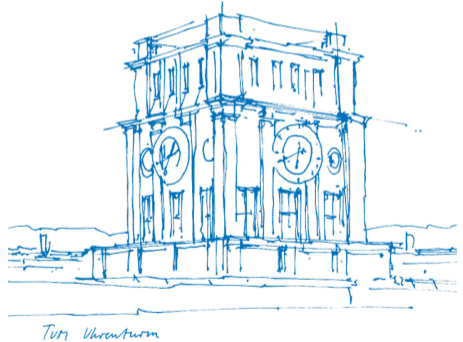


preCICE: a coupling library for partitioned multi-physics simulations

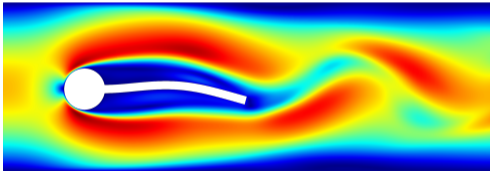
2nd CCP-WSI Hackathon

Gerasimos Chourdakis
Technical University of Munich

June 30, 2022

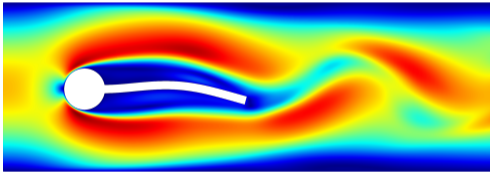


Perspective: Partitioned multi-physics simulations

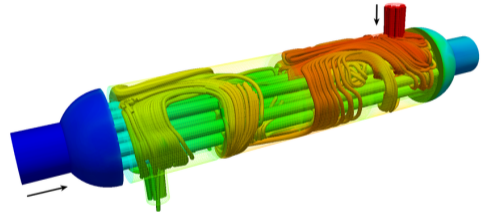


Fluid-Structure Interaction:
Turek-Hron FSI3 benchmark

Perspective: Partitioned multi-physics simulations

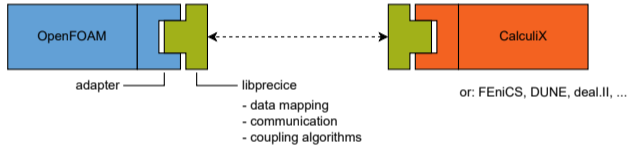


Fluid-Structure Interaction:
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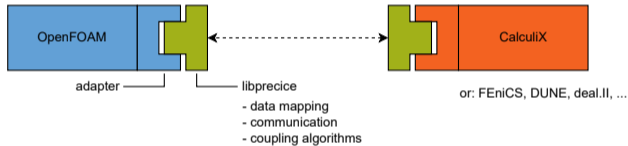


Conjugate Heat Transfer:
heat exchanger

preCICE in a nutshell

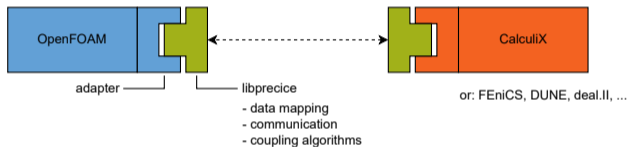


preCICE in a nutshell



```
while (t < t_end){  
    solve(dt);  
    precice.write_data(force);  
    max_dt = precice.advance(dt);  
    precice.read_data(displacement);  
}
```

