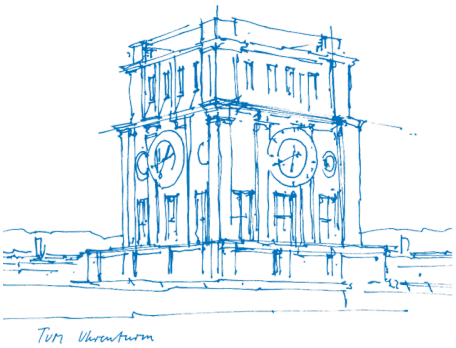
preCICE: a coupling library for partitioned multi-physics simulations

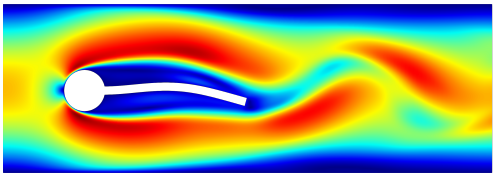
2nd CCP-WSI Hackathon

Gerasimos Chourdakis
Technical University of Munich

June 30, 2022

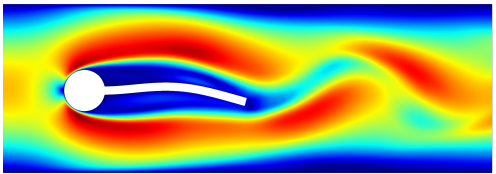


Perspective: Partitioned multi-physics simulations



Fluid-Structure Interaction:
Turek-Hron FSI3 benchmark

Perspective: Partitioned multi-physics simulations



Fluid-Structure Interaction:
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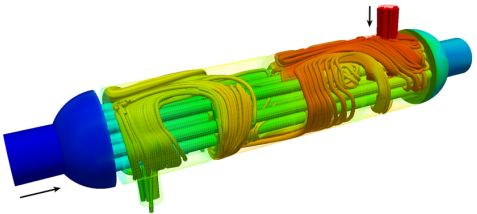
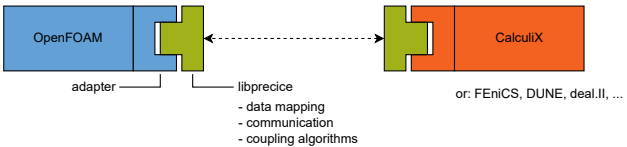


Conjugate Heat Transfer:
heat exchanger

preCICE in a nutshell



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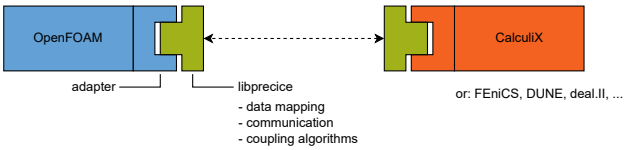


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while (t < t_end){
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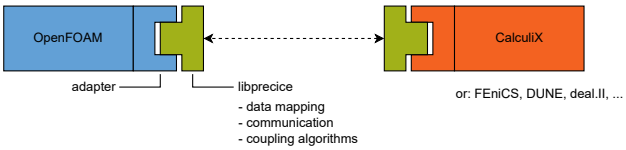


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Adapters and examples for: OpenFOAM, SU2, CalculiX, deal.II, FEniCS, DUNE, Nutils, ...

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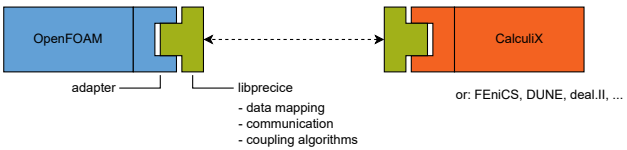


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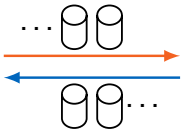
API in C++, C, Fortran, Python, Matlab, Julia

Main features



Communication

Options:
- MPI ports (fast)
- TCP sockets (robust)

Fully-parallel, peer-to-peer

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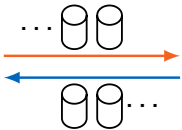

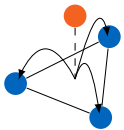

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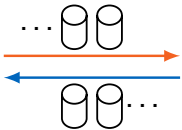
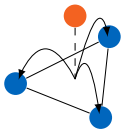
Data mapping

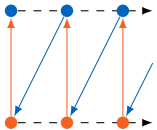
Options:
- radial-basis functions
- projection-based
- conservative/consistent
- direct mesh access

Compute on any side

Main features







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Coupling schemes

Options:
- serial / parallel
- explicit / implicit
- compositional, multi
- IQN, Aitken, ...

