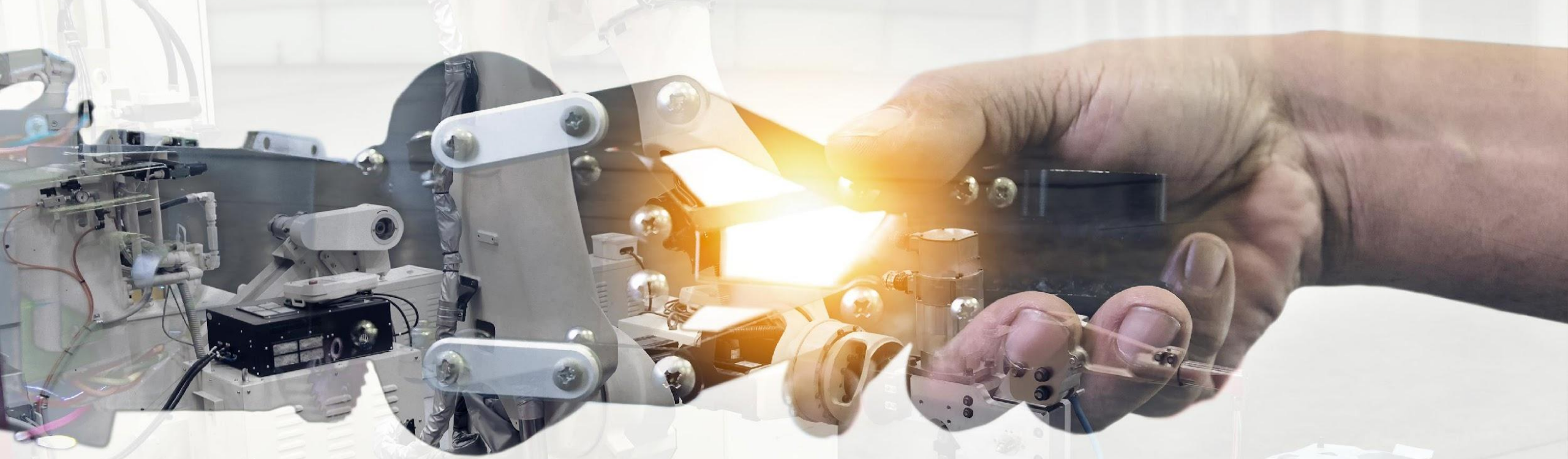

SZTAKI

Easy quantum resource access for EOSC users

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EOSC Symposium - 17.11.2022

ELKH | Eötvös Loránd Research Network

Outline

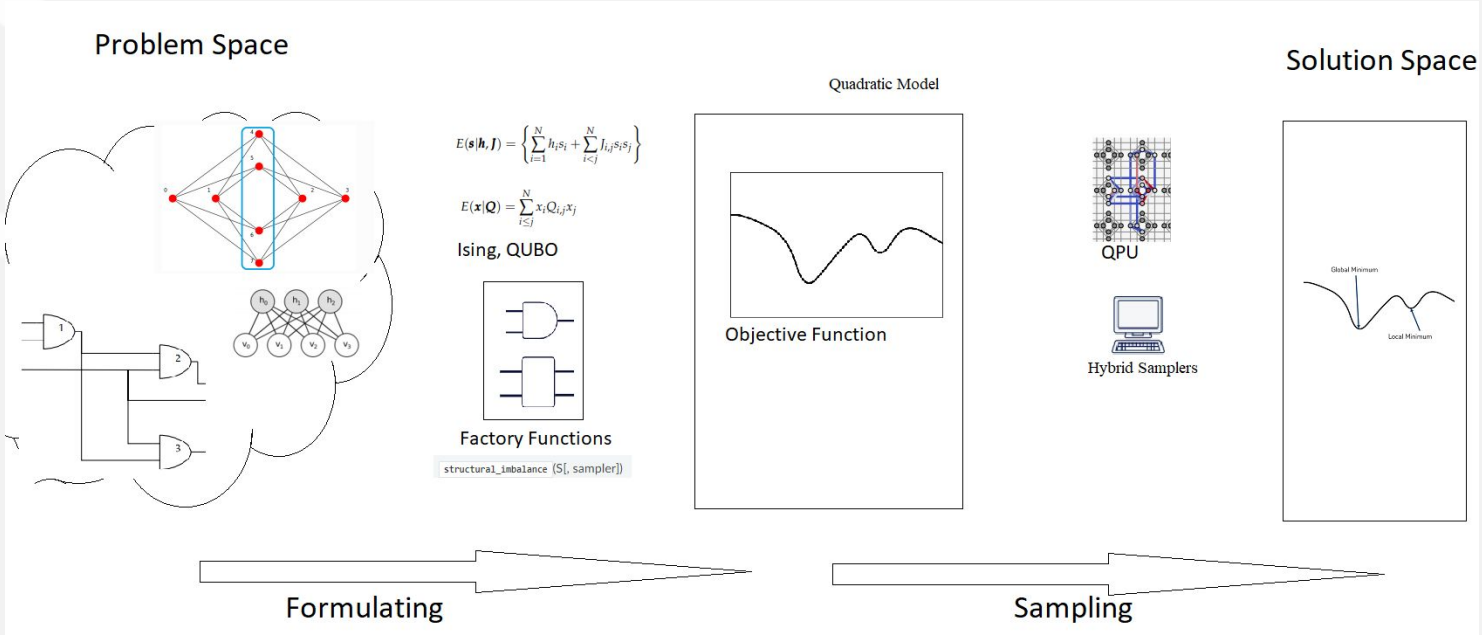
- Quantum computing problems
- Available hardware
- Programming SDKs, Frameworks
- Reference Architecture for cloud users
- EGI Notebook service integration

