
([1]Pennsylvania State University, United States of America; [2]University of Colorado, United States of America; [3]National Renewable Energy Laboratory, United States of America)

AN OPEN-SOURCE BENCHMARK OF IEEE TEST CASES FOR EASILY TESTING A NEW APPROACH FOR STEADY STATE CALCULATIONS IN POWER SYSTEMS

Joy El Feghali, Quentin Cossart, Gautier Bureau, Baptiste Letellier, Ian Menezes, Florentine Rosiere, Marco Chiaramello
(RTE Réseau de transport d'électricité, France)

SESSION 6-C: Other industrial applications, such as electric drives, power systems, aerospace, etc. 3
TIME: Wednesday, 11/Oct/2023, 2:00 PM - 3:15 PM
LOCATION: Room Oxygen
CHAIR: Markus Pollak

DROPWISE CONDENSATIONWATER DRAINAGE MODEL

Marcus Karel Richardson[1], Robert Francis Kunz[2]
([1]Boeing, United States of America; [2]Penn State University)

MODELING SPECIALIZED ELECTRIC POWER GENERATORS, EXCITATION SYSTEMS AND PRIME MOVERS USED BY NORTH AMERICAN UTILITIES

Md Shamimul Islam[1], Giuseppe Laera[1], Marcelo de Castro Fernandes[1], Luigi Vanfretti[1], Chetan Mishra[2], Kevin D. Jones[2]
([1]Rensselaer Polytechnic Institute, New York, United States of America; [2]Dominion Energy, Virginia, United States of America)

NUMERICALLY EFFICIENT DEGRADATION MODEL OF CATALYST LAYERS IN PEM FUEL CELLS USING MODELICA

Jakob Trägner, Steffen Heinke, Wilhelm Tegethoff, Jürgen Köhler
(Institut für Thermodynamik, TU Braunschweig, Germany)

SESSION 6-D: Automotive applications 1
TIME: Wednesday, 11/Oct/2023, 2:00 PM - 3:15 PM
LOCATION: Charles
CHAIR: Christian Vering

MASS CONSERVATION IN VAPOR COMPRESSION CYCLES: A METHOD FOR ENSURING CONSISTENCY WITH REDUNDANT DYNAMIC STATES

Daniel Andersson[2], John Batteh[1], Matthis Thorade[3], Lixiang Li[1]
([1]Modelon Inc., United States of America; [2]Modelon AB, Sweden; [3]Modelon Deutschland GmbH, Germany)

RACE CAR COOLING SYSTEM MODEL FOR REAL TIME USE IN A DRIVING SIMULATOR

Massimo Stellato[1], Luca Bergianti[1], Alessandro Picarelli[2]
([1]Dallara Automobili, Italy; [2]Claytex, United Kingdom)

SWITCHING AND AVERAGING MODELS OF A BIDIRECTIONAL, HALF-BRIDGE BASED DC-DC CONVERTER WITH LOAD DISTRIBUTION

Andrea Reindl[1], Andreas Lang[2], Michael Niemetz[2], Hans Meier[2]
([1]OTH Regensburg / TU Berlin, Germany; [2]OTH Regensburg, Germany)

ABSTRACTS - POSTER SESSION

POSTER PRESENTATION
TIME: Tuesday, 10/Oct/2023, 3:00 PM - 3:30 PM
Wednesday, 11/Oct/2023, 10:45 AM - 11:15 AM
LOCATION: Room Gold

CALIBRATION WORKFLOW FOR MECHANICAL AND THERMAL APPLICATIONS

Tim Willert[1], Peter Sundström[2]
([1]Modelon K.K., Japan; [2]Modelon AB, Sweden)

The calibration of models against measurement data is important to ensure model dynamics that are close to its real-world system. Derivative-free minimizing methods can be used for any model calibration regardless of continuous differentiability requirements, and find a (local) minimum in a reasonable number of iteration steps. A user-friendly, python-based calibration Dash app to use with the cloud-based Modelica platform Modelon Impact is introduced. Basic calibration setup is done through the GUI of the app and graphical feedback (i.e. plots) is provided. Two example calibrations are shown: A mechanical Furuta pendulum that only uses Modelica Standard Library components is calibrated against real-world measurement data, and a low-fidelity heat exchanger testbench model that uses Modelon's Air Conditioning Library is calibrated against a corresponding high-fidelity model.

ABSTRACTS - POSTER SESSION

SSP IN A MODELICA ENVIRONMENT

Dag Brück
(Dassault Systèmes AB, Sweden)

System Structure and Parameterization (SSP) is a tool independent standard to define complete systems. Dymola now supports import and export of SSP files, and this paper describes how SSP support was implemented in Dymola and discusses some of the constraints and unavoidable compromises.

ABSTRACTS - POSTER SESSION

AN FMI- AND SSP-BASED MODEL INTEGRATION METHODOLOGY FOR A DIGITAL TWIN PLATFORM OF A HOLISTIC RAILWAY INFRASTRUCTURE SYSTEM

Ozan Kugu[1], Shiyang Zhou1, Rebecca Nowak[2], Gabor Müller[3], Stefan Harald Reiterer[3], Alexander Meierhofer[3], Stefan Lachinger[4], Lukas Wurth[1], Manfred Grafinger[1]
([1]Technische Universität Wien, 1060 Vienna, Austria; [2]VRVis Zentrum für Virtual Reality und Visualisierung Forschungs-GmbH, 1220 Vienna, Austria; [3]Virtual Vehicle Research GmbH, 8010 Graz, Austria; [4]AIT - Austrian Institute of Technology GmbH, 1210 Vienna, Austria)

Nowadays, the digitalization of large-scale railway infrastructure systems is a major trend, which helps to reduce the life-cycle costs of the railway transportation. For this purpose, the Digital Twin (DT) technology can be used to interoperate different digital data and models, belonging to the railway infrastructure system, in a virtual platform for predictive maintenance, diagnostics and condition monitoring in the railway sector. However, the simulation models of the infrastructure system are tooldependent, lack ease-of-use and platform compatibility. Therefore, we have to customise them in order to make them more representative and then integrate easily and tool-independently into the DT platform. For this purpose, we propose to use the Functional Mock-up Interface (FMI) and System Structure Parameterization (SSP) technologies as open interface standards between the models and software tools. In this work, we demonstrate the application of the FMI and SSP standards separately for two use cases, which include a multibody simulation (MBS) model of a railway vehicle and residual life time (RLT) calculation of a steel bridge.

ABSTRACTS - POSTER SESSION

PNRG – A LIBRARY FOR MODELING VARIABLE STRUCTURE ENERGY GRIDS IN MODELICA USING ENERGETIC PETRI NETS

Christian Gutsche[1,2], Zizhe Wang[1,2,] Sebastian Götz[2], Volodymyr Prokopets[2], Uwe Aßmann[2]
([1]Boysen-TU Dresden-Research Training Group; [2]Chair of Software Technology, Technische Universität Dresden, Dresden, Germany Christian Gutsche[1,2], Zizhe Wang[1,2], Sebastian Götz[2], Volodymyr Prokopets[2], Uwe Aßmann[2])

Operating energy grids with a high share of renewable energy sources (RES) requires system reconfiguration as a response to environmental condition changes. To understand them better, simulations are needed and Modelica is an excellent choice for that. Energy grids with event-based reconfigurations are an instance of variable structure systems (VSS). However, the full support of VSS in Modelica is challenging and topic of ongoing research. Petri nets (PNs) offer a formalism for capturing the variability of VSS. The capability to simulate PNs in Modelica gives an opportunity to model VSS. This paper presents an approach to utilize PNs in Modelica for modeling variable structure energy grids. Therefore, we introduce energetic Petri nets, a special type of PNs and an experimental library called PNRG for PN-based energy system modeling is presented. Furthermore, possibilities and limits of modeling energy grids are discussed and an outlook how to develop this technique is provided.

ABSTRACTS - POSTER SESSION

ENERGY EFFICIENCY MEASURES FOR EXISTING FACTORY BUILDINGS

Xenia Kirschstein, Anja Schaffarczyk, Miriam Schuster, Nadja Bishara
(Institute of Structural Mechanics and Design, Technical University of Darmstadt, Germany)

As part of the research project ETA im Bestand, the simulation library ThermalIntegrationLibrary was developed for the identification and evaluation of energy efficiency measures in existing factories. In this paper the package containing the building models is presented (section 2.1). It enables the user to simulate building related efficiency measures independently or combined with machines and technical building equipment. Special focus is placed on the efficiency measure hereafter referred to as enclosure, which designates a thermally activated construction around a number of machines to facilitate the capturing of waste heat emitted to the ambient air. The correct implementation of the enclosure is validated using measurement data obtained from an experiment with a small demonstrator (section 2.2). Furthermore an application example of the package is given, applying a few simple efficiency measures to an exemplary production hall (section 2.3). The respective results are presented in section 3.

ABSTRACTS - POSTER SESSION

HYBRID POWER SYSTEMS SIMULATION AND OPTIMIZATION UTILIZING SSP AND FMI

Dai Araki[1], Magnus Sandell[2]
([1]Toshiba Digital Solutions Corporation; [2]Toshiba Europe Ltd)

Collaborative model-based development of hybrid power system often requires large-scale co-simulation and system parameter optimization. FMI and SSP standards establish model exchange at various levels of abstraction and interoperability between tools. This study examines the architecture of parallel processing SSP and FMI simulation that can perform high-speed computation with multi-core distribution. We combine AI based optimization and co-simulation and builds a collaborative development platform for hybrid power systems design. Performance experiments uses hybrid vehicle simulation model published by JAMBE (MBD promotion center in Japan).

SIMULATION OF VEHICLE HEADLAMP LEVELLING SYSTEMS

Filip Cieslar[1], Martin Düsing[2]
([1]HELLA GmbH & Co. KGaA,, Czech Republic; [2]HELLA GmbH & Co. KGaA,, Germany)

Adjustment systems are used in vehicle headlamps to regulate the flare on the street. The kinematic system within the headlamp is driven automatically based on level sensor signals and can additionally be manually set to a start position. In modern cars the automatic vehicle headlamp levelling is legal duty due to the strong cut-off line (COL) between dark and light. This cut-off can be measured in a workshop but not during operation. Due to the complex kinematics including nonlinear contacts, friction and damping a Modelica model is used to calculate the position of the COL. The results show a characteristic hysteresis of the horizonal position during automatic movement. The simulation results are compared to measurements and show good agreement.

ABSTRACTS - POSTER SESSION

PIECEWISE-STEADY-STATE MODELICA SIMULATIONS FOR THE CONCEPTUAL DESIGN PHASE OF INDUSTRIAL PROCESSES

Raphael Agner, Jonas Grand, Andrin Duss, Beat Wellig
(Lucerne University of Applied Sciences and Arts, Switzerland)

The conceptual design of industrial processes is challenging as relatively little information about the eventually selected equipment and their operation is known in this early design stage. Furthermore, the systems are increasingly integrated with themselves, and their design must be addressed systematically. Simulation can assist in better understanding the effects of design decisions on the resulting system performance. To facilitate the simulation of industrial processes in this early design phase, this paper proposes an approach to modeling system components specifically aimed at employing known key design parameters and assuming steady-state behavior of the process for a certain period of time (e.g. one hour). A solution over a longer period of time (e.g. for a year) can then be obtained by simulating a multitude of such shorter periods, leading to the piecewise-steady-state solution. The proposed approach is developed with an exemplary case study, based on a real industrial site. The resulting model computes the annual load profile within the range of seconds for the given case study.

ABSTRACTS - POSTER SESSION

HOME ENERGY DYNAMICS: A MODELICA MODELLING TOOLKIT FOR IDENTIFYING PATHWAYS TO DECARBONISE UK DWELLINGS

Ilaria Salerno[1], Carl Holland[1], Bunmi Adefajo[1], Alessandro Picarelli[2] ([1]Energy System Catapult Ltd., United Kingdom; [2]Claytex, Technia, United Kingdom)

This paper presents a novel buildings modelling toolkit called 'Home Energy Dynamics' (HED) and describes recent improvements to its operation. In this study, HED is used to simulate a domestic dwelling, showing its current energy performance and how it changes when energy efficiency retrofit measures and low carbon technologies are implemented in the dwelling. Changes to energy demand, energy cost, and greenhouse gas emissions are analysed; as the packages of measures increase, energy demand and greenhouse gas emissions decrease, but energy cost does not - due to the large difference in unit costs between gas and electricity prices. Recent improvements to the operation of HED are described; these changes have significantly reduced the time taken to perform simulations and have allowed many results to be generated simultaneously rather than consecutively.