Same high-level API
Configurable at runtime

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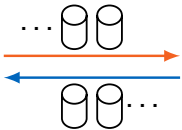

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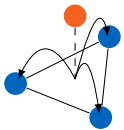

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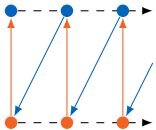

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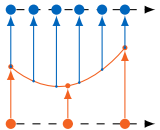


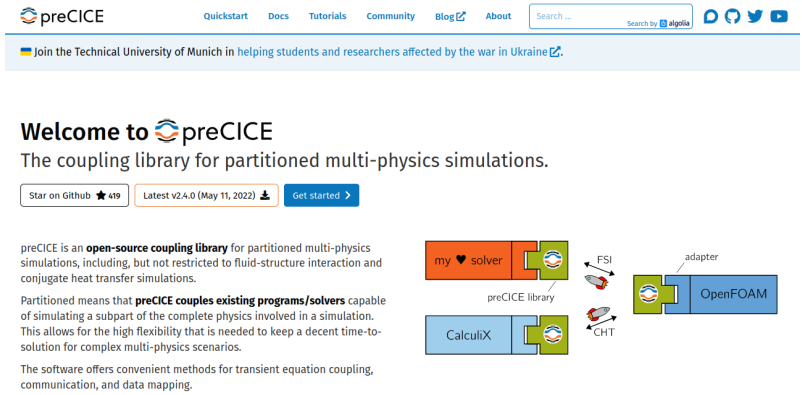
Time interpolation

Options:
- waveform iteration

Experimental since v2.4.0

Walking around the website (1)

- Available adapters
- Tutorials
- Quickstart

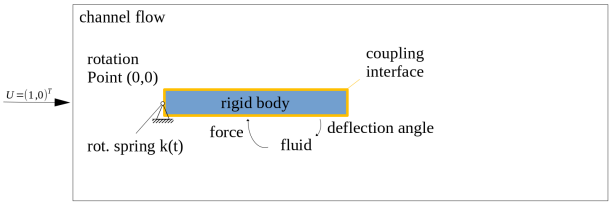


Live demo

Quickstart tutorial:
precice.org/quickstart.html

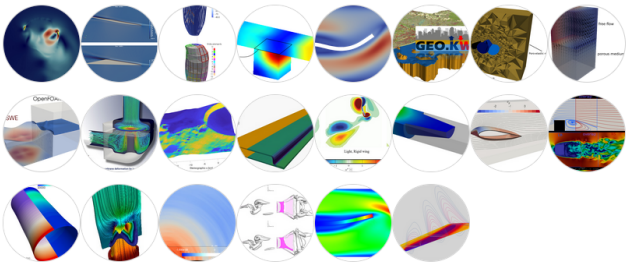
Running on the preCICE demo VM:
precice.org/installation-vm.html

Homework: Run it yourself! :-)



Walking around the website (2)

- Couple your code
- User stories
- Who uses preCICE



Related to WSI

- DCAE GmbH: Dam break FSI
- Tutorial: Multiple perpendicular flaps
- Univ. Luxembourg: FSI + DEM
- F. Espinosa (TUM): OpenFOAM + SWE

Roadmap

Public roadmap: `https://precice.org/fundamentals-roadmap.html`

Library:

- Geometric multi-scale mapping (1D-3D, 2D-3D)
- Dynamic coupling meshes
- Cell-based linear interpolation for volumetric coupling
- Adaptive and flexible macro-micro coupling

Also:

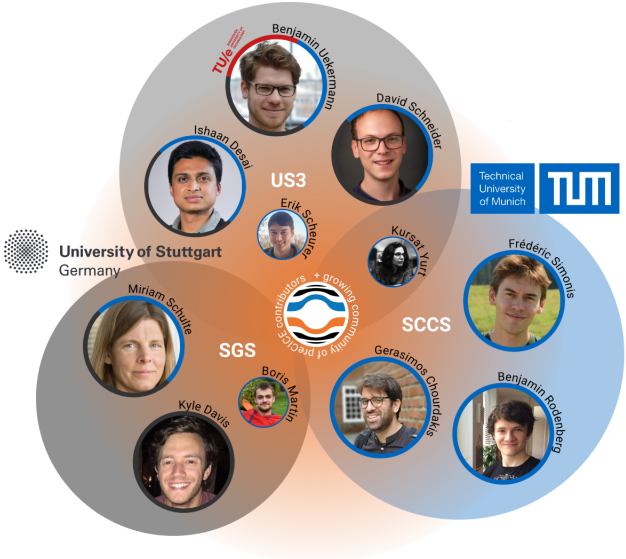
- OpenFOAM: Volume coupling, two-phase fluid-fluid coupling in main branch

