Fraunhofer CML

Fraunhofer Center for Maritime Logistics and Services CML

Potentials of Quantum Computing for Enhanced Maritime Operations

Anisa Rizvanolli

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The Fraunhofer Society and Fraunhofer CML

Applied research for economy and society

Fraunhofer Society

30.000
Staff

76 Institutes
and research units

2,9 Bio. €
Financial volume

Fraunhofer CML, Hamburg

2010
Foundation in Hamburg

Focus on application-oriented research for the maritime industry

Cooperation with Institute of Maritime Logistics of TUHH

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Fraunhofer CML

Innovating the Maritime Sector.

- Founded 2010 at Hamburg University of Technology
- Direction: Prof. Dr.-Ing. Carlos Jahn
- Currently around 90 employees
- Applied research in the maritime sector
- Innovative solutions for companies and institutions in shipping, port management and logistics
- Initiation and implementation of future-oriented technologies and processes

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Fraunhofer CML: Innovating the Maritime Sector

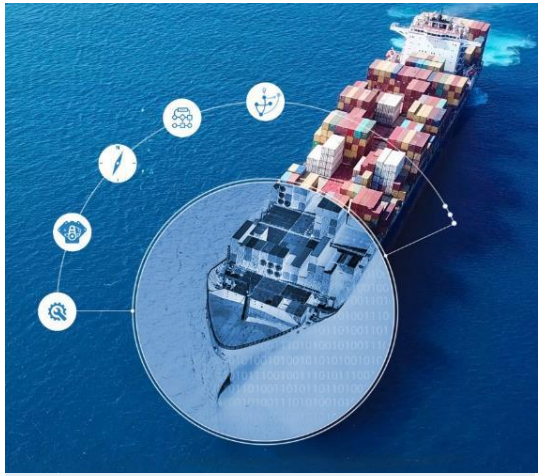
Fields of Research

Ports and Transport Markets

Analysis and optimization of nodes in the maritime supply chain

Sea Traffic and Nautical Solutions

Technologies for autonomous systems and nautical assistance systems



Ship and Information Management

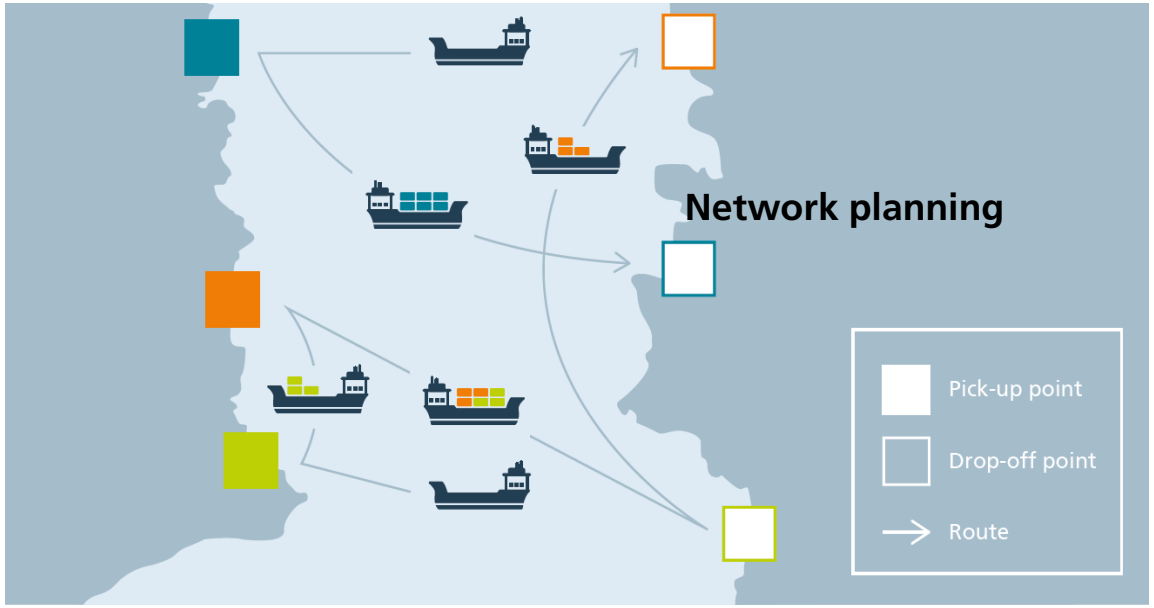
Software development with focus on digital solutions for fleet management, ship operation and maritime services