ABSTRACTS - POSTER SESSION

MODELING AND CONTROL DESIGN OF AN EDUCATIONAL MAGNETIC LEVITATION SYSTEM

Anton Haumer
(Ostbayerische Technische Hochschule Regensburg, Germany)

A magnetic levitation system is a perfect educational example of a nonlinear instable system. Only with suitable control, a small permanent magnet can be held floating stable below a coil. After modeling and simulation of the system, control of the system can be developed. At the end, the control algorithm can be coded on a microcontroller, connected to a pilot plant.

COUPLING OF THERMAL AND ELECTRICAL SYSTEMS FOR THE SIMULATION OF ECS ARCHITECTURES

Nicolás Ablanque[1], Sriram Gurumurthy[2], Santiago Torras[1], Antonello Monti[2], Joaquim Rigola[1], Carles Oliet[1]
([1]Heat and Mass Transfer Technological Center (CTTC), Universitat Politècnica Catalunya (UPC), Spain; [2]ACS, EONERC, RWTH Aachen University, Germany)

This work is focused on the coupling of two complex models based on different underlying physics: a vapor compression refrigerating system and its electrical drive system. The main challenge was to correctly handle the large simulation time constant difference which is three orders of magnitude smaller for the electrical system. The two models have been originally developed following very specific requirements (i.e. high numerical robustness and low time consumption) for their suitable use in simulations of large and complex aircraft Environmental Control Systems (ECS). The direct coupling of both systems has been observed to cause numerical instabilities, therefore, a coupling approach based on non-invasive dynamic relaxations has been implemented. The resulting combined simulations have shown to be numerically stable for the whole range of operation and for a wide range of time steps.

ABSTRACTS - POSTER SESSION

A PENALTY FUNCTION-BASED MODELICA LIBRARY FOR MULTI-BODY CONTACT COLLISION

Ziheng Zhu, Hualong Zhao, Xueqi Ma, Yuhui Liu, Lu Chen, Fanli Zhou
(SUZHOU TONGYUAN SOFT.&CTRL. TECH.CO.LTD, China)

Contact collisions are prevalent in mechanical multi-body systems and have always been a significant limiting factor for engineering technology development. This paper examines the fundamental types of contact in multi-body dynamics systems and explores their inherent topological relationships. Based on the multi-body dynamics theory and penalty function contact algorithm, this paper constructed the multi-body dynamics contact model using Modelica, which is a multi-domain unified modeling language. To enhance the applicability of the contact model library in the modeling of multi-body system, the contact model provides a connection interface compatible with the multi-body library in the Modelica standard library.

ABSTRACTS - POSTER SESSION

AUTOMATIC OPTIMIZATION OF ENERGY SUPPLY SYSTEMS IN BUILDINGS AND CITY QUARTERS BASED ON MODELICA MODELS

Torsten Schwan[1], David Feige[2], Leonhard Wenzel[1], Charlotte Voelckner[1], Martin Leuschke[1]
([1]EA Systems Dresden GmbH, Germany; [2]HKL Ingenieurgesellschaft mbH) T

he evaluation and analysis of complex energy supply systems with Modelica models is increasingly becoming part of the planning and design processes. Dynamic system modeling is more and more important, especially for questions regarding the use of storage and the integration of volatile renewable resources by means of intelligent control.

However, this still too often requires extensive engineering work and time-consuming modeling efforts, although the basic work steps are largely comparable and based on the same fundamentals. Especially the open interfaces to and from Modelica offer extensive possibilities for automation and generalization of these processes.

This paper describes such a new integrative and automated optimization framework for energy systems of buildings and districts, which uses Modelica models and FMUs iteratively for the identification of optimal system configurations.

ABSTRACTS - SESSION 1-A

SESSION 1-A: Large-scale system modelling 1
TIME: Tuesday, 10/Oct/2023, 10:35 AM - 12:15 PM
LOCATION: Room Carbon
CHAIR: Dirk Müller

MOPYREGTEST: A PYTHON PACKAGE FOR CONTINUOUS INTEGRATION-FRIENDLY REGRESSION TESTING OF MODELICA LIBRARIES

Philipp Emanuel Stelzig
(simercator GmbH, Germany)

Regression testing is a commonly used strategy in continuous integration workflows to ensure reproduceability of outputs. It is widely in software engineering and model development, including Modelica. In this article we introduce the open source regression testing framework MoPyRegtest written in Python. Its primary focus is to provide Modelica library developers with a simple regression testing tool that features test automation and can integration with continuous integration toolchains, in particular for open source developments. In order to simulate the Modelica models for testing analysis, we provide an interface to Modelica simulation tools that support Modelica Scripting with .mos files. Our current implementation works with OpenModelica. We outline the design and functionality of MoPyRegtest and showcase its potential usefulness for open source development of Modelica models and libraries.

SIMULATION MODEL AS A SERVICE (SMAAS): A CONCEPT FOR INTEGRATED DEPLOYMENT, EXECUTION AND TRACKING OF SYSTEM SIMULATION MODELS

Philipp Emanuel Stelzig, Benjamin Rodenberg
(simercator GmbH, Germany)

System simulation is dealing with increasingly multiphysical and cyber-physical systems that involve multiple engineering domains. In development and production, system manufacturers often rely on supplier parts and their digital representations. To deal with this inherently collaborative setting in a more efficient way we propose a concept of Simulation Model as a Service (SMaaS) developed at simercator. In this article, we apply established workflows from software engineering to system simulation to create more efficient workflows, discuss the compliance with technical, economic, and regulatory requirements, and present a software for digital supply chain management that implements SMaaS.

CONTROL DEVELOPMENT AND SIZING ANALYSIS FOR A 5TH GENERATION DISTRICT HEATING AND COOLING NETWORK USING MODELICA

Ettore Zanetti, David Blum, Michael Wetter
(Lawrence Berkeley National Laboratory, United States of America)

5th generation district heating and cooling networks (5GDHC) are a relatively new concept. They are based on the idea that a single district loop at a ambient tem-

perature range can be used for heating and cooling simultaneously. This paper improves on a 5GDHC called the reservoir network. The study updates the sewage heat exchanger plant model to more realistically represent seasonal changes, uses the novel pump models with variable efficiency, introduces a ground coupled district pipe model to consider the inertia of the district network and a new control strategy for storage and sewage heat exchanger was implemented. the new approach reduced operating costs, mainly due to pumping cost for storage, sewage

heat exchanger plant and distribution pump, while increasing the overall robustness of the approach in different sizing conditions. Thanks to the new controller, the pumping consumption was reduced by 21% with respect to the baseline, while showing that the approach is robust against design changes such as reduction in borehole field size and increasing the sewage heat exchanger size, since the pumping energy savings become 29%. Lastly borehole field temperature stability was analyzed through a 40Y simulation.

MARCO: AN EXPERIMENTAL HIGH-PERFORMANCE COMPILER FOR LARGE-SCALE MODELICA MODELS

Giovanni Agosta[1], Francesco Casella[1], Daniele Cattaneo[1], Stefano Cherubin[2], Alberto Leva[1], Michele Scuttari[1], Federico Terraneo[1] ([1]Politecnico di Milano, Italy; [2]Edinburgh Napier University)

This paper introduces MARCO, a research compiler aimed at the efficient generation of efficient simulation code from a large-scale Modelica model. MARCO's design goals, requirements, and specifications are dis- cussed in the paper, as well as the software architec- ture, the current development status, and a future develop- ment roadmap. The results of two test cases demonstrate MARCO's capability to handle non-trivial Modelica mod- els with over 10 million equations very efficiently.

ABSTRACTS - SESSION 1-B

SESSION 1-B: Discrete modeling techniques – FEM, CFD, DEM (Discrete Element Method) 1
TIME: Tuesday, 10/Oct/2023, 10:35 AM - 12:15 PM
LOCATION: Room Silver
CHAIR: Martin Otter

OBJECT-ORIENTED MODELLING OF FLEXIBLE CABLES BASED ON ABSOLUTE NODAL COORDINATE FORMULATION

Jianchen Wu[1], Baokun Zhang[1], Dedong Liang[1], Yujie Guo[2], Lu Chen[1], Ji Ding[1], Fanli Zhou[1]
([1]Suzhou Tongyuan Software&Control Technology Co., Ltd., China; [2]College of Aerospace Engineering, Nanjing University of Aeronautics and Astronautics, China)

Cable-pulley system consists of several segments of cables, winches, and pulleys, which is used in a wide range of engineering applications such as lifting equipment and pulley systems, however its dynamics simulation has been a tough issue in the Modelica community. The absolute nodal coordinate formulation (ANCF) uses global displacements and slopes at nodes to describe the geometry of the deformed body, which allows the derivation of constant mass matrices and zero-valued quadratic velocity dependent centrifugal and Coriolis forces, demonstrating its powerful capacity to model flexible multi-body systems for nearly two decades. This paper presents an object-oriented approach to model cable-pulley system, where flexible cables are discretized using ANCF cable elements. It is compatible with the Modelica Multibody Library by using a unified Frame interface and enables coupled analysis of cables and rigid bodies. The paper provides a rich set of application examples showing the ease and efficiency of the Modelica-based component drag-and-drop modelling way for modelling cable-pulley system.

DEVELOPMENT OF A NOVEL QUASI-2D PEM ELECTROLYZER MODEL IN MODELICA

Ansgar Reimann[1], Paul Kohlenbach[2], Lars Röntzsch[3]
([1]Fraunhofer IEG, Germany; [2]BHT Berlin, Germany; [3]BTU Cottbus, Germany)

To increase the efficiency of PEM electrolysis, simulation models are required that accurately describe the system's electrochemical and thermal behavior in a computationally efficient manner and are thus suitable for developing control strategies. Therefore, a pseudo-2D PEM electrolyzer model is presented in this paper, which is a compromise between the previously developed models regarding their model complexity. The electrochemical behavior is described with equations commonly used in the literature and the thermal behavior with correlations for gas-liquid heat transfer. Preliminary validation indicates that the model can describe the electrochemical behavior and thermal dynamics of a PEM electrolysis stack with good accuracy.

MODELICA ASSOCIATION STANDARDS AND SURROGATE MODELING TO ENABLE MULTI-FIDELITY SIMULATIONS

Olle Lindqvist[1], Robert Hällqvist[2,4], Raghu Chaitanya Munjulury[3,4] ([1]FCS Verification & Validation, Saab Aeronautics, Sweden; [2]System Simulation and Concept Development, Saab Aeronautics, Sweden;[3]Technical Management & Maintenance, Saab Aeronautics, Sweden; [4]Division of Fluid and Mechatronic Systems (FLUMES), Linköping University, Sweden)

System simulations are particularly useful when analyzing complex systems. Simulations are often cheaper and safer than physical tests of the actual system(s) of interest. Models can be additionally created for systems that do not exist to find solutions that are impossible to analyze experimentally in early life-cycle stages. Models used in system simulations require appropriate input data to give results with the required fidelity and, in the end, credibility. Integration is often challenging as each system commonly constitutes contributions from several engineering domains. Relying on relevant open standards for information exchange is seen as a means of mitigation. The results of the presented work encompass a developed methodology that allows Computational Fluid Dynamics (CFD) results to be integrated into a simulator using system identification and open standards. Reduced Order Models (ROMs) are generated based on results from a CFD analysis. These ROMs are coupled to lumped parameter system simulation models through the mechanisms of the System Structure and Parameterization (SSP) and Functional Mock-up Interface (FMI) standards. In addition, several important factors to consider before using the proposed methodology are presented. These include the intended use of the ROM, knowing the flow inside the system, what resources are available, and any potential licensing issues.

DISTRIBUTED PARAMETER PNEUMATICS

Felix Fischer, Katharina Schmitz
(ifas, RWTH Aachen University, Germany)

Pneumatics is a branch of engineering that deals with the use of pressurized air or gases to create mechanical motion. It involves the study and application of systems and components such as air compressors, valves, cylinders, and actuators to control and transmit power through the use of compressed air.

For highly dynamic events in pneumatic systems, such as fast switching processes in automation technology, lumped-parameter simulation is not sufficient to correctly calculate the pressure build-up in pipes. The propagation and reflections of different pressure waves and refraction waves cannot be accounted for by the zero-dimensional models provided by the Modelica.Fluid library.

Therefore, a method for calculating such events using the finite volume method is presented in this paper. The library presented in this work, uses Gudonov's scheme and an arbitrary Riemann-solver and gas model to calculate the time evolution inside 1D or 2D discretized pneumatic components as well as systems composed of these components.