Quantum computing problems

- In traditional computing functions are created to perform some sort of calculation, which is translated to CPU code to alter the registers of the CPU and the content of the memory
- Quantum computing follows different paradigms:
  - Quantum annealing problem solving (e.g. D-Wave)
  - Quantum circuits, based on quantum gates (e.g. IonQ),

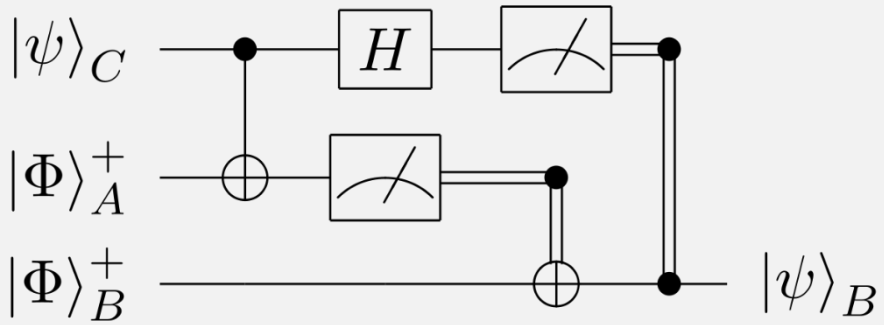
Quantum annealing: D-Wave approach

- Instead of solving a problem programmatically, we are defining an objective function for the problem in an adequate format, where the global minimum of the function represents the best solution for the problem
- Use the quantum hardware to find a global minimum for the objective function through sampling/solving
- https://docs.ocean.dwavesys.com/en/stable/overview/solving_problems.html

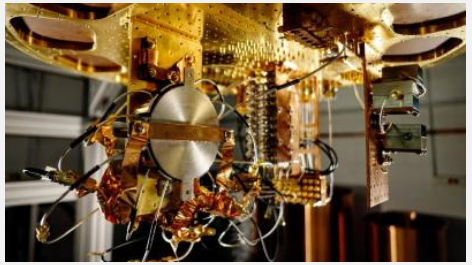


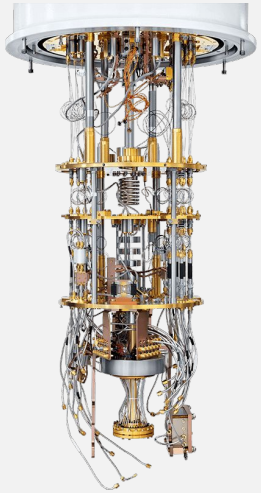
Quantum circuits

- Qiskit definition: „A quantum circuit is a computational routine consisting of coherent quantum operations on quantum data, such as qubits, and concurrent real-time classical computation. It is an ordered sequence of quantum gates, measurements and resets, all of which may be conditioned on and use data from the real-time classical computation.”