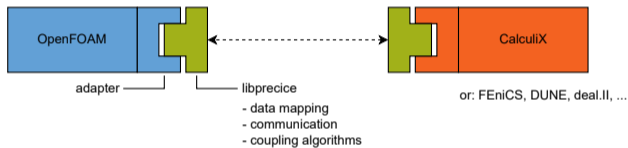
preCICE in a nutshell



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

preCICE in a nutshell

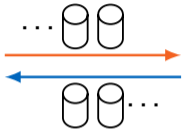


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}
```

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

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

Main features



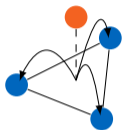
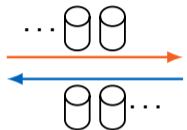
Communication

Options:

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

Fully-parallel, peer-to-peer

Main features



Communication

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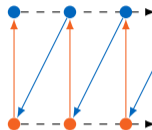
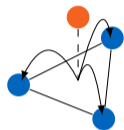
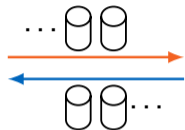
Data mapping

Options:

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

Compute on any side

Main features



Communication

- Options:
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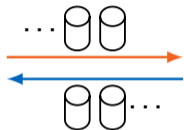
Compute on any side

Coupling schemes

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

Same high-level API
Configurable at runtime

Main features

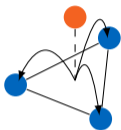


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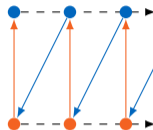


Data mapping

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Compute on any side

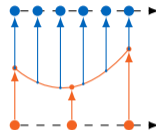


Coupling schemes

Options:

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

Same high-level API
Configurable at runtime



Time interpolation

Options:

- waveform iteration

Experimental since v2.4.0

Walking around the website (1)



Welcome to preCICE

The coupling library for partitioned multi-physics simulations.



preCICE is an **open-source coupling library** for partitioned multi-physics simulations, including, but not restricted to fluid-structure interaction and conjugate heat transfer simulations.

Partitioned means that **preCICE couples existing programs/solvers** capable of simulating a subpart of the complete physics involved in a simulation. This allows for the high flexibility that is needed to keep a decent time-to-solution for complex multi-physics scenarios.

The software offers convenient methods for transient equation coupling, communication, and data mapping.



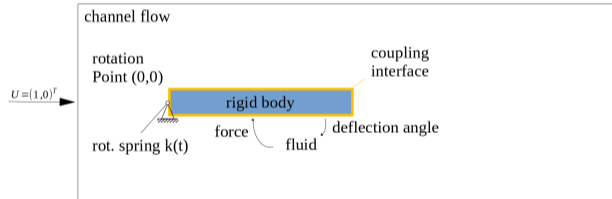
- Available adapters
- Tutorials
- Quickstart

Live demo

Quickstart tutorial:
precice.org/quickstart.html

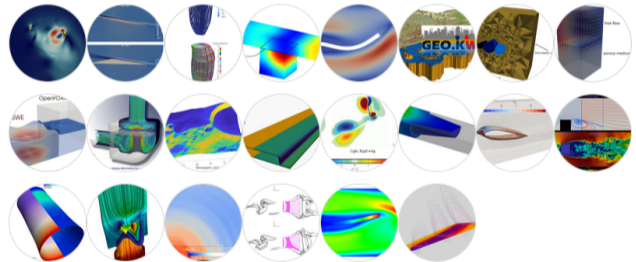
Running on the preCICE demo VM:
precice.org/installation-vm.html

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:

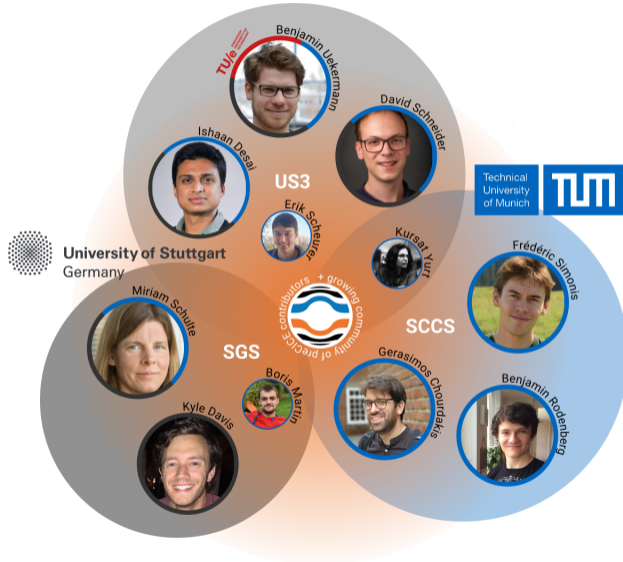
- OpenFOAM: Volume coupling, two-phase fluid-fluid coupling in main branch

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

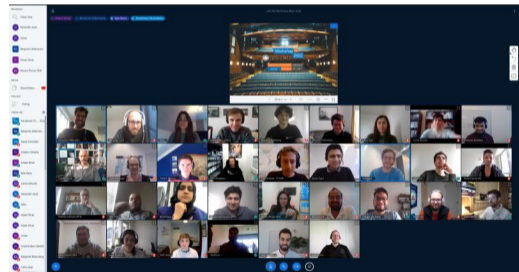
People



Meet the people



Technical University of Munich February
Germany 13 - 16



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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



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!)



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SOFTWARE TOOL ARTICLE

preCICE v2: A sustainable and user-friendly coupling library [version 1; peer review: 2 approved]

Gerasimos Chourdakis , Kyle Davis , Benjamin Rodenberg , Miriam Schulte , Frédéric Simonis , Benjamin Uekermann , Georg Abrams, Hans-Joachim Bungartz, Lucia Cheung Yau, Ishaan Desai , Konrad Eder, Richard Hertrich, Florian Lindner , Alexander Rusch , Dmytro Sashko, David Schneider , Amin Totounferoush , Dominik Volland, Peter Vollmer , Oguz Ziya Koseomur

This article is included in Excellent Science gateway

Open Peer Review

Approval Status ✔✔ ⓘ

	1	2
Version 1	✔	✔
29 Apr 22	view	view

1. **Axelle Viré**, Delft University of Technology, Delft, The Netherlands
2. **Garth Wells** , University of Cambridge, Cambridge, UK

Comments on this article

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)