ABSTRACTS - SESSION 1-C

SESSION 1-C: Applications of Modelica for optimization and optimal control 1
TIME: Tuesday, 10/Oct/2023, 10:35 AM - 12:15 PM
LOCATION: Room Oxygen
CHAIR: John Batteh

A RENEWABLE HEAT PLANT MODELICA LIBRARY FOR DYNAMIC OPTIMIZATION WITH OPTIMICA

Thomas Colin De Verdiere[1,2], Sylvain Serra[2], Sabine Sochard[2], Pierre Garcia[1], Pierre Delmas[1], Jean-Michel Renaume[2]
([1]Newheat, France; [2]Universite de Pau et des Pays de l'Adour, E2S UPPA, LaTEP, Pau, France)

Almost half of the energy consumed globally is under the form of heat, produced mainly through fossil fuels. Switching to using renewable energy instead is a real challenge. Combining renewable thermal energy with thermal storage is a complex system to operate. To harness the full potential of thermal plants, advanced control strategies need to be implemented. Dynamic real-time optimization (DRTO) seems promising to fine tune controller setpoints of plants. The goal of our study is to ultimately enable DRTO by using Optimica because of its ease of use and Modelica's modularity. This paper presents a Modelica library developed to first perform offline dynamic optimization with Optimica, and would ultimately be used in a DRTO strategy. The library enables to model a renewable thermal plant composed of solar thermals, heat pumps and thermal storages. The model of each subcomponent has been validated. Initial dynamic optimizations of plant operation give promising results.

EFFICIENT GLOBAL MULTI PARAMETER CALIBRATION FOR COMPLEX SYSTEM MODELS USING MACHINE-LEARNING SURROGATES

Julius Aka[1,2], Johannes Brunnemann[1], Svenne Freund[2], Arne Speerforck[2]
([1]XRG Simulation GmbH, Germany; [2]Hamburg University of Technology, Hamburg)

In this work, we adress challenges associated with multi parameter calibration of complex system models of high computational expense.

We propose to replace the Modelica Model for screening of parameter space by a computational effective Machine-Learning Surrogate, followed by a polishing with a gradient-based optimizer coupled to the Modelica Model.

Our results show the superiority of this approach compared to common-used optimization strategies. We can resign on determining initial optimization values while using a small number of Modelica model calls, paving the path towards efficient global optimization. The Machine Learning Surrogate, namely a Physics Enhanced Latent Space Variational Autoencoder (PELS-VAE), is able to capture the impact of most influential parameters on small training sets and delivers sufficiently good starting values to the gradient-based optimizer.

In order to make this paper self-contained, we give a sound overview to the necessary theory, namely Global Sensitivity Analysis with Sobol Indices and Variational Autoencoders.

FAST CHARGE ALGORITHM DEVELOPMENT FOR BATTERY PACKS UNDER ELECTROCHEMICAL AND THERMAL CONSTRAINTS WITH JMODELICA.ORG

Alberto Romero, Johannes Angerer (Kreisel Electric, Austria)

Strict operating boundaries on commercial lithium ion cells are defined to mitigate the effect of aging (loss of capacity and increase in internal resistance), as well as avoiding safety hazards, like the appearance of lithium plating during charge, which can lead to internal short circuit and subsequent thermal runnaway. Therefore, to develop fast charge algorithms that maximize charging speeds, electrochemical and thermal constraints must be considered. Most studies so far have focused on the single cell problem, whereas pack-level fast charge challenge has been tackled directly by the industry. The reason is that the temperature difference between cells within a battery pack is often considered small, and therefore that optimal charging profiles can be extrapolated from single cell investigations. In practice, temperature spread can reach up to 10 K from coldest to warmest points in the pack, and at least 5 K between same position of different cells. With this in mind, a Nonlinear Model Predictive Control (NLMPC) scheme is proposed that considers both electrochemical and thermal constraints at pack level, establishing, at least on a theoretical basis, the practical limits of fast charge. We demonstrate how active thermal management, i.e., controlling the fluid inlet temperature, is critical to reducing charging times below 40 min (from 0% to 80% state of charge), and discuss some challenges when using online optimization-based control techniques

COMPARATIVE STUDY AND VALIDATION OF PHOTOVOLTAIC MODEL FORMULATIONS FOR THE IBPSA MODELICA LIBRARY BASED ON ROOFTOP MEASUREMENT DATA

Laura Maier[1], Christoph Nytsch-Geusen[2], Kushagra Mathur[2], Michael Wetter[3], Dirk Müller[1]
([1]Institute for Energy Efficient Buildings and Indoor Climate, E.ON Energy Research Center, RWTH Aachen University; [2]Institute for Architecture and Urban Planning, Berlin University of the Arts; [3]Lawrence Berkeley National Laboratory, Berkeley, California)

Domain-overarching system models are crucial to investigate sector coupling concepts. Specifically, the coupling of building and electrical energy systems becomes crucial to integrate renewable energy sources such as photovoltaic power systems (PV). For such interdisciplinary simulation models, Modelica is a suitable language. However, most open-source Modelica libraries are either domain-specific or lack simple-to-parameterize PV models. We close this gap by developing a PV model for the IBPSA Modelica library. The model comprises two I-V-characteristic models and three mounting-dependent approaches to calculate the cell temperature. The I-V-characteristic models follow a single- and two-diodes approach. This study uses measurement data from a rooftop PV system in Berlin, Germany, for validation. The focus lies on comparing the implemented single- and two-diodes approach. Results prove that both models accurately calculate the modules' DC power output and cell temperature. The two-diodes approach slightly outperforms the single-diode one at the expense of a higher parameterization effort.

ABSTRACTS - SESSION 1-D

SESSION 1-D: Mechatronics and robotics 1
TIME: Tuesday, 10/Oct/2023, 10:35 AM - 12:15 PM
LOCATION: Charles
CHAIR: Wangda Zuo

PAVING THE WAY FOR HYBRID TWINS USING NEURAL FUNCTIONAL MOCK-UP UNITS

Tobias Thummerer[1], Artem Kolesnikov[2], Julia Gundermann[2], Denis Ritz[3], Lars Mikelsons[1]
([1]University of Augsburg, Germany; [2]ESI Germany GmbH, Dresden, Germany; [3]Technische Universität Dresden, Germany)

Porting Neural Ordinary Differential Equations (NeuralODEs), the combination of an artificial neural network and an ODE solver, to real engineering applications is still a challenging venture. However, we will show that Neural Functional Mock-up Units (NeuralFMUs), an evolved subgroup of NeuralODEs that contain Functional Mock-up Units (FMUs), are able to cope with these challenges. This paper briefly introduces to the topics NeuralODE and NeuralFMU and describes the procedure and considerations to apply this technique to a real engineering use case. Further, different workflows to apply NeuralFMUs dependent on tool capabilities and use case requirements are discussed. The presented method is illustrated with the creation of a Hybrid Twin of an hydraulic excavator arm, which has various challenges such as discontinuity, nonlinearity, oscillations and characteristic maps. Finally we will show, that the created Hybrid Twin, on basis of measurement data from a real system, gives more accurate results compared to a conventional simulation model based on first principles.

MODELING AND SIMULATION OF DYNAMICALLY CONSTRAINED OBJECTS FOR LIMITED STRUCTURALLY VARIABLE SYSTEMS IN MODELICA

Robert Reiser, Matthias J. Reiner
(German Aerospace Center (DLR), Germany)

This work introduces a new solution for the modeling and simulation of dynamically constrained objects for limited structurally variable systems purely in Modelica. A combination of a collision detection algorithm, the limitation of collisions, and a method to constrain objects based on forces leads to a constraint network in Modelica. It allows a stable and accurate simulation of applications such as robot tool changers in a flexible way without the need for predefined connections in the model.

A GRAPH-BASED META-DATA MODEL FOR DEVOPS: EXTENSIONS TO SSP AND SYSML2 AND A REVIEW ON THE DCP STANDARD

Stefan H. Reiterer, Clemens Schiffer, Mario Schwaiger
(Virtual Vehicle Research, Austria)

Computer simulation has become a vital tool for modeling complex systems. However, the development and deployment of simulation models often involve multiple stages, tools, and teams, which can lead to significant challenges in maintaining quality, reliability, and efficiency. DevOps, a set of practices that combines software development and IT operations, has emerged as a promising approach to streamline the simulation development.

However, most system engineers are not DevOps specialists and there are a lot of manual steps involved when writing build pipelines and configurations of simulations. For this purpose, an abstract graph-based meta-data model was presented in previous work to provide an automation framework for DevOps with simulations. In this work we want to continue our investigations by expanding and harmonizing this approach to better work with established standards like SSP, SysML2 and DCP and demonstrating it's application on real-life use cases.

INTRODUCING DIALECTIC MECHANICS

Dirk Zimmer, Carsten Oldemeyer
(German Aerospace Center (DLR), Germany)

This paper introduces a new method for mechanical systems with its own interface that enables the object-oriented formulation of very stiff contacts. It thereby suppresses high frequencies and yields stable replacement dynamics leading to an equivalent steady state. Potential applications are the efficient modeling and simulation of robotic manipulation or the easier handling of what formerly have been variable-structure systems.

ABSTRACTS - SESSION 2-B

SESSION 2-B: Symbolic algorithms and numerical methods for model transformation and simulation 1
TIME: Tuesday, 10/Oct/2023, 1:45 PM - 3:00 PM
LOCATION: Room Silver
CHAIR: Benoît Caillaud

PSEUDO ARRAY CAUSALIZATION

Karim Abdelhak[1], Francesco Casella[2], Bernhard Bachmann[1]
([1]University of Applied Sciences Bielefeld, Germany; [2]Politecnico di Milano)

In the current state-of-the-art modeling tools for simulation, it is common to describe system behavior symbolically using mixed continuous and discrete differential-algebraic equations, so called hybrid DAEs. To correctly resolve higher index problems, hybrid systems and to efficiently use ODE solvers, a matching and sorting problem has to be solved, commonly referred to as causalization. Typically multidimensional equations and variables are scalarized, which leads to excessive build time and generated code size in the case of large systems.

An algorithm will be presented, that preserves array structures as much as possible while still solving the problem of causalization in scalar fashion. Test results carried out in the OpenModelica tool show a reduction in build time of one/two orders of magnitude and of a factor two/three in the simulation run time for models of the ScalableTestSuite library.

UNDERSTANDING AND IMPROVING MODEL PERFORMANCE AT SMALL MASS FLOW RATES IN FLUID SYSTEM MODELS

Robert Flesch, Annika Kuhlmann, Johannes Brunnemann, Eiden Jörg
(XRG Simulation GmbH, Germany)

This paper provides a detailed analysis of the reasons behind the poor simulation performance observed when mass flow rates become very small, commonly referred to as zero mass flow issues. By using simple example models, we effectively demonstrate the underlying causes of these simulation performance issues. We highlight various contributing factors that play a significant role in exacerbating the problem.

Furthermore, we propose and examine countermeasures to mitigate these challenges. These countermeasures include modifications to the model itself, utilization of available settings in simulation tools, and adjustments to the solver. By implementing and evaluating these countermeasures, we illustrate their impact on improving simulation performance in scenarios involving low mass flow rates.

HYBRID DATA DRIVEN/THERMAL SIMULATION MODEL FOR COMFORT ASSESSMENT

Romain Barbedienne[1], Sara Yasmine Ouerk[1], Mouadh Yagoubi[1], Hassan Bouia[2], Aurélie Kaemmerlen[2], Benoit Charrier[2]
([1]IRT-SystemX, France; [2]EDF, France)

Machine learning models improve the speed and quality of physical models. However, they require a large amount of data, which is often difficult and costly to acquire. Predicting thermal comfort, for example, requires a controlled environment, with participants presenting various characteristics (age, gender, ...). This paper proposes a method for hybridizing real data with simulated data for thermal comfort prediction. The simulations are performed using Modelica Language. A benchmarking study is realized to compare different machine learning methods. Obtained results look very promising with an F1 score of 0.999 obtained using the random forest model.

ABSTRACTS - SESSION 2-C

SESSION 2-C: Thermodynamic and energy systems applications 1
TIME: Tuesday, 10/Oct/2023, 1:45 PM - 3:00 PM
LOCATION: Room Oxygen
CHAIR: Christopher Laughman

THERMALSYSTEMSCONTROLLIBRARY: A MODELICA LIBRARY FOR DEVELOPING CONTROL STRATEGIES OF INDUSTRIAL ENERGY SYSTEMS

Fabian Borst, Michael Georg Frank, Lukas Theisinger, Matthias Weigold
(PTW TU Darmstadt, Germany)

The transformation of energy-intensive industries towards greenhouse gas neutrality leads to increasing complexity of industrial energy supply systems. This affects particularly thermal energy systems due to waste heat utilization measures as well as the integration of renewable energy sources and further storage capacities. This complexity is also reflected in the control strategies of such systems, which makes the development of dynamic simulation models for testing them a research field of growing interest.