- Implementations:
  - IonQ
  - Rigetti
  - Oxford Quantum Circuits
  - IBM
  - Google





Quantum hardware providers

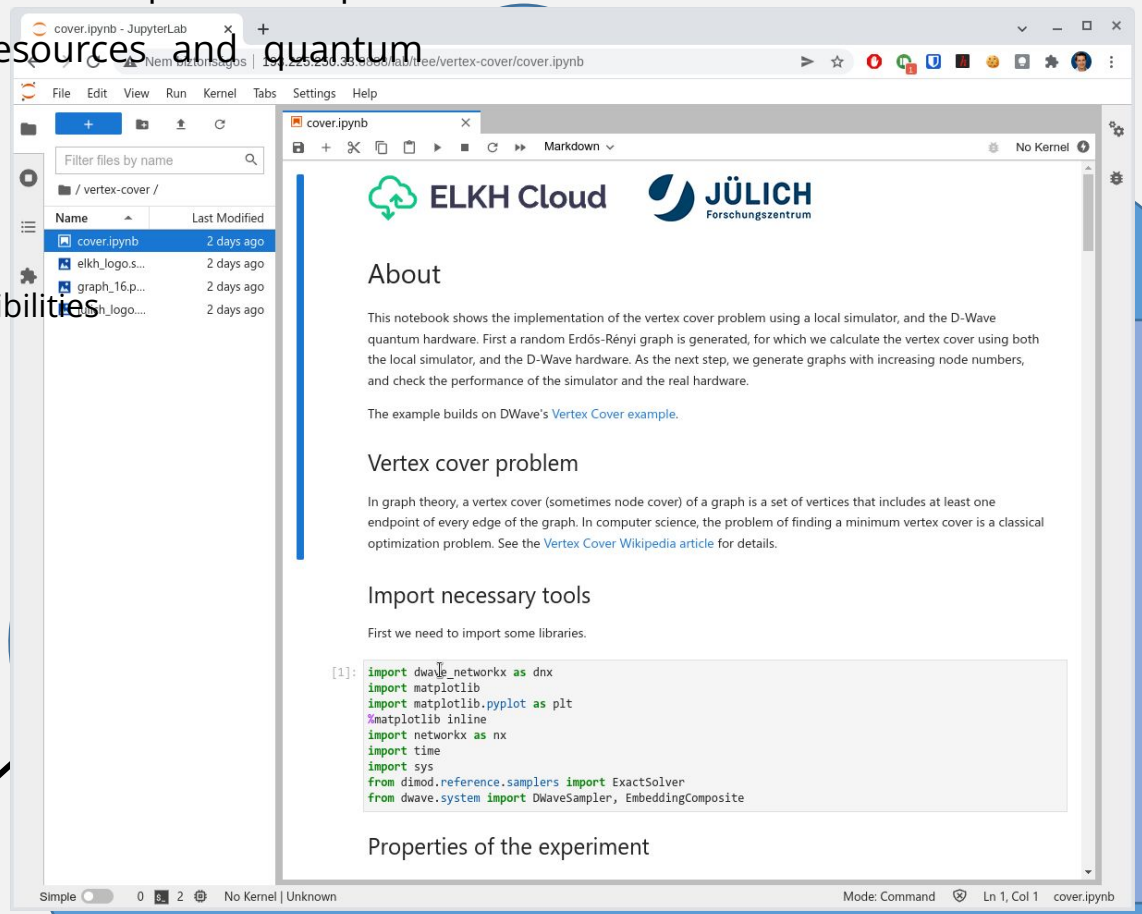
- D-Wave:
  - Annealing systems
  - Provided through D-Wave Leap
  - Simulator available
- Amazon Braket:
  - Annealing systems: D-Wave
  - Gate-based systems: IonQ, Rigetti, Oxford Quantum Circuits
  - Simulator available for gate-based systems
- IBM:
  - Gate-based systems
  - Simulator available
- Azure:
  - Gate-based systems: IonQ, Rigetti, Oxford Quantum Circuits
  - Simulator available
- Google

Programming SDKs, Frameworks

- Providers offer their SDKs for easy access:
  - D-Wave: Ocean SDK (Python)
  - Amazon: AWS Braket SDK (Python)
  - IBM: Qiskit (Python)
  - Azure: Quantum Development Kit (Q#, Qiskit, Cirq)
  - Google: Cirq (Python)
- Frameworks enabling the adaptation of quantum paradigm:
  - PennyLane: Differentiable programming, Machine learning, Quantum chemistry
  - Qiskit: Machine learning, Finance, Optimization, Nature
  - Strawberry Fields: Graph algorithms, Machine learning, Chemistry

QuickStart reference architecture for cloud users

- Aim: offer a reference architecture for cloud users which allows the quick startup for experimenting with quantum computing, using cloud resources and quantum simulators/hardware
- Implemented as a set of containers including features:
  - Jupyter Lab for easy code editing and execution
  - Apache Spark cluster for demonstration of multiple solution possibilities
  - Prepared examples
- Included SDKs, Frameworks:
  - D-Wave Ocean SDK
  - Amazon Braket SDK
  - PennyLane
  - Qiskit
- Startup possibilities:
  - Docker Compose
  - Kubernetes