Port Technologies

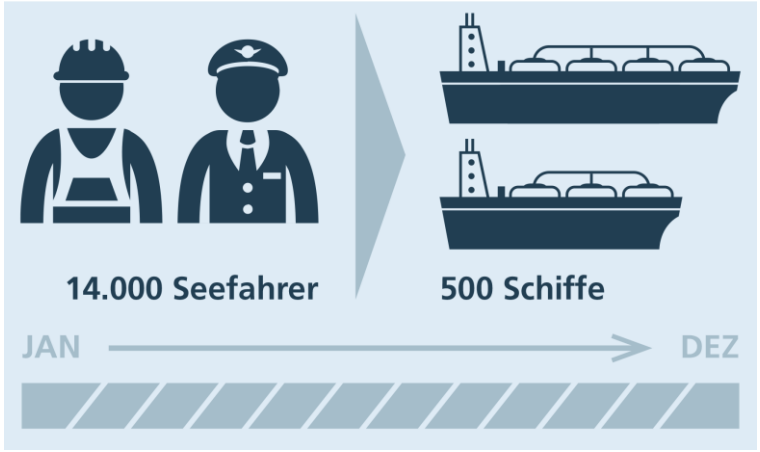
Mobile robotics and AI for new application areas in port operations

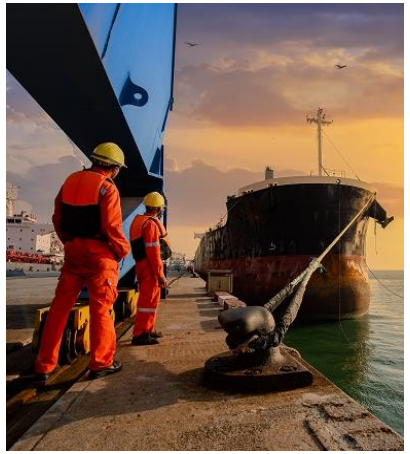
Optimization Problems in maritime logistics

Quantum Computing as a tool for Optimization



- Manual, experience-based and suboptimal processes
- Lack of data / digitalization (media breaks)
- Rarely mathematical tools in operation
- High complexity and need for real-time calculations