The ThermalSystemsControlLibrary is a novel Modelica library, which aims at standardized modeling of industrial energy supply systems for control strategy development. Based on a generic data model, all components cover physical as well as control modeling and are particularly suitable for testing supervisory control strategies within external frameworks using the FMI standard. The library is validated for an exemplary use case of an industrial energy supply system comparing two different supervisory control strategies.

HVAC AND CONTROL TEMPLATES FOR THE MODELICA BUILDINGS LIBRARY

Michael Wetter[1], Antoine Gautier[2], Jianjun Hu[1], Hubertus Tummescheit[3] ([1]Lawrence Berkeley National Laboratory, United States of America; [2]Solamen SAS, Beaupreau en Mauges, France; [3]Modelon Inc, United States of America)

This article reports on our experience in creating Modelica models for systems with thousands of configurations and closed-loop controls. The development of such templates required exploration of class parameterization techniques and data structures for handling large sets of equipment parameters. By describing these issues and the approach taken, we show how the Modelica language can support advanced templating logic. The main limitation we encountered relates to parameter assignment and propagation. The interpretation of parameter attributes at user interface runtime, or the handling of non-trivial constructs involving record classes at compile time is not consistently supported by Modelica tools. This leads to choices that are difficult to make when looking for a generic implementation.

MODELING AND SIMULATION OF THE HYDROGEN VALUE CHAIN WITH THERMOSYSPRO AND MODELICA

Sebastian Vallejo Jimenez[1], Luis Corona Mesa-Molesv, Damien Faille[2], Dina Irofti[2]
([1]ENSTA Paris; [2]EDF R&D)

Hydrogen will play a key role in the global energy transition if we are able to produce it with low-carbon emissions. However, clean hydrogen production today is mostly limited to demonstration projects ranging from 2 up to 20 MW. Modeling the way low-carbon hydrogen is produced, stored and used will allow us to significantly improve our understanding of how clean hydrogen could be produced and thus increase the production efficiency.

In this paper, we show that the newest version of ThermoSysPro (TSP), an open-source Modelica library for modeling energy systems, provides a suitable framework to model and simulate the hydrogen production, storage and consumption. The model presented in this paper contains three electrolyzers, a storage station and a vehicle station. We present how the model was built, which components were adapted and how, and show that its simulation can be useful in the design phase, as well as for diagnosis purposes.

ABSTRACTS - SESSION 2-D

SESSION 2-D: Real-time and hardware-in-the-loop simulation 1
TIME: Tuesday, 10/Oct/2023, 1:45 PM - 3:00 PM
LOCATION: Charles
CHAIR: Sriram Karthik Gurumurthy

DIALECTIC MECHANICS: EXTENSION FOR REAL-TIME SIMULATION

Carsten Oldemeyer, Dirk Zimmer
(Deutsches Zentrum für Luft- und Raumfahrt(DLR), Germany)

Dialectic mechanics was introduced as an approximative modeling alternative to the classic Newtonian formulation of mechanics. It allows for additional freedom in placing a systems eigenvalues to facilitate simulation of systems, that are not suitable for most integration methods, when modeled according to the classic approach. The original idea of dialectic mechanics enables the suppression of high frequencies, but may still yield very stiff systems unsuitable for explicit integration methods. An additional term is added to enable real-time simulation with explicit methods. The goal of this paper is an analysis of the resulting equations and a comparison to the classic Newtonian formulation, aiming for an understanding of which applications most benefit from using dialectic mechanics.

TESTING THE VERIFICATION AND VALIDATION CAPABILITY OF A DCP BASED INTERFACE FOR DISTRIBUTED REAL-TIME APPLICATIONS

Mikel Segura[1], Alejandro J. Calderón[1], Tomaso Poggi[2], Rafael Barcena[3]
([1]Ikerlan, Spain; [2]Mondragon Unibertsitatea, Spain; [3]University of the Basque Country, Spain)

Cyber-physical systems are composed of a variety of elements developed by different vendors that are often geographically distributed. Therefore, its development process presents a double challenge: each element has to be developed individually and, at the same time, a correct interaction with the rest of the elements has to be ensured. In a previous work, we proposed and developed an interface, based on the non-proprietary Distributed Co-simulation Protocol standard, to ease the interaction between these elements. In this paper, we improve it to be applicable in a variety of hardware platforms and we test its applicability for the verification and validation process. To do so, firstly, we prove that our interface is hardware agnostic, demonstrating its easy implementation on different platforms. Secondly, we test its applicability in different X-in-the-Loop simulations. Finally, we also test its behaviour in distributed real-time executions, a necessary requirement for linking elements from different suppliers and helping to preserve their Intellectual Property.

A COUPLED LUMPED PARAMETERS-REDUCED ORDER MODELS APPROACH FOR NEAR REAL-TIME APPLICATIONS INVOLVING CFD

Andrea Lorenzo Lario, Gabriele Ottino
(Dofware S.r.l., Italy)

In this paper, a computational pipeline is introduced for coupling Modelica with Reduced Order Models able to solve detailed fluid dynamic phenomena in near real-time. The reduced model is encapsulated within a Functional Mock-up Unit in order to allow its co-simulation with Modelica models. The proposed methodology is tested on a case of practical interest in the automotive field. A car mock-up is built where the body is represented by the Ahmed body, and a Modelica model is used for reproducing the behavior of the rear suspensions. The reduced order model is aimed at retrieving the aerodynamic forces acting, instant by instant, on the body, thus soliciting the Modelica suspension system; the resulting angle of attack and advancement velocity feed the reduced model, thus closing the loop. Results achieved by the ROM-based co-simulation model are compared with the ones obtained by the model co-simulated with the full-order counterpart. Great improvements are achieved in terms of computational time, the accuracy being almost the same.

ABSTRACTS - SESSION 3-B

ESSION 3-B: Symbolic algorithms and numerical methods for model transformation and simulation 2
TIME: Tuesday, 10/Oct/2023, 3:30 PM - 5:10 PM
LOCATION: Room Silver
CHAIR: Adrian Pop

ACCELERATING THE SIMULATION OF EQUATION-BASED MODELS BY REPLACING NON-LINEAR ALGEBRAIC LOOPS WITH ERROR-CONTROLLED MACHINE LEARNING SURROGATES

Andreas Heuermann[1], Philip Hannebohm[1], Matthias Schäfer[2], Bernhard Bachmann[1]
([1]Hochschule Bielefeld - University of Applied Sciences and Arts, Germany; [2]LTX Simulation GmbH, Germany)

When simulating a Modelica model, non-linear algebraic loops may be present, which involves solving multiple equations simultaneously. The classical Newton-Raphson method is commonly employed for solving a non-linear equation system (NLS). However, the computational burden of using this method during simulation can be significant. To tackle this issue, utilizing artificial neural networks (ANNs) to approximate the solution of algebraic loops is a promising approach. While ANN surrogates offer fast performance, ensuring the correctness of the computed solution or quantifying reliability can be challenging.

This publication presents a prototype, based on the OpenModelica compiler (OMC), that automates the extraction of time-consuming algebraic loops. It generates training data, trains ANNs using machine learning (ML) methods, and replaces the algebraic loops with ANN surrogates in the simulation code. A hybrid approach, combining the trained surrogate with the nonlinear Newton solver, is then used to compute the solution with a desired level of accuracy.

OBJECT-ORIENTED FORMULATION AND SIMULATION OF MODELS USING LINEAR IMPLICIT EQUILIBRIUM DYNAMICS

Dirk Zimmer (German Aerospace Center, Germany)

New robust and yet powerful Modelica libraries as the DLR Thermo-Fluid Stream library or the introduction of dialectic mechanics use a special modeling approach that uses linear implicit equilibrium dynamics. In this paper, we study the basic motivation of this approach, its benefits and drawbacks before finally showing how to get from the models to applicable simulation code.

EXPLOITING MODELICA AND THE OPENIPSL FOR UNIVERSITY CAMPUS MICROGRID MODEL DEVELOPMENT

Fernando Fachini[1], Srijita Bhattacharjee[1], Miguel Aguilera[2], Luigi Vanfretti[1], Giuseppe Laera[1], Tetiana Bogodorova[1], Ardeshir Moftakhari[3], Michael Huylo[4], Atila Novoselac[4]
([1]Rensselaer Polytechnic Institute, United States of America; [2]OPAL-RT Technologies,; [3]Pennsylvania State University; [4]University of Texas at Austin)

The need for modeling different aspects of microgrid design and operation has seen the development of various tools over time for different analysis purposes. In this study, Modelica has been adopted as the language of choice to construct a University Campus Microgrid model, utilizing the Modelica Standard Library and the OpenIPSL library. This paper explores the advantages of utilizing Modelica for campus microgrid modeling, emphasizing its benefits and unique features. Modelica features, such as the use of record structures and replaceable templates prove to be particularly advantageous for the modeling task, enabling flexibility and efficiency in the modeling process. Furthermore, comprehensive validation tests are conducted to ensure the accuracy and reliability of subsystems (e.g. specific power generator systems), before assembling the microgrid network model as a whole. The results demonstrate the efficacy of Modelica in accurately modeling and simulating microgrids, highlighting its potential for advancing microgrid research and development.

TOWARDS THE SEPARATE COMPILATION OF MODELICA: MODULARITY AND INTERFACES FOR THE INDEX REDUCTION OF INCOMPLETE DAE SYSTEMS

Albert Benveniste, Benoît Caillaud, Mathias Malandain, Joan Thibault
(Inria centre at Rennes University)

A key feature of the Modelica language is its object-oriented nature: components are instances of classes and they can aggregate other components, so that extremely large models can be efficiently designed as „trees of components''. However, the structural analysis of Modelica models, a necessary step for generating simulation code, often relies on the flattening of this hierarchical structure, which undermines the scalability of the language and results in widely-used Modelica tools not being able to compile and simulate such large models.

In this paper, we propose a novel method for the modular structural analysis of Modelica models. An adaptation of Pryce's Sigma-method for non-square DAE systems, along with a carefully crafted notion of component interface, make it possible to fully exploit the object tree structure of a model. The structural analysis of a component class can be performed once and for all, only requiring the information provided by the interface of its child components. The resulting method alleviates the exponential computation costs that can be yielded by model flattening; hence, its scalability makes it ideally suited for the modeling and simulation of large cyber-physical systems.

ABSTRACTS - SESSION 3-C

SESSION 3-C: Applications of Modelica for optimization and optimal control 2
TIME: Tuesday, 10/Oct/2023, 3:30 PM - 5:10 PM
LOCATION: Room Oxygen
CHAIR: Francesco Casella

PARAMETER ESTIMATION OF MODELICA BUILDING MODELS USING CASADI

Carlos Durán Cañas[1], Javier Arroyo[1], Joris Gillis[1,2], Lieve Helsen[1,3] ([1]Department of Mechanical Engineering, KU Leuven, Heverlee, Belgium; [2] Flanders Make@KU Leuven; [3] EnergyVille, ThorPark, Waterschei, Belgium)

Predictive control can substantially improve the energy performance of buildings during operation, but it requires a model of the building to be implemented. Gray-box model identification starts from a physics-based model (white-box element) and complements it with measurements from the operation of the building (black-box element). The level of detail of the original model is limited by the optimization problem that needs to be solved when estimating its parameters. Consequently, it is common to heavily simplify building models hindering the intelligibility of their parameters and limiting their application potential. This paper investigates the accuracy and scalability of different transcription methods for parameter estimation of building models. The methodology starts from a Modelica model as an initial guess which is transferred to CasADi using the Functional Mockup Interface to solve the parameter estimation problem. The study demonstrates the high effectiveness of multiple shooting. Single shooting and direct collocation could be more suitable for setups with faster integration times or with increased granularity in the training data, respectively.

PRESENTATION, VALIDATION AND APPLICATION OF THE ENERGYPROCESS LIBRARY

Francois Nepveu[1], Sylvain Mathonniere[2], Nicolas Lamaison[2], Gael Enee[1] ([1]CEA, CEA Pays de la Loire, 44343 Bouguenais cedex, France; [2]Univ. Grenoble Alpes, CEA, Liten, Campus Ines, 73375 Le Bourget du Lac, France)

Green production of hydrogen and its derivatives is becoming a cornerstone of industry decarbonation. Apart from the technological development point of view, optimizing the overall production chains dynamically is essential for the competitiveness of these systems.

In this paper, we describe how we built, validated and used a Modelica-based library dedicated to the simulation and optimization of energy process for the production of green molecules. Especially, models of complex media, salt cavity hydrogen storage and electrolysis module are presented.

An example application shows that the models of the library are particularly handy for the modeling of a 5MW electrolysis module, which is used for the calibration of an optimization model.