Cloud

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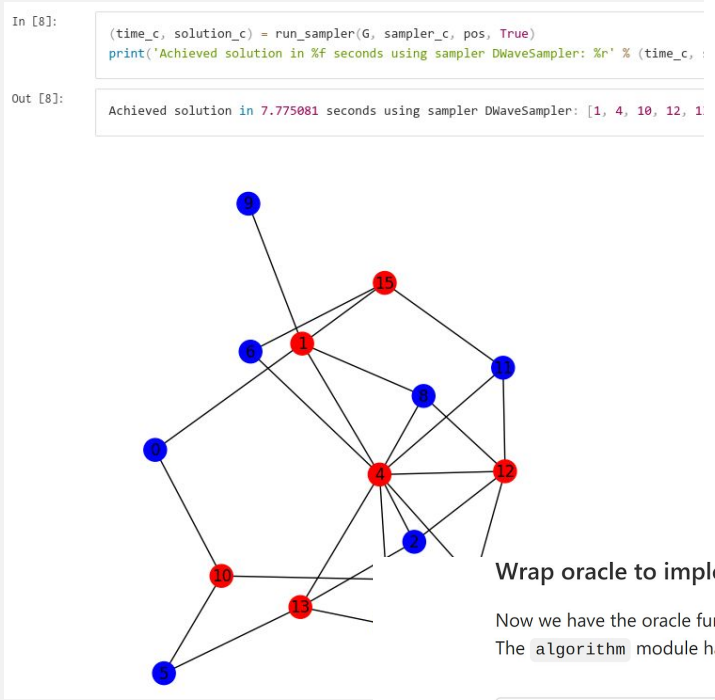
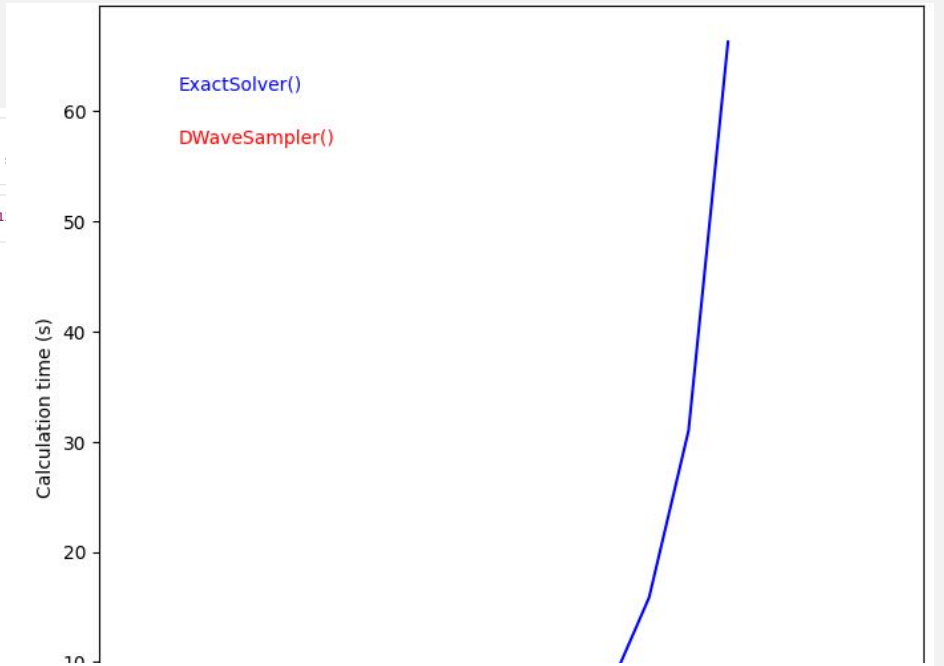
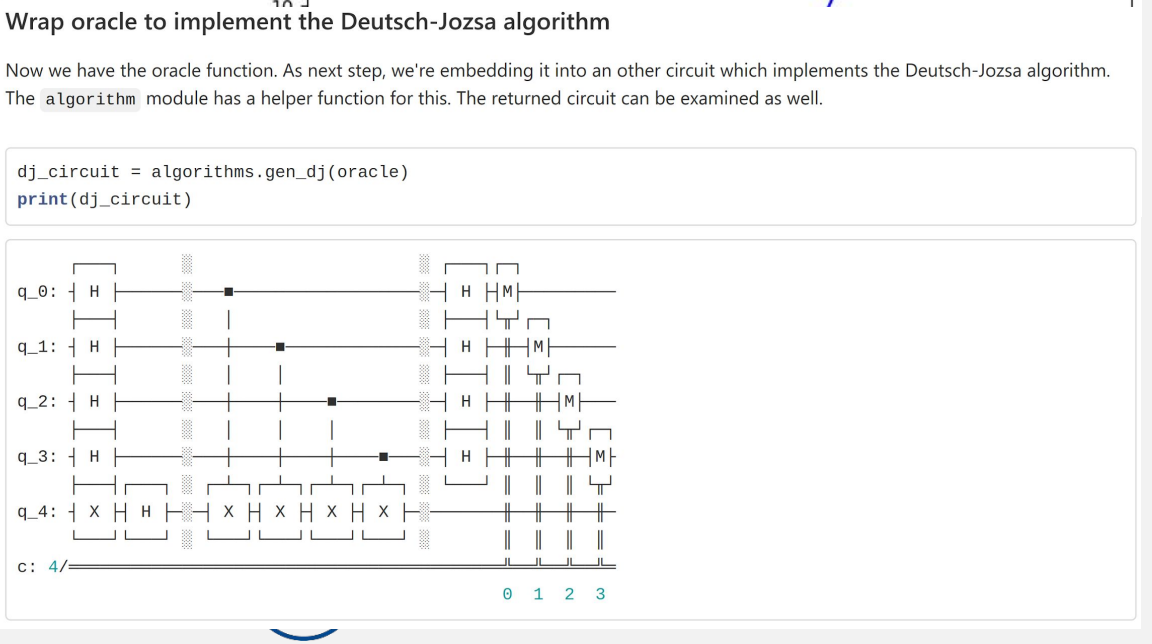
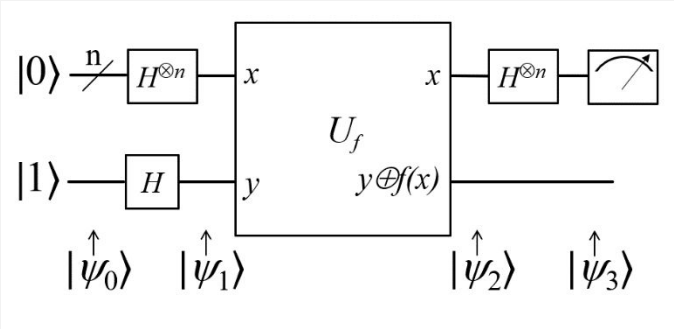
Reference Architecture examples