Resources

- Documentation: `precice.org`
- Forum: `precice.discourse.group`
- Code: `github.com/precice` (library: LGPLv3, everything public)

- YouTube: `youtube.com/c/preCICECoupling`
- Twitter: `twitter.com/preCICE_org`
- Also: ResearchGate, LinkedIn

People

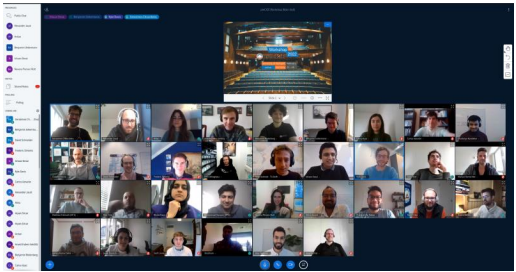

Benjamin Uekermann
David Schneider
Ishaan Desai
US3
Erik Scheuer
Kursat Yurt
University of Stuttgart
Germany
Technical University of Munich
Frédéric Simonis
+ growing community of preCICE contributors
Miriam Schulte
SGS
SCCS
Gerasimos Chourdakis
Boris Martin
Benjamin Rodenberg
Kyle Davis

Meet the people

Workshop #4 2023

preCICE

Technical University of Munich	February
Germany	13 - 16



Next week on Zoom

Best Practices for HPC Software Developers (Webinars)

Jump to: About the Series | Upcoming webinars | Past webinars | 2022 |2021 | 2020 | 2019 | 2018 | 2017 | 2016

Upcoming Webinars

Webinars are free and open to the public, but registration is required.

65. **Growing preCICE from an as-is Coupling Library to a Sustainable, Batteries-included Ecosystem** [Register]
    - **Date and Time:** Wednesday, July 6, 2022, 01:00 pm EDT
    - **Presenter:** Gerasimos Chourdakis (Technical University of Munich)

Challenge: Sustainable funding

1. Research-driven, niche topic: academic funding important
2. Research proposals together with users
3. Workshops
4. More support and collaboration requests than we can handle

Solution: Support program

Funding

Supported by:

Federal Ministry
for the Environment, Nature Conservation,
Nuclear Safety and Consumer Protection

based on a decision of
the German Bundestag

DFG

- Research Software Sustainability
- EXC 2075 SimTech

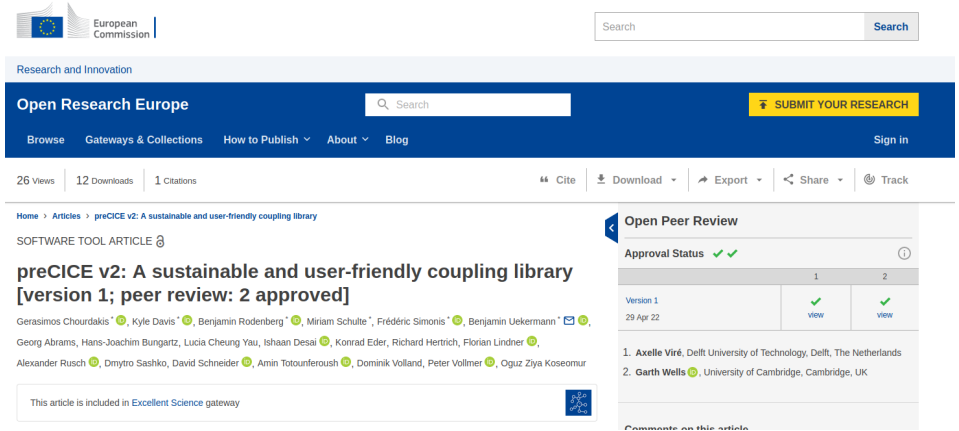
EuroTech Universities

SPPEXA

KONWIHR

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 754462

Key reference (fresh!)



Summary

- Main perspective: FSI, CHT, ...
- Cloud of points as coupling mesh
- Communication: MPI (fast), sockets (robust), p2p
- Data mapping: RBF, projection-based methods
- Coupling algorithms built-in: IQN, Aitken, serial/parallel
- Time interpolation: waveform (experimental)
- High-level API, configurable at runtime
- Ready-to-use for OpenFOAM, CalculiX, deal.II, and more

Slides & feedback:
go.tum.de/869601

gerasimos.chourdakis@tum.de

(Note: looking for a research stay abroad in 2023)