IMPORT AND EXPORT OF FUNCTIONAL MOCKUP UNITS IN CASADI

Joel Andersson (Jae Andersson Consulting LLC, United States of America)

This paper presents the recently added support for import and export of functional mockup units (FMUs) in CasADi, an open-source software framework for numerical optimization. Of particular interest is the efficient calculation of derivatives, especially in the context of sensitivity analysis and dynamic optimization. We show how the import interface allows for both first and second derivatives can be efficiently and accurately calculated and - importantly - validated for correctness. We also outline the FMU export interface, which leverages CasADi mature and efficient support for forward and adjoint derivative calculation and C code generation. Finally, potential future developments of the support are discussed.

APPLICATION OF THE OPENMODELICA-MATLAB INTERFACE TO INTEGRATED SIMULATION AND SUCCESSIVE LINEARIZATION BASED MODEL PREDICTIVE CONTROL

Mohammad Hadi Alizadeh[1], Ali M. Sahlodin[1], Arunkumar Palanisamy[2], Francesco Casella[3], Peter Fritzson[2]
([1]Amirkabir University of Technology (Tehran Polytechnique), Iran, Islamic Republic of; [2]Department of Computer and Information Science (IDA), Linköping University, Sweden; [3]Dipartimento di Elettronica, Informazione e Bioingegneria, Politecnico di Milano, Italy)

This paper presents the implementation of successive linearization based model predictive control (SLMPC) efforts through the interfacing of OpenModelica and Matlab using the OMMatlab tool. The dynamic system (here a chemical process) and the model predictive control (MPC) algorithm are implemented in OpenModelica and Matlab, respectively. The model linearization procedure is carried out through OMMatlab, which is highly optimized in terms of run-time by using a single executable file and adapting it at each sample time. Also, necessary theories for a continuous model discretization are discussed for both nonlinear Modelica and linearized continuous models. A procedure for constructing an Extended Kalman Filter (EKF) from a continuous Modelica model is also presented. The usability of the OpenModelica-Matlab interface for SLMPC is demonstrated by control of liquid levels in a tanks-in-series problem.

ABSTRACTS - SESSION 3-D

SESSION 3-D: Thermodynamic and energy systems applications 2
TIME: Tuesday, 10/Oct/2023, 3:30 PM - 5:10 PM
LOCATION: Charles
CHAIR: Michael Wetter

A LIBRARY TO SIMULATE PROCESSES IN THE FACTORY HALL

Julia Gundermann, Torsten Blochwitz
(ESI Germany GmbH, Germany)

The Modelica language is well suited to model systems with discrete and continuous dynamics. If one wants to model the flow of items through manufacturing steps such as preparation, mounting, or transport in the shop floor, this feature is crucial. The library ProcessSimulation can be used to model such processes. By default, it omits the technical details of the process steps, and focuses on the flow of material items through the process steps. In addition to that, a base model to calculate the energy consumption in the different manufacturing steps is provided. It can be enriched with technical details of the components. The library can be used for the calculation of (net) energy consumption, but also for task planning.

DYNAMIC MODELING AND EXPERIMENTAL VALIDATION OF DISHWASHER WITH HEAT PUMP SYSTEM

Erdoğan Mert Şeren, Mutlu İpek
(Arçelik Global, Turkiye)

Integration of heat pump systems with conventional dishwashers or household water heaters using electric heaters offers a promising solution to significantly reduce expected energy consumption. In this study, a comprehensive approach was undertaken to develop sub-models for each component of the heat pump dishwasher. These sub-models were subsequently integrated to form a complete cycle model of the heat pump dishwasher. The specific components modeled included the compressor, evaporator, condenser, and capillary tube. Furthermore, an algorithm was devised to ensure the proper functioning of all the individual models, in accordance with the operational principles of the dishwasher. To validate the model, the temperature variation within the dishwasher during the heating and cooling phases was compared against experimental data. The maximum deviation observed in the cabinet temperature of the dishwasher was found to be 1 °C, with a corresponding deviation of 0.5 minutes in the cycle duration. Moreover, the maximum deviation in power consumption amounted to 2.4%, while a maximum deviation of 2.9% was noted in energy consumption. The results obtained from the model closely aligned with the experimental outcomes, thereby confirming its accuracy and reliability.

LARGETESMODELINGTOOLKIT: A MODELICA LIBRARY FOR LARGE-SCALE THERMAL ENERGY STORAGE MODELING AND SIMULATION

Michael Reisenbichler-S.[1,2], Franz Wotawa[2], Keith O'Donovan[1,3], Carles Ribas Tugores[1], Franz Hengel[1]
([1]AEE - Institute for Sustainable Technologies, Austria; [2]Institute of Software Technology, Graz University of Technology, Austria; [3]Modelon Deutschland GmbH, Germany)

This paper introduces the LargeTESModelingToolkit, a novel Modelica library for modeling and simulation of large-scale pit and tank thermal energy storage. This first comprehensive Modelica library in the field provides the flexibility and tools needed to develop new storage models tailored to the desired application. It also offers researchers and industrial users pre-built storage models for simulation studies to answer the relevant questions for an optimized design at storage and system level.

In this paper we present the library's key features and structure, and introduce the underlying physical and mathematical foundations and modeling approaches. Moreover, we discuss the validation of the models, present the first results, and show the library's applicability using an exemplary simulation case study.

ON THE CHARACTERISTICS OF ONE-DIMENSIONAL COMPRESSIBLE FLOW

Hongtao Qiao[1], Takashi Kobayashi[2], Christopher Laughman[1], Scott Bortoff[1]
([1] Mitsubishi Electric Research Labs, United States of America; [2]Mitsubishi Electric Corporation)

Eigen decomposition of the governing equations that describe one-dimensional compressible flow has been presented. Analytical solution of the characteristics of the flow was derived. Simulation studies were conducted to support the theoretical analyses and wave propagation results were discussed in detail. It was found that acoustic effect due to the dynamic momentum led to a significant slowdown in the simulation and could be neglected in models without significant loss in accuracy for applications where energy transfer is of greater interest.

ABSTRACTS - SESSION 4-A

SESSION 4-A: New features of the Modelica language and of FMI 1
TIME: Wednesday, 11/Oct/2023, 9:30 AM - 10:45 AM
LOCATION: Room Carbon
CHAIR: Luigi Vanfretti

MODELICA 3.6 - CHANGES, BENEFITS AND IMPLEMENTATION

Hans Olsson (Dassault Systèmes, Sweden)

The latest release of the Modelica Language Specification version 3.6 brings several benefits to users, and this paper will discuss the changes and the benefits for the clearer parameter defaults, clearer start-value priority, selective model extension, and multi-lingual support. The benefits only occur when the features are implemented in Modelica tools, and to facilitate that, the paper will discuss the design choices when implementing the new standard in Dymola 2023x Refresh 1 and 3DEXPERIENCE 2023x FD03.

MODELICA MODELS IN SSP

Dag Brück (Dassault Systèmes AB, Sweden)

This is a proposed optional extension for SSP 2.0 that defines how Modelica models can be referenced in SSP. It specifies the mapping of key Modelica concepts to SSP, which necessitates a few small extensions. The purpose is to broaden the scope of SSP to embrace the more powerful modeling concepts of Modelica, for environments that can support it.

BEYOND FMI - TOWARDS NEW APPLICATIONS WITH LAYERED STANDARDS

Christian Bertsch[1], Matthias Blesken[2], Torsten Blochwitz[3], Andreas Junghanns[4], Benedikt Menne[2], Pierre R. Mai[5], Kevin Reim[2], Klaus Schuch[6], Torsten Sommer[7], Markus Süvern[2], Patrick Täuber[2] ([1]Robert Bosch GmbH, Germany; [2]dSpace GmbH, Germany; [3]ESI Group, Germany; [4]Synopsys, Germany; [5]PMSF IT Consuling; [6]AVL List GmbH, Austria; [7]Dassault Systems, Germany)

The FMI standard - just like any other standard - faces the challenge of balancing generality with enabling specific use cases. Including every domain or use-case specific extension in the core standard would significantly increase its length, making it unreadable and unimplementable. To allow for extensions of the core standard for specific use cases, the Modelica Association developed the concept of layered standards, first in the SSP standard and later in FMI. This paper presents the concept of layered standards and describes the layered standards currently under development by the FMI Project: XCP support of FMUs, network communication, and structured variables and regular maps in FMI 3.0.

ABSTRACTS - SESSION 4-B

SESSION 4-B: Thermodynamic and energy systems applications 3
TIME: Wednesday, 11/Oct/2023, 9:30 AM - 10:45 AM
LOCATION: Room Silver
CHAIR: Hubertus Tummescheit

CONVECTION OF CHEMICALS AND OTHER SUBSTANCES WITH THERMOSYSPRO

Giorgio Simonini, Arnaud Duval, Sarah Hocine-Rastic, Mathilde Praud (EDF, France)

Digital twins are a powerful support tool for plant operation: they provide further understanding on ongoing phenomena and allow realistic projection of the current plant state into the future. Among other twins, EDF is developing a digital twin of the chemistry of the secondary circuits of its nuclear plants. Such a tool will give access to the pH in any point of the circuit and in any operating condition (e.g. partial load, power transients...), outperforming the current, limited, monitoring techniques. It is expected to help operators and engineers to better monitor the circuit (e.g. for erosion corrosion) and anticipate the consequences on equipment of different operating strategies (e.g. for amines' injection pumps maintenance). ThermoSysPro, the EDF R&D's thermal-hydraulic library, is the bedrock of the tool under development. To meet the needs of the target application, modeling of amines convection and some related chemistry, allowing the computation of pH, are introduced in a new version of the library. Moreover, the presented approach aims at proposing a general framework allowing the convection of custom substances (i.e. easily customized by the end user following its needs). This will open the door for a wide range of other applications: radioactive substances, pollution (e.g. salted water ingress coming from a heatexchanger leak), just to cite a few, could be modeled in ThermoSysPro to augment the scope of the digital twins.

HEAT CONSUMER MODEL FOR ROBUST AND FAST SIMULATIONS OF DISTRICT HEATING NETWORKS

Johannes Zipplies, Janybek Orozaliev, Klaus Vajen
(University of Kassel, Department of Solar and Systems Engineering, Germany)

Dynamic thermo-hydraulic simulations of district heating networks are an essential tool to investigate concepts for their sustainable design and operation. The way the numerous heat consumers are modeled has crucial impact on the simulation performance. The proposed model for heat consumers is designed to require low computational effort by using a simplified modeling approach, avoiding state events and limiting its dynamics, while still reproducing their main characteristics. It is tested for a demonstration network, showing its ability to yield realistic results throughout the whole range of operational states including undersupply situations. The results show that the heat consumer model itself requires little time to simulate but still significantly influences the simulation time. Fast dynamics and including a bypass in the model increase the simulation time, so that users should sensibly choose how to use these options. Furthermore, heat consumer models triggering unnecessary state events result in the highest computational effort.

LOW-ORDER AQUIFER THERMAL ENERGY STORAGE MODEL FOR GEOTHERMAL SYSTEM SIMULATION

Alessandro Maccarini[1], Michael Wetter[2], Davide Varesano[3], Martin Bloemendal[4], Alireza Afshari[1], Angelo Zarrella[3]
([1]Department of the Built Environment, Aalborg University, Denmark; [2]Building Technology and Urban Systems Division, Lawrence Berkeley National Laboratory, USA; [3]Department of Industrial Engineering, University of Padova, Italy; Department of Water Management, [4]Delft University of Technology, and KWR water research, The Netherlands)

This paper presents a low order aquifer thermal energy storage (ATES) model for simulation of combined subsurface and above-surface energy systems. The model is included in the Modelica IBPSA Library, which is a free open-source library with basic models for building and district energy and control systems. The model uses a lumped-component method, in which the transient conductive-convective heat and mass transfer equation is radially discretized. To verify the accuracy of the model, we present an intra-model comparison from a simulation test suite. Results show that the Modelica ATES model is in good agreement, with a normalized mean bias error for yearly variation of aquifer temperatures of $1.6\times10-2$ and $9\times10-5$ at 1 m and 10 m distance from the well.