- A set of examples are offered
- For D-Wave resources:
  - **Minimum vertex cover**
  - Point clustering
  - EV charger placement
  - Logic gate simulation
  - Quadratic Model examples
- Using IBM Qiskit:
  - **Deutsch-Jozsa algorithm**



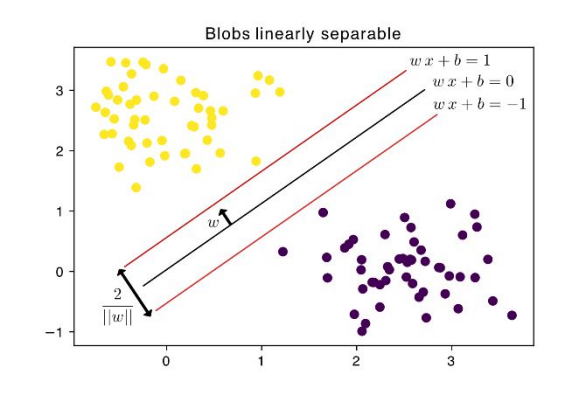






Usage, exploitation possibilities

- Offered for interested ELKH Cloud users
- Experiment with manufacturing-related problems in the CO-VERSATILE project, and Hungarian TKP NKTA programs
- Implement Quantum Support Vector Machine algorithms inside the Hungarian Artificial Intelligence National Laboratory (MILAB)



EGI Notebook service integration

- A browser-based tool for interactive analysis of data using EGI storage and compute services
- Accessible through https://notebooks.egi.eu/hub/login
- Adding quantum resource access to EGI Notebooks:
  - Ongoing work
  - SDKs and frameworks offered by the quantum reference architecture will be included
  - Examples downloaded on demand
- Results:
  - Quantum resources will be accessible for EOSC users
  - Local simulators usable right from within the Notebook server started for a user
  - External access credentials are still required to compute using real quantum hardware

Interested?

- Check out the reference architecture, try it for yourself:

  https://git.sztaki.hu/science-cloud/reference-architectures/quantum

- If you have a fitting problem, don't hesitate to contact!

- Any feedback welcome:

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