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Hardware

Overview

Technical Maturity → **Potential**

- **Classical Computer**

- **Digitaler Annealer**

Fujitsu

- **Quantum Annealer**

D-Wave

- **Universal Quantum Computer**
  - **NISQ**
  - **Fault tolerant**

IBM

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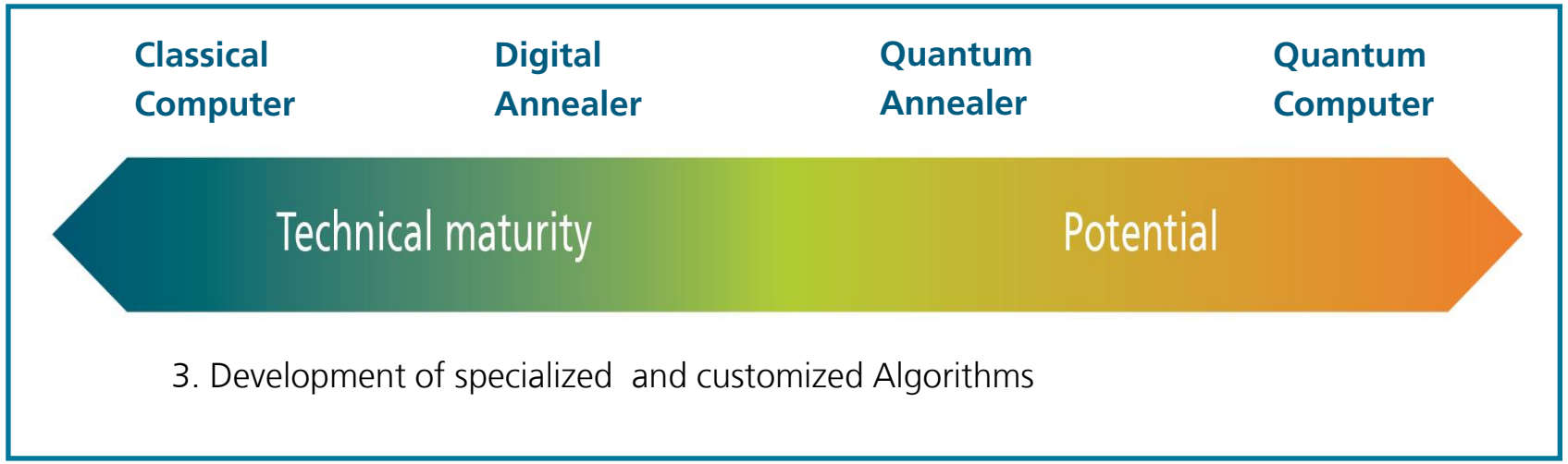
Fraunhofer CML: Focus on Applications

Mapping and solving problems from operations

Technology/platform independent works

1. Optimization problem from operations

2. Formalization as mathematical Model



4. Increased efficiency in operations

Current Pilot Application: Maritime Inventory Routing Problem

Tanker Shipping Company

Customer Problem

Planning the best route for tanker ships under consideration of various constraints

- Port and ship capacity
- Compatibility ship-port
- Restrictions for specific goods

Approach

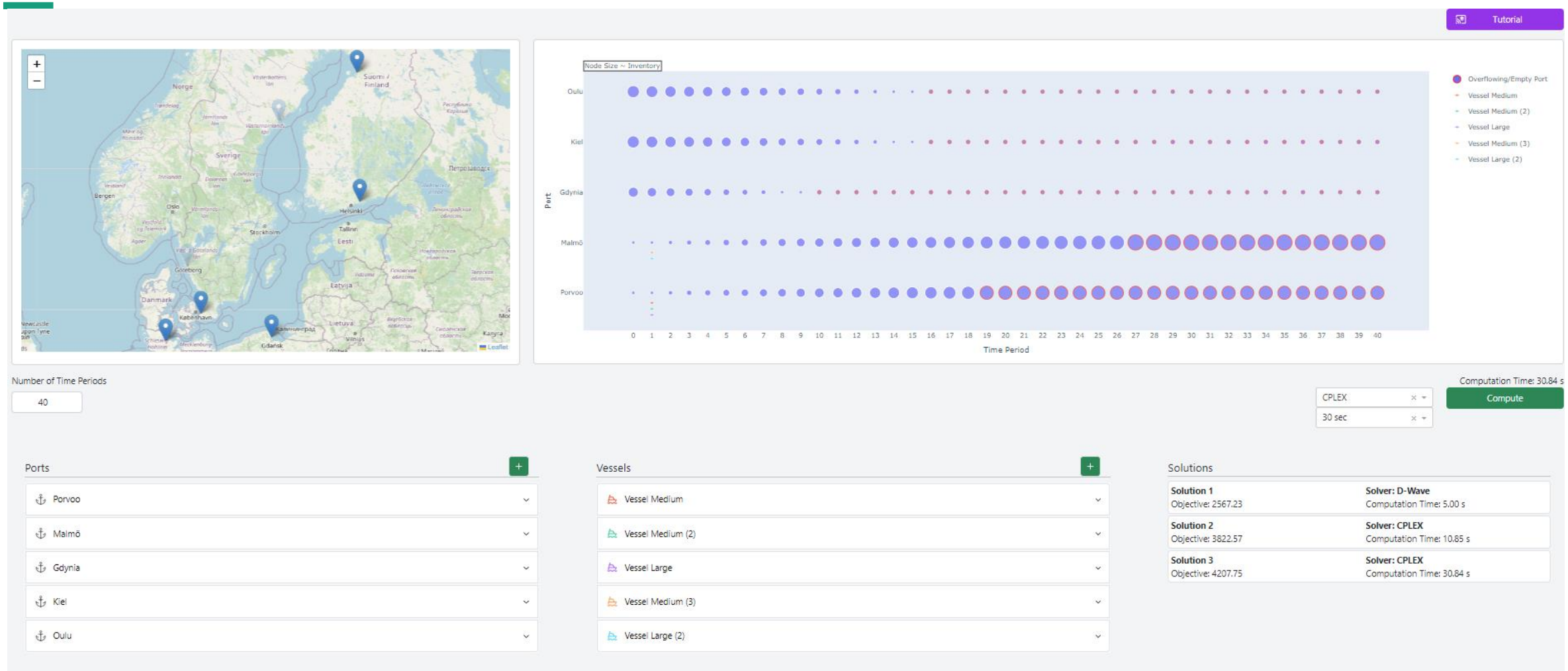
- Develop customer specific mathematical model
- Transform for CQM
- Run on generic classical and quantum solvers
- Develop specialized hybrid solver for routing
- Implement interface to enable easy DoE