ABSTRACTS - SESSION 4-C

SESSION 4-C: Other industrial applications, such as electric drives, power systems, aerospace, etc. 1
TIME: Wednesday, 11/Oct/2023, 9:30 AM - 10:45 AM
LOCATION: Room Oxygen
CHAIR: Anton Haumer

USING THE DLR THERMOFLUID STREAM LIBRARY FOR THERMAL MANAGEMENT OF FUEL CELL SYSTEMS IN AVIATION

Niels Weber[1], Camiel Cartignij[2], Dirk Zimmer[1]
([1]German Aerospace Center (DLR), Germany; [2]Eindhoven University of Technology, Netherlands)

For more environmental friendly aircraft, different propulsion systems are considered. Either fuel cell or fully electrically driven aircraft come along with challenging heat dissipation tasks. An intelligent thermal management system is essential to prevent failures and to ensure a reliable operation of the propulsion system. The exploration space for appropriate cooling systems seems endless, hence it is vital to rely on robust modeling libraries that enable a quick design and simulation of different architectures. The open source DLR Thermofluid Stream Library (TFS) forms such a basis and proved to be expedient in that sense. This paper gives an overview of a complete fuel cell system for future aircraft that covers the most essential subsystems and is modeled solely of components contained in the TFS. The focus is on different cooling systems and methods that can be quickly investigated in the context of the overall fuel cell system throughout an entire flight mission.

A MODELICA LIBRARY TO ADD CONTACT DYNAMICS AND TERRAMECHANICS TO MULTI-BODY MECHANICS

Fabian Buse, Antoine Pignède, Stefan Barthelmes (DLR, Germany)

The Contact Dynamics library extends the multi-body Modelica Standard Library with contact calculation to the environment, namely soft soil and hard obstacles. A focus is on terramechanics, i. e. wheels driving on soft and dry soil, and a handful of models are implemented. Additionally, a Hertz contact model for hard and elastic contact, between bodies themselves or to obstacles in the environment (e. g. rocks in the soft soil), is available as well. The capabilities of the library have been key in the development of rovers for planetary exploration such as the upcoming MMX mission to the Martian moon Phobos.

SUPPORTING INFINITELY FAST PROCESSES IN CONTINUOUS SYSTEM MODELING

John Kristofer Tinnerholm[1], Francesco Casella[2], Adrian Pop[1]
([1]Department of Computer and Information Science (IDA), Linköping University, Sweden; [2]Dipartimento di Elettronica, Informazione e Bioingegneria, Politecnico di Milano, Italy)

In this article, we examine the consequences of introducing a new construct into an equation-based language to model infinitely fast processes. We do this by extending the equation-based language Modelica with a special time constant, Θ. Θ provides modelers with an additional language construct that they can utilize both to improve performance of numerical integration for existing models as well as formulating and simulating models that existing tools struggle with. We present two cases where clear net benefits of introducing this new operator are illustrated.

The first being an artificial DAE-System using a monotonic function, the second being an electrical circuit with and without a parasitic capacitance. Based on or observations we believe that by enabling modelers to express common idealizations using Θ we can improve both performance and maintainability, since ide- alizations made by the modeler are encoded explicitly in the model.

ABSTRACTS - SESSION 4-D

SESSION 4-D: Medicine and biology applications 1
TIME: Wednesday, 11/Oct/2023, 9:30 AM - 10:45 AM
LOCATION: Charles
CHAIR: Peter Ambjörn Fritzson

CREATING CARDIOVASCULAR AND RESPIRATORY MODELS USING PHYSIOLIBRARY 3.0

Marek Matejáka[1,2]
([1]Charles University inPrague, Czech Republic; [2] Institute for Clinical and Experimental Medicine, Czech Republic)

The free open-source library called Physiolibrary (https://github.com/MarekMatejak/Physiolibrary) in version 3.0 recast components from physiological domains such as hydraulic (cardiovascular), thermal, osmotic and chemical into Modelica Standard Library (MSL) concept of Fluid/Media. Components are expanded to include gases transports, acid-base, electrolytes, nutrients delivery and endocrines by simple selecting pre-packaged media. They can be connected directly (the same medium) or across membranes (different media), allowing small physiological models to be easily coupled within more quantitative ones with minimal effort.

DESIGN IDEAS BEHIND BIOPROCESS LIBRARY FOR MODELICA

Jan Peter Axelsson
(Vascaia AB, Sweden)

In this paper I describe key design ideas behind the Bioprocess Library. The library facilitates modelling and simulation of bioprocesses mainly for the pharmaceutical industry. It borrows some structures from MSL Fluid and Media but differs in central design choices and is much simpler. A typical application consists of both configuration of standard components from the library and tailor-made Modelica code defining the application dependent medium and bioprocess reactions. The guiding idea is that configuration of components works well for defining the setup of process equipment for a production line, while more flexibility is needed for modelling bioprocess reactions and therefore equations are used. Another central design idea is that components of equipment are centrally adapted to the medium used. One could say that the library is parameterised with the application media and reaction models. The focus of this paper is structural aspects of the library rather than the content.

BODYLIGHT.JS 2.0 - WEB COMPONENTS FOR FMU SIMULATION, VISUALISATION AND ANIMATION IN STANDARD WEB BROWSER

Tomas Kulhanek[1,2] , Arnost Mladek[2], Jiri Kofranek[1,2] , Filip Jezek[2,3]
([1]Creative Connections, Czechia; [2]Charles University, Prague, Czechia; [3]University of Michigan, Ann Arbor, USA)

Simulators used in teaching and education comprises a mathematical model of the system under study and user interface that allows to control model inputs and visualize model state and results in an intuitive way. This paper presents web components - that can be used to build in-browser web simulator. The models used for the web simulators must be written in standard Modelica language and compiled as standard FMU (Functional mockup unit). The toolchain version Bodylight.js 2.0 contains tools to compile FMU into WebAssembly language able to be executed directly by web browser. Bodylight.js 2.0 web components can be then used to combine model, interactive animation and charts into rich web document in HTML or Markdown syntax only without any other programming or scripting.

ABSTRACTS - SESSION 5-A

SESSION 5-A: New features of the Modelica language and of FMI 2
TIME: Wednesday, 11/Oct/2023, 11:15 AM - 12:30 PM
LOCATION: Room Carbon
CHAIR: Christian Bertsch

DESIGN PROPOSAL OF A STANDARDIZED BASE MODELICA LANGUAGE

Gerd Kurzbach[1], Oliver Lenord[2], Hans Olsson[3], Martin Sjölund[4], Henrik Tidefelt[5]
([1]ESI Germany GmbH, Germany; [2]Robert Bosch GmbH, Germany; [3]Dassault Systèmes, Sweden; [4]Department of Computer and Information Science (IDA), Linköping University, Sweden; [5]Wolfram MathCore, Sweden)

This paper is presenting the design proposal of a simplified version of the Modelica language. Base Modelica is designed to serve as an intermediate representation enabling a clean separation of front-end and back-end matters when processing a Modelica model. Furthermore, is it intended as a basis to restructure the Modelica Language Specification considering two parts: the basic features and the advanced language constructs. After discussing the motivation, solution approach, and risks, the paper is highlighting a selection of design choices that have been made for the current pre-release version of the language. Code examples are given to illustrate and highlight various aspects of the language. Open issues, conclusions, and an outlook finalize the paper. By attracting more tool vendors and researchers to work with this intermediate representation the whole Modelica community is expected to benefit from new utilities to inspect, analyze, optimize and process equations-based models in general and Modelica models in particular.

A PRECICE-FMI RUNNER TO COUPLE FMUS TO PDE-BASED SIMULATIONS

Leonard Willeke, David Schneider, Benjamin Uekermann
(University of Stuttgart, Germany)

Partitioned simulation or co-simulation allows simulating complex systems by breaking them up into smaller subsystems. The Functional Mock-Up Interface (FMI) enables co-simulation for models based on ODEs and DAEs, but typically not PDEs. However, only PDE-based models are able to accurately simulate physical aspects requiring spatial resolution, such as heat transfer or fluid-structure interaction.

We present a preCICE-FMI runner software to integrate FMUs with the open-source coupling library preCICE. preCICE couples PDE-based simulation programs, such as OpenFOAM or FEniCS, in a black-box fashion to achieve partitioned multi-physics simulations. The runner serves as an importer to execute any FMU and to steer the simulation. Additionally, it calls preCICE to communicate and coordinate with other programs. The software is written in Python and relies on the Python package FMPy. We showcase two example cases for the coupling of FMUs to ODE- and PDE-based models.

SECURE EXCHANGE OF BLACK-BOX SIMULATION MODELS USING FMI IN THE INDUSTRIAL CONTEXT

Christian Wolf[1], Miriam Schleipen[1], Georg Frey[2]
([1]EKS InTec GmbH, Germany; [2]Chair of Automation and Energy Systems, Saarland University, Germany)

FMI is a standard for exchanging simulation models in a platform-agnostic way, also in form of black-box models. In the industrial context, it is common to exchange such black-box simulation models especially between partners. Using and running such models, though, is a security issue as there is no way to verify and validate the content of the models. This security issue must be addressed especially in the industrial context where security is considered high priority in general. Based on an exemplary model exchange, possible attacks are analyzed in this work. By using cryptography, three different approaches to pack the additional metadata are presented that aim at providing end-to-end integrity checks to a black-box simulation models. Together with administrative measures, this allows to define those FMUs to be trusted and executed. For sake of completeness, a prototype was implemented to help with the cryptographic processes and show the effectiveness of the provided solution.

ABSTRACTS - SESSION 5-B

SESSION 5-B: Experimental language designs and implementations related to Modelica 1
TIME: Wednesday, 11/Oct/2023, 11:15 AM - 12:30 PM
LOCATION: Room Silver
CHAIR: Dirk Zimmer

THE COMMON REQUIREMENT MODELING LANGUAGE

Daniel Bouskela[1], Lena Buffoni[2], Audrey Jardin[1], Vince Molnair[3], Adrian Pop[2], Armin Zavada[4] ([1]Electrecite de France, France; [2]Linköping University, Sweden; [3]Budapest University of Technology and Economics, Hungary; [4]IncQuery Labs cPlc., Hungary)

CRML (the Common Requirement Modeling Language) is a new language for the formal expression of requirements. The ambition is to release the language as an open standard integrated into the open source modeling and simulation tool OpenModelica and interoperable with the open systems engineering standard SysMLv2. CRML allows to express requirements as multidisciplinary spatiotemporal constraints that can be verified against system design by co-simulating requirements models with behavioral models. Particular attention is paid to the following aspects. The requirements models must be easily legible and sharable between disciplines and stakeholders and must capture realistic constraints on the system, including time-dependent constraints with probabilistic criteria, in recognition of the fact that no constraint can be fulfilled at any time at any cost. The theoretical foundation of the language lies on 4-valued Boolean algebra, set theory and function theory. The coupling of the requirements models to the behavioral models is obtained through the specification of bindings, the automatic generation of Modelica code from the CRML model and use of the FMI and SSP standards.

CRML and the proposed methodology is compatible with SysMLv2, forming a comprehensive workflow and tool-chain encompassing requirement analysis, system design and V&V. The final objective is to facilitate the demonstration of correctness of system behavior against assumptions and requirements by building a workflow around Model-Driven Engineering and Open Standards for automating the creation of verification simulators.

VARIABLE STRUCTURE SYSTEM SIMULATION VIA PREDEFINED ACAUSAL COMPONENTS

Andrea Neumayr, Martin Otter (German Aerospace Center, Germany)

This article outlines a new approach of the experimental open-source modeling and simulation system Modia to simulate systems where the number of variables and equations can be changed after compilation and also during simulation, without having to re-generate and rec-ompile the code.

Details are given for heat transfer in an insulated rod, where the discretisation of the rod is completely hidden from the symbolic engine.

It is discussed how this approach could also be used in a future version of Modelica and/or FMI.

Furthermore, this feature is also used in various variants to speed up collision handling in 3D mechanical systems.

For example, by rigidly fixing an object after it has been gripped, with or without calculating the elastic response, and thereby dynamically changing the number of degrees of freedom.

MOCITEMPGEN: MODELICA CONTINUOUS INTEGRATION TEMPLATE GENERATOR

David Jansen, Fabian Wüllhorst, Sven Hinrichs, Dirk Müller (RWTH Aachen University, E.ON Energy Research Center, Institute for Energy Efficient Buildings and Indoor Climate, Germany)

Modelica enables an object-oriented approach to model complex systems in product development and research, and, thus, the development of various model libraries. Library development requires collaborative development in a team of multiple developers. A typical challenge in collaborative development, especially in the area of open source, is to create models of uniform quality despite different levels of knowledge among developers. Techniques such as Continuous Integration (CI) from the field of software development, can help to solve these challenges. However, the adaptation of CI for the area of Modelica model development currently requires the manual creation of complex templates and a high degree of manual configuration. In this paper we present MoCITempGen, an open source tool for automated generation of CI structures for the widely used modeling language Modelica. The tool is succesfully applied on two Modelica libraries to demonstrate the functionality.

ABSTRACTS - SESSION 5-C

SESSION 5-C: Other industrial applications, such as electric drives, power systems, aerospace, etc. 2
TIME: Wednesday, 11/Oct/2023, 11:15 AM - 12:30 PM
LOCATION: Room Oxygen
CHAIR: Marcus Karel Richardson

STEADY STATE AND DYNAMIC SIMULATION OF A SMALL-SCALE HOLLOW FIBER MEMBRANE HUMIDIFIER

Markus Pollak[1], Manuel Kutz[2], Christian Schulze[2], Wilhelm Tegethoff[1,2], Jürgen Köhler[1]
([1]Institut für Thermodynamik, Technische Universität Braunschweig, Germany; [2]TLK-Thermo GmbH, Germany)

Membrane humidifiers are often used in mobile Proton Exchange Membrane (PEM) fuel cell systems to humidify the supply air of the fuel cell. The purpose of a humidifier in a PEM fuel cell system is to prevent a dry-out of the fuel cell membrane. In this paper, a humidifier model based on the number of transfer units (NTU) approach is set-up in Modelica, calibrated and validated using measurement of a test rig. In a first step, the model is evaluated for steady state operating conditions. Second the developed membrane humidifier model is simulated with dynamically changing operating conditions that are typical for mobile applications. Those simulation results are then compared to measurements. The aim of our study is to evaluate the accuracy of the NTU humidifier model under various operating scenarios. Our results indicate that the NTU model is suitable to predict the water transfer under steady state as well as dynamically changing operating conditions with low deviations to measurements.

MODELING COMPONENTS OF A TURBINE-GENERATOR SYSTEM FOR SUB-SYNCHRONOUS OSCILLATION STUDIES WITH MODELICA

Eric Segerstrom[1], Luigi Vanfretti[2], Chetan Mishra[3], Kevin D. Jones[3] ([1]University of Vermont; [2]Rensselaer Polytechnic Institute, United States of America; [3]Dominion Energy)

In power systems, subsynchronous oscillations associated with the interaction between a mechanical rotor shaft and electrical system can lead to equipment damage if improperly mitigated. This paper describes the development of a scalable, multi-mass torsional shaft model and a synchronous machine model with DC offset torque components included using Modelica. When coupled, these models can be used to perform shaft torsional studies. Two methods of coupling the shaft with the rest of the turbine-generator system are devised and analyzed. A single-machine, infinite-bus test system using the torsional shaft model and generator model developed in this paper is proposed to observe the penetration of subsynchronous oscillations throughout an electrical system. The test system is then modified to model subsynchronous resonance leading to system instability. Analysis of the models described in this paper highlights the value of the Modelica_LinearSystems2 library in determining the torsional mode shapes and frequencies associated with a turbine-generator system model.

DRONELIBRARY: MULTI-DOMAIN DRONE MODELING IN MODELICA

Meaghan Podlaski[1], Luigi Vanfretti[2], Dietmar Winkler[3]
([1]GE Research; [2]Rensselaer Polytechnic Institute; [3]University of South-Eastern Norway)

In the development of complex, novel electrified aerial systems such as Unmanned Aerial Vehicles (UAVs) and electric vertical take-off and landing (eVTOL) systems, multi-domain modeling and simulation studies can provide indispensable insight on system design and performance. In this paper, a Modelica library used to model multi-domain drone models is introduced. This library models a drone in the electrical, mechanical, and control domains, with examples for applications such as battery-power analysis, virtual reality simulation and user interaction.

ABSTRACTS - SESSION 5-D

SESSION 5-D: Thermodynamic and energy systems applications 4
TIME: Wednesday, 11/Oct/2023, 11:15 AM - 12:30 PM
LOCATION: Charles
CHAIR: Laura Maier

OPTIMAL SCHEDULING OF IES CONSIDERING THERMAL TRANSMISSION DELAY BASED ON MODELICA AND JULIA

Yong Qiu, Jin Wang, Shubin Zhang, Yuan He, Haiming Zhang, Ji Ding, Fanli Zhou
(Suzhou Tongyuan Software & Control Technology Co. , Ltd, China, People's Republic of)

The Integrated Energy System (IES) enables integrated control and coordinated optimization of multiple energy flows. Due to the complexity of dynamic characteristics of multiple energy flows and the significant differences in time scales, thermodynamic problems occur during the operation of the system. In this paper, we propose an IES operation method that comprehensively considers thermodynamics to reduce the impact of thermal transmission delay on the system's operational strategy, including modeling, evaluation, and scheduling programs. Firstly, an IES model is established to describe the dynamic characteristics of the energy supply network. Secondly, a two-stage optimization scheduling model considering thermal transmission delay is established to reduce the impact of thermal transmission delay on the operation decisions of IES, and the thermal power imbalance rate index is proposed to measure the impact of thermodynamics. Finally, the proposed method's effectiveness is validated by utilizing a comprehensive energy system as an example and implementing it on the MWORKS platform using the Modelica and Julia languages.

SIMULATION STUDY OF FLOW INSTABILITY IN PARALLEL MULTI-CHANNEL SYSTEMS BASED ON MODELICA

qiushi Tong[1], xing LV[1], Kangjie Deng[2], Xiaokang Zeng[2], JI Ding[1], Fanli Zhou[1]
([1]Suzhou Tongyuan Software & Control Technology Co. , Ltd, China, People's Republic of; [2]CNNC Key Laboratory on Nuclear Reactor Thermal Hydraulics Technology Nuclear Power Institute of China)

In parallel channels of a nuclear reactor core, flow instability can cause a significant decrease in critical heat flux (CHF) or mechanical oscillation of the fuel components, endangering the normal operation of the reactor. The NUMAP software, developed based on the two-fluid six-equation theory and using the Modelica language, is a multi-domain unified modeling and simulation platform for nuclear power plants. In this paper, a parallel dual-channel system model was constructed based on the NUMAP software, referencing a high-temperature and high-pressure steam-water two-phase thermohydraulic experimental device, to simulate flow instability phenomena. The comparison with experimental data validated the transient analysis ability of the NUMAP software for flow instability phenomena. Based on this, the flow instability boundary of a parallel multi-channel system was calculated under the same operating conditions. When the number of parallel channels was 2, 3, and 4, the calculated flow instability boundary error did not exceed ±5%, verifying that a parallel dual-channel structure can be used to obtain the flow instability boundary when there are multiple parallel heating channels.

Keywords: parallel channels, flow instability, Modelica, NUMAP

INTEGRATION OF HEAT FLOW THROUGH BORDERS BETWEEN ADJACENT ZONES IN AIXLIB'S REDUCED-ORDER MODEL

Philip Groesdonk[1,2], David Jansen[3], Jacob Estevam Schmiedt[1], Bernhard Hoffschmidt[1,2]
([1]Institute for Solar Research, German Aerospace Center (DLR), Germany; [2]Chair of Solar Components, RWTH Aachen University, Germany; [3]Institute for Energy Efficient Buildings and Indoor Climate, RWTH Aachen University, Germany)

For dynamically simulating the thermal behavior of a building, the reduced-order model (ROM) implemented in the Modelica IBPSA and AixLib libraries provides a time-efficient calculation method based on the standard VDI 6007-1. Additionally, the Python package TEASER features a possibilty to fill the model parameters with automatically generated typical and/or enriched building data. So far, both have not been capable of modelling heat flow through borders between thermal zones. In this contribution, we present the integration of this feature into the open-source software combination. Additional new features include non-constant soil temperatures and a new approach to estimate interior building elements in cases without proper knowledge. Calculation results are presented for an exemplary application and show satisfactory agreement with measured values. The respective code (including the example presented here) is in the process of being published as part of the AixLib and TEASER open-source repositiories.

ABSTRACTS - SESSION 6-A

SESSION 6-A: Thermodynamic and energy systems applications 5
TIME: Wednesday, 11/Oct/2023, 2:00 PM - 3:15 PM
LOCATION: Room Carbon
CHAIR: Dominik Hering

5TH GENERATION DISTRICT HEATING AND COOLING MODELICA MODELS FOR PROSUMER INTERACTION ANALYSIS

Orestis Angelidis[1], Daniel Zinsmeister[2], Anastasia Ioannou[1], Daniel Friedrich[3], Alan Thomson[4], Gioia Falcone[1]
([1]University of Glasgow, United Kingdom; [2]Technical University of Munich, Germany; [3]The University of Edinburgh, United Kingdom; [4]Ramboll, United Kingdom)

5th Generation District Heating and Cooling (5GDHC) provides a promising pathway for decarbonising the thermal sector. To quantifying the synergies between heating, cooling, and electricity, complex thermofluid models are required. Modelica offers a potential solution for developing such models but there is a scarcity of accessible and usable models. This paper addresses this gap by presenting a comprehensive set of Modelica models for key elements of 5GDHC systems: prosumers, balancing units, and hydraulic interfaces. The models prioritise usability by facilitating the utilisation of Func-tional Mock-up Interface and Power Hardware-in-the-Loop (PHIL) methodologies. Component design, rele-vant controls and the applicability of PHIL setups are discussed. A theoretical case exemplifies hardware min-imisation, using only heat exchangers to investigate prosumer behaviour. The paper concludes with a discus-sion on the potential use of these models, opportunities for improvement, and the need for further research and experimental investigations in understanding 5GDHC systems.

HEAT EXCHANGER SURROGATES FOR A VAPOR COMPRESSION SYSTEM

Nasrulloh Ratu Bagus Satrio Loka[1], Nicolás Ablanque Mejía[2], Santiago Torras Ortiz[2], Sriram Karthik Gurumurthy[3], Antonello Monti[3], Joaquim Rigola[2], Carles Oliet[2], Ivo Couckuyt[1], Tom Dhaene[1]
([1]INTEC, Ghent University - IMEC, Belgium; [2]Universitat Politècnica de Catalunya - Barcelona Tech (UPC), Heat and Mass Transfer Technological Center (CTTC), Spain; [3]ACS, EONERC, RWTH Aachen University, Germany)

Given the computationally intensive nature of heat exchanger simulators, utilizing a data-driven surrogate model for efficiently computing the heat exchanger outputs is desirable. This study focuses on developing integrated surrogate models of heat exchangers for a vapor compression system in Modelica. The surrogate models are designed to serve as steady-state equivalents based on an efficient physics-based model which was calibrated using reference data obtained from a more advanced simulation model. Subsequently, the calibrated model was employed to generate the training and testing data for the development of Gaussian Process (GP) and Multi-Layer Perceptron (MLP) surrogates. The obtained findings indicate that GPs exhibit high accuracy when applied to the heat exchanger's outputs with smooth behavior. GPs also demonstrate excellent data efficiency compared to MLPs. In cases where the GP struggles to model specific outputs effectively, MLPs are able to capture the more complex behavior. Moreover, hyperparameter optimization is employed to identify optimal MLP topologies. Finally, the fast and compact surrogate model was integrated into the Modelica/Dymola environment. This adaptation allowed the surrogate models to be directly combined with the physical model of the heat exchanger.

ELECTRODE BOILER MODEL FOR ANCILLARY SERVICE SIMULATION

Rene Just Nielsen, Thomas Egsgaard Pedersen
(Added Values P/S, Denmark)

A generic component-based model of an industrial electrode boiler with internal control systems is presented. A mechanistic modelling approach was taken to include as much process and control information as possible and to generate detailed simulation results. The model is intended for qualitative studies of electrode boiler dynamics in the context of district heating generation and power grid ancillary services in collaboration with other electric power consuming units.

An example boiler control scheme is designed and included in the simulation model as this is paramount to the dynamic response of the system. Simulations of standstill, load changes, and startup from hot and cold state show that the strictest ancillary service requirements can be fulfilled when the boiler is kept at operating temperature.

ABSTRACTS - SESSION 6-B

SESSION 6-B: Multi-engineering modeling and simulation with free and commercial Modelica libraries
TIME: Wednesday, 11/Oct/2023, 2:00 PM - 3:15 PM
LOCATION: Room Silver
CHAIR: Francesco Casella

STATUS OF THE CLARA LIBRARY: DETAILED TRANSIENT SIMULATION OF COMPLEX ENERGY SYSTEMS

Ales Vojacek, Johannes Brunnemann, Tim Hanke, Thomas Marx-Schubach, Jörg Eiden
(XRG Simulation GmbH, Germany)

This paper presents the current state of the open-source Modelica library ClaRa, which provides its users with the capability to proficiently tackle tasks in the disciplines of thermal hydraulics, instrumentation and control pertaining to power plants and other kind of energy systems. We provide a comprehensive overview of how the library has successfully broadened its scope over the years of its development, transcending the original focus on conventional power plants to encompass renewable power plants, waste heat utilization, general process plants, refrigeration cycles, heat pumps and beyond. The new version, ClaRa 1.8.1, brings an exciting addition to the already impressive suite of features - support for the utilization of various artificial intelligence models in Modelica simulation tools. Furthermore, the authors unveil ClaRa's ambition to serve as a potential publication platform for third-party models from a steadily growing community of ClaRa users. This is underscored by several application models. Finally, we also describe the funding scheme for maintenance of open source ClaRa by an extended commercial version, ClaRaPlus.