Deliverable

- Formalization of the problem
- Quantum Annealing: potential and limits
- Know-How transfer

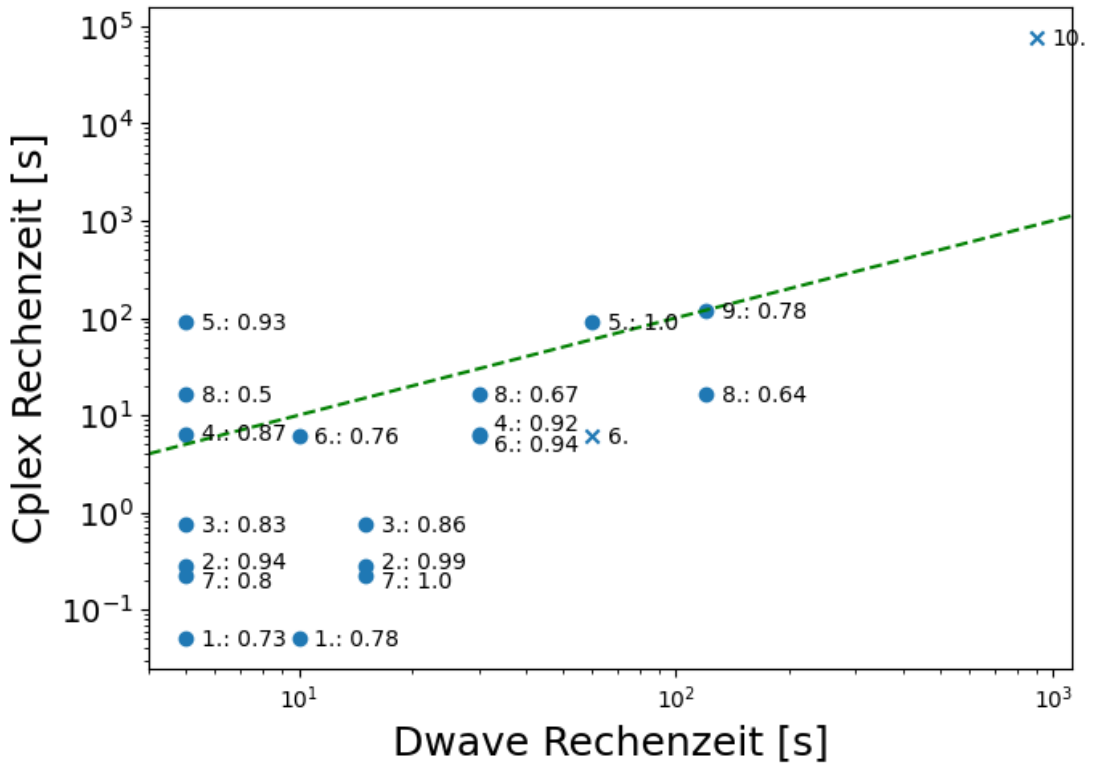
Demonstrator

Calculating different scenarios



MIRP Benchmarking on D-Wave

Work in Progress



1.	12	2	3	reduced
2.	12	3	3	reduced
3.	12	3	4	reduced
4.	12	4	4	reduced
5.	30	2	2	reduced
6.	16	7	4	normal
7.	30	2	2	normal
8.	30	3	3	normal
9.	20	7	4	normal
10.	45	7	4	normal

QC Potentials for Optimization Use Cases

Possible Approach

Problem properties

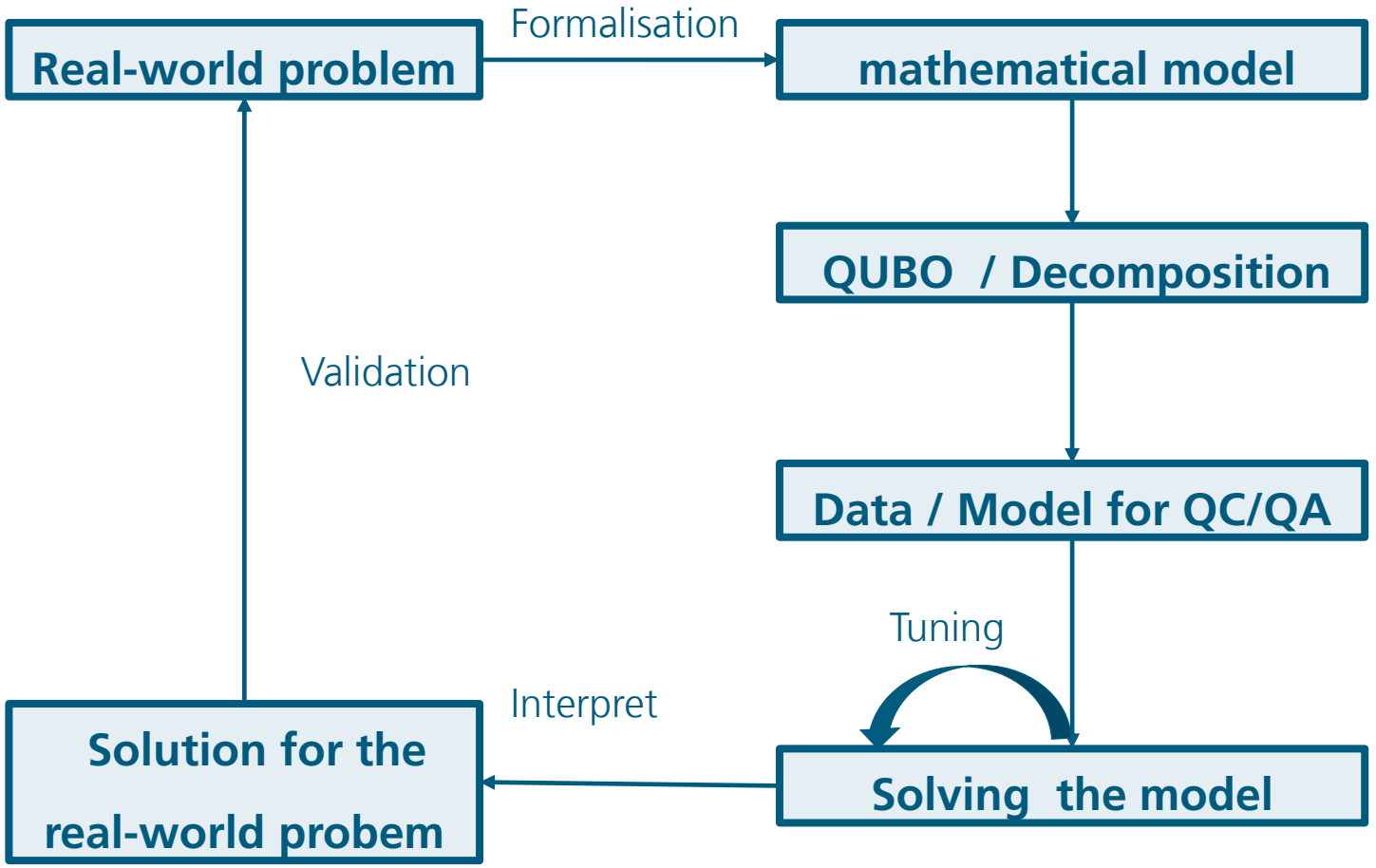
- Combinatorial nature
- Data bottleneck
- Hig automatiation potential

Approach

- First checks with a surrogate model
- Plattform independent
- Hybrid Solutions
- Deeper insights in collaboration projects

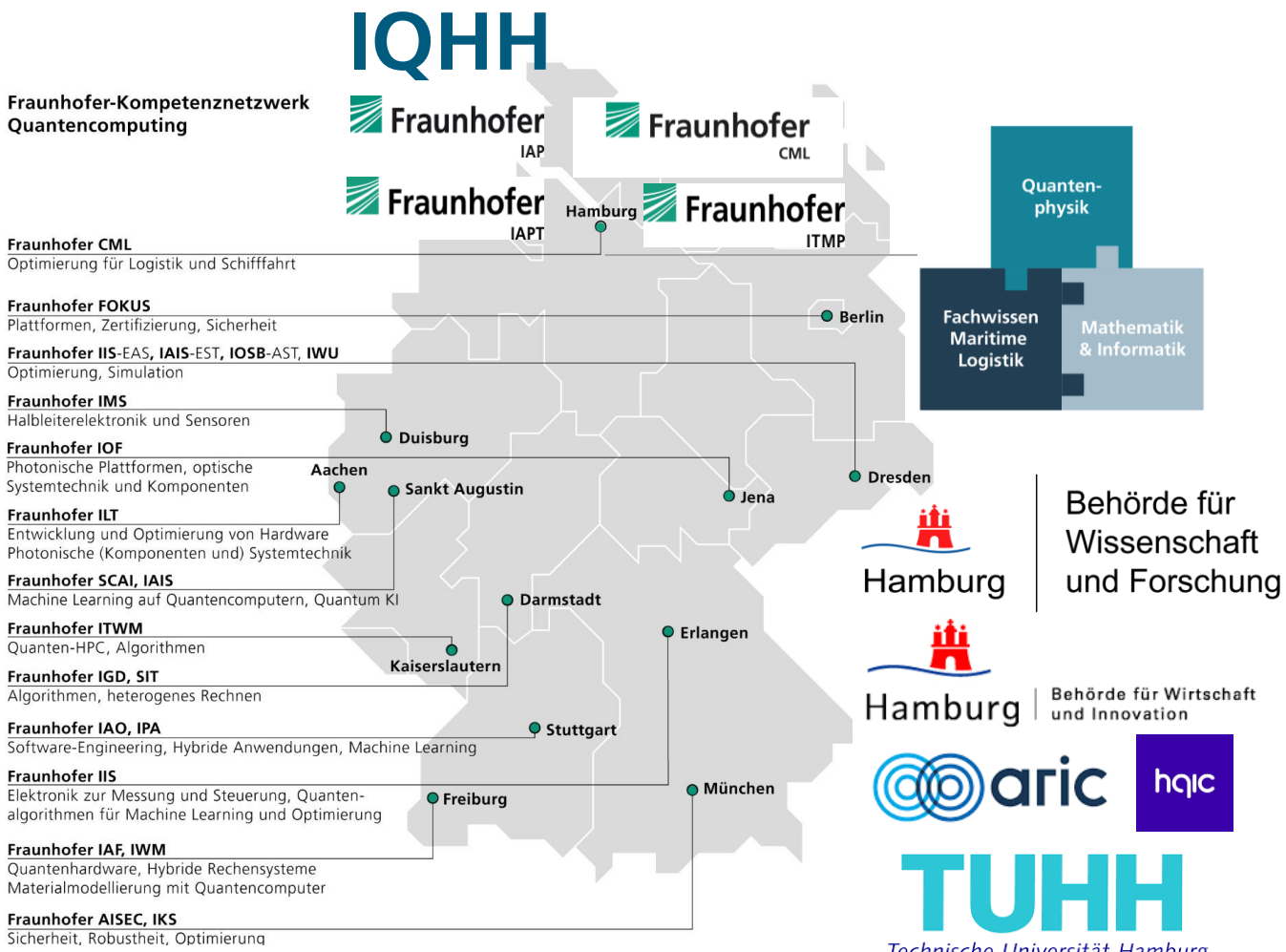
Advantages

- Automatization and Optimization
- Fast calculations of good solutions
- Know-How Transfer



Focus and Network

Exploring the potentials of quantum



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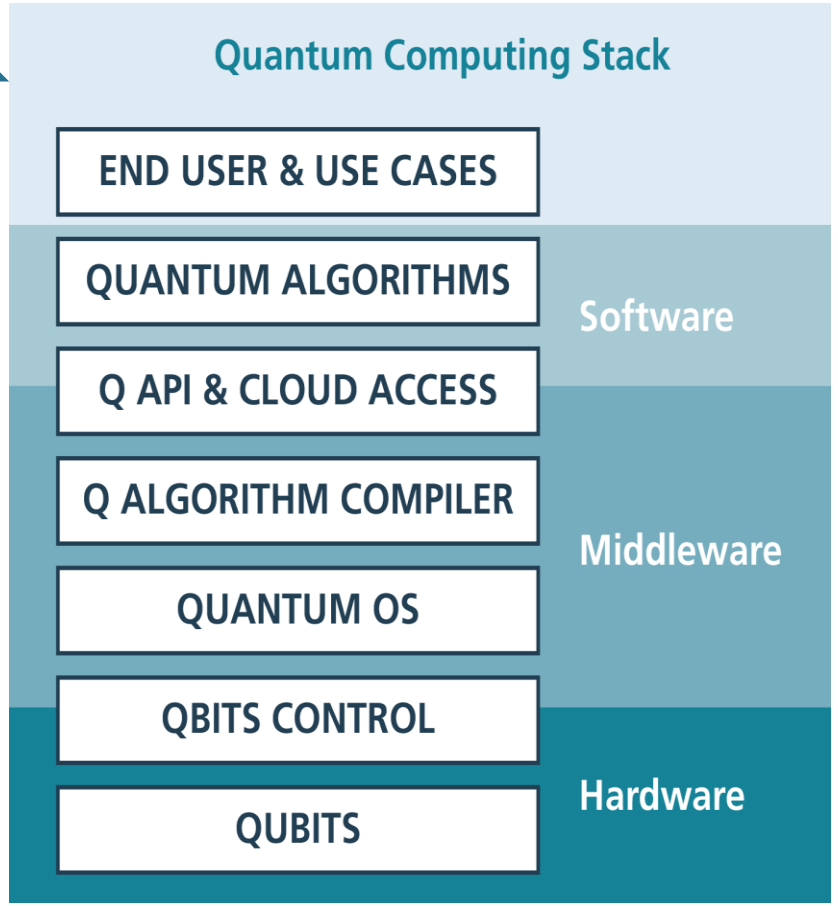

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Contact

Dr.-Ing. Anisa Rizvanolli
Team Leader
"Maritime Scientific Computing and Optimization"

+49 1515 1648120
anisa.rizvanolli@cml.fraunhofer.de