OPEN-SOURCE MODELS FOR SAND-BASED THERMAL ENERGY STORAGE IN HEATING APPLICATIONS

Kathryn Hinkelman[1], David Milner[2], Wangda Zuo[1,3]
([1]Pennsylvania State University, United States of America; [2]University of Colorado, United States of America; [3]National Renewable Energy Laboratory, United States of America)

This paper presents a new open-source modeling package in the Modelica language for particle-based silica-sand thermal energy storage (TES) in heating applications, available at https://github.com/sbslab/modelica-sand. Silica sand is an abundant, low-cost, and efficient storage medium for concentrated solar power and electricity generation. Although uncommon today, solid particle TES could benefit building and district heating systems, particularly as building electrification and renewable energy penetration increases. To enable heating system design and evaluation with sand TES, this work developed and open-source released Modelica models from base classes through complete systems with both physical equipment and controls. This paper first presents the new models. Then, we demonstrate their application with a heating plant that supplies steam for district heating, while also providing power-to-heat grid services by storing excesses renewable electricity as thermal energy.

AN OPEN-SOURCE BENCHMARK OF IEEE TEST CASES FOR EASILY TESTING A NEW APPROACH FOR STEADY STATE CALCULATIONS IN POWER SYSTEMS

Joy El Feghali, Quentin Cossart, Gautier Bureau, Baptiste Letellier, Ian Menezes, Florentine Rosiere, Marco Chiaramello
(RTE Réseau de transport d'électricité, France)

Power systems modeling and simulation are essential to conduct studies on the electrical transmission system and ensure its security. For this purpose, RTE, the French Transmission System Operator (TSO), is developing Dynaωo, a hybrid Modelica/C++ open-source suite of simulation tools for power systems. Most power systems models for Dynaωo are developed in the Modelica language using the Dynaωo Modelica library. This paper presents a full Modelica standard electrical power system benchmark implemented using the Dynaωo library. The IEEE 14-bus system benchmark is modeled here for steady-state calculation, with an approach that replaces the static load flow. Two test cases are simulated using the OpenModelica environment showing differences in the final steady-state result. We show flexibility in modeling with this library where different system behaviors can be observed and where models with different levels of details can be replaced depending on the application: steady-state calculation, long-term stability, or short-term stability.

ABSTRACTS - SESSION 6-C

SESSION 6-C: Other industrial applications, such as electric drives, power systems, aerospace, etc. 3
TIME: Wednesday, 11/Oct/2023, 2:00 PM - 3:15 PM
LOCATION: Room Oxygen
CHAIR: Markus Pollak

DROPWISE CONDENSATIONWATER DRAINAGE MODEL

Marcus Karel Richardson[1], Robert Francis Kunz[2]
([1]Boeing, United States of America; [2]Penn State University)

Modeling of condensation is important to estimating the residual water in small channels. The residual water that forms becomes a water source for permeable materials such as wooden structure or insulation. A model has been implemented in Modelica that will predict the amount of residual moisture after a period of water build up. This model includes parameters to relate droplet physics to a control volume. The parameters provide an macroscopic means of varying droplet adhesion force, droplet velocity, and drainage dynamics. Using CFD data as an example of real world data, this model has been correlated to demonstrate the effects of the parameters.

MODELING SPECIALIZED ELECTRIC POWER GENERATORS, EXCITATION SYSTEMS AND PRIME MOVERS USED BY NORTH AMERICAN UTILITIES

Md Shamimul Islam[1], Giuseppe Laera[1], Marcelo de Castro Fernandes[1], Luigi Vanfretti[1], Chetan Mishra[2], Kevin D. Jones[2]
([1]Rensselaer Polytechnic Institute, New York, United States of America; [2]Dominion Energy, Virginia, United States of America)

The North American Electric Reliability Corporation (NERC) is expected to mandate model validation of power plant equipment in the near future. This will create a need to validate models for a large fleet of existing and future power plants. Historically, model validation of synchronous generators, excitation system, turbine governor, and other power system equipment has been conducted in diverse platforms. As a contribution to the power system model implementation using Modelica language and validation against commercial tools this work continues to develop power system component models and enriching the Open-Instance Power System Library (OpenIPSL). As a part of the development of OpenIPSL this paper describes the development of models used by North American utilities that follow NERC modeling requirements, including models of a synchronous generator, an excitation system, a turbine and governor using Modelica language in Dymola. The component implementation process is described and the validation of the models implemented in Modelica against PSS/E using both a single machine infinite bus (SMIB) and multi-machine system models is illustrated.

NUMERICALLY EFFICIENT DEGRADATION MODEL OF CATALYST LAYERS IN PEM FUEL CELLS USING MODELICA

Jakob Trägner, Steffen Heinke, Wilhelm Tegethoff, Jürgen Köhler
(Institut für Thermodynamik, TU Braunschweig, Germany)

Degradation of the catalyst layer is a major challenge for the commercialization of polymer electrolyte membrane fuel cells (PEMFCs). Numerical modeling helps to understand and analyse the degradation phenomena, to transfer results from accelerated stress tests (ASTs) to real applications and to optimize operating conditions regarding degradation. We implemented a typical catalyst degradation model for platinum used in literature in Modelica. A numerical analysis shows the problem of "stiffness" for these models, meaning the tremendous difference in time constants. Assuming the platinum ion concentration in the ionomer to be in quasi-equilibrium helps to reduce the "stiffness", increases simulation speed and numerical robustness without any relevant inaccuracy. For a typical AST, the simulation speed can be more than doubled ending in a real-time factor of over 1,000. Thus, 500 hours of AST can be simulated within less than 30 minutes, which gives room for extensive analysis with the model.

ABSTRACTS - SESSION 6-D

SESSION 6-D: Automotive applications 1
TIME: Wednesday, 11/Oct/2023, 2:00 PM - 3:15 PM
LOCATION: Charles
CHAIR: Christian Vering

MASS CONSERVATION IN VAPOR COMPRESSION CYCLES: A METHOD FOR ENSURING CONSISTENCY WITH REDUNDANT DYNAMIC STATES

Daniel Andersson[2], John Batteh[1], Matthis Thorade[3], Lixiang Li[1]
([1]Modelon Inc., United States of America; [2]Modelon AB, Sweden; [3]Modelon Deutschland GmbH, Germany)

This paper describes a method to resolve a potential inconsistency when employing redundant dynamic thermofluid states for modeling of vapor compression cycles. Following a brief introduction regarding the motivation and use of redundant thermofluid states, a series of test models ranging from simple component models to complex system models are developed to illustrate the potential inconsistency with Air Conditioning Library. Based on observations of the simulation results from these test models, a method for ensuring consistency is proposed and implemented. The method is then demonstrated on the test suite and evaluated for effectiveness, robustness, and computational efficiency.

RACE CAR COOLING SYSTEM MODEL FOR REAL TIME USE IN A DRIVING SIMULATOR

Massimo Stellato[1], Luca Bergianti[1], Alessandro Picarelli[2]
([1]Dallara Automobili, Italy; [2]Claytex, United Kingdom)

Powertrain performance optimization is one of main targets in racecar and road hypercar development. A key activity needed for both endothermal and electric powertrains is the cooling system sizing through simulation to make sure that the temperature limits are not exceeded in the most aggressive conditions minimizing or avoiding power derating. This article describes the implementation of a 1D cooling system simulation model integrated with a vehicle multibody model to be used real time in the Dallara dynamic driving simulator with human driver. This activity is the result of a collaboration between Dallara which uses the model implemented to develop and optimize the cooling system architecture of its vehicles, and Claytex which develops the libraries used to generate these simulation models.

SWITCHING AND AVERAGING MODELS OF A BIDIRECTIONAL, HALF-BRIDGE BASED DC-DC CONVERTER WITH LOAD DISTRIBUTION

Andrea Reindl[1], Andreas Lang[2], Michael Niemetz[2], Hans Meier[2] ([1]OTH Regensburg / TU Berlin, Germany; [2]OTH Regensburg, Germany)

Batteries are used in numerous applications such as mobile devices, electric vehicles, home storage systems and islanded microgrids. Bidirectional DC-DC converters are vital for the integration of batteries, for the power conversion during (dis)charge and the battery management. Modeling of these is helpful, especially for the design of larger, more complex systems consisting of multiple DC-DC converters in parallel. Due to the high switching frequencies, the simulation of DC-DC converters is associated with increased computational time and effort. In this paper, three models of different complexity and accuracy are proposed for a bidirectional DC-DC converter consisting of two phase-shifted half-bridges. Two switching models, which differ mainly in the way the MOSFET are driven, account for the individual switching operations and exhibit high accuracy. An averaging model replaces the switching elements with current and voltage sources providing the mean values. It is particularly suitable for multiple components and longer simulation durations. The dynamic behavior of the models is analyzed using the step responses of the load current. For validation, these are compared with the theoretical transfer function. The three models are analyzed comparatively in terms of computational time and effort. The calculation time of the averaging model has been reduced by two thirds compared to the strictly complementary switching model and by 96 % relative to the model with diode emulation mode. The averaging model requires only one third of the computation time of the complementary switching model and only 3.5 % of that of the model with diode emulation.

THANK YOU TO OUR SPONSORS

PLATIN SPONSOR

GOLD SPONSORS

SILVER SPONSORS

BRONZE SPONSORS

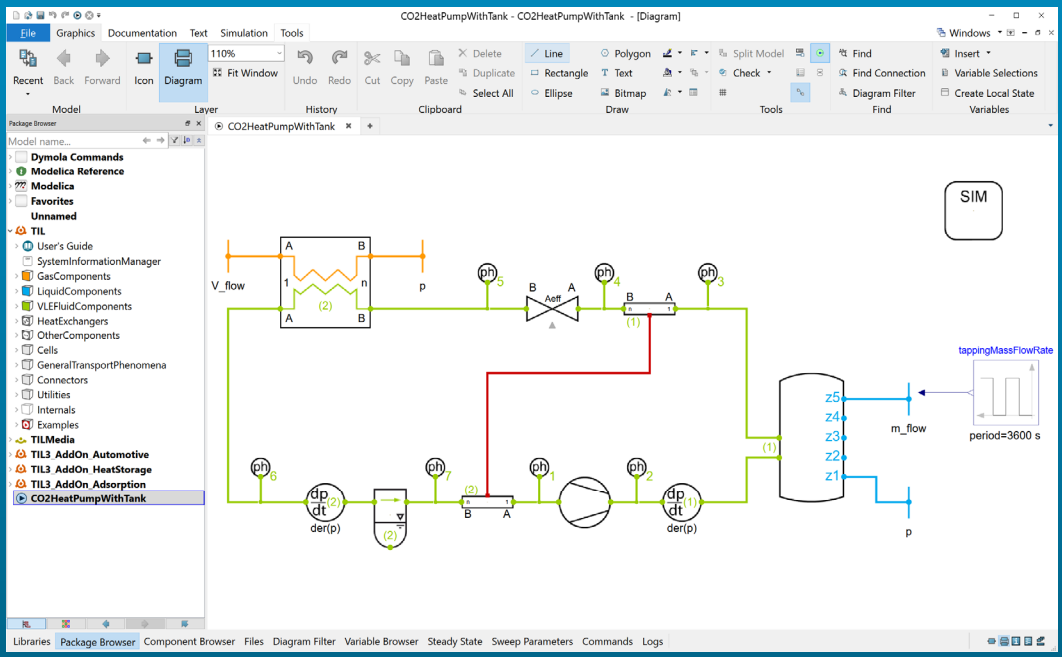
VIRTUAL WORLDS EXTEND AND IMPROVE THE REAL WORLD

Dassault Systèmes, the **3D**EXPERIENCE® Company, provides business and people with virtual universes to imagine sustainable innovations for today and tomorrow.

For more information, visit **www.3ds.com**

DASSAULT SYSTEMES | The **3D**EXPERIENCE® Company

LTX Simulation GmbH



We simulate energy systems

Simulate heat pumps in automotive, rail and building applications.
Use Modelica to enhance energy efficiency in production sites and cities.
Provide Dymola to users in Germany, Austria and Switzerland.
Support customers in choosing a proper combination of Modelica and FMI tools.

Your job application is welcome!

www.ltx.de | info@ltx.de
LTX Simulation GmbH | Munich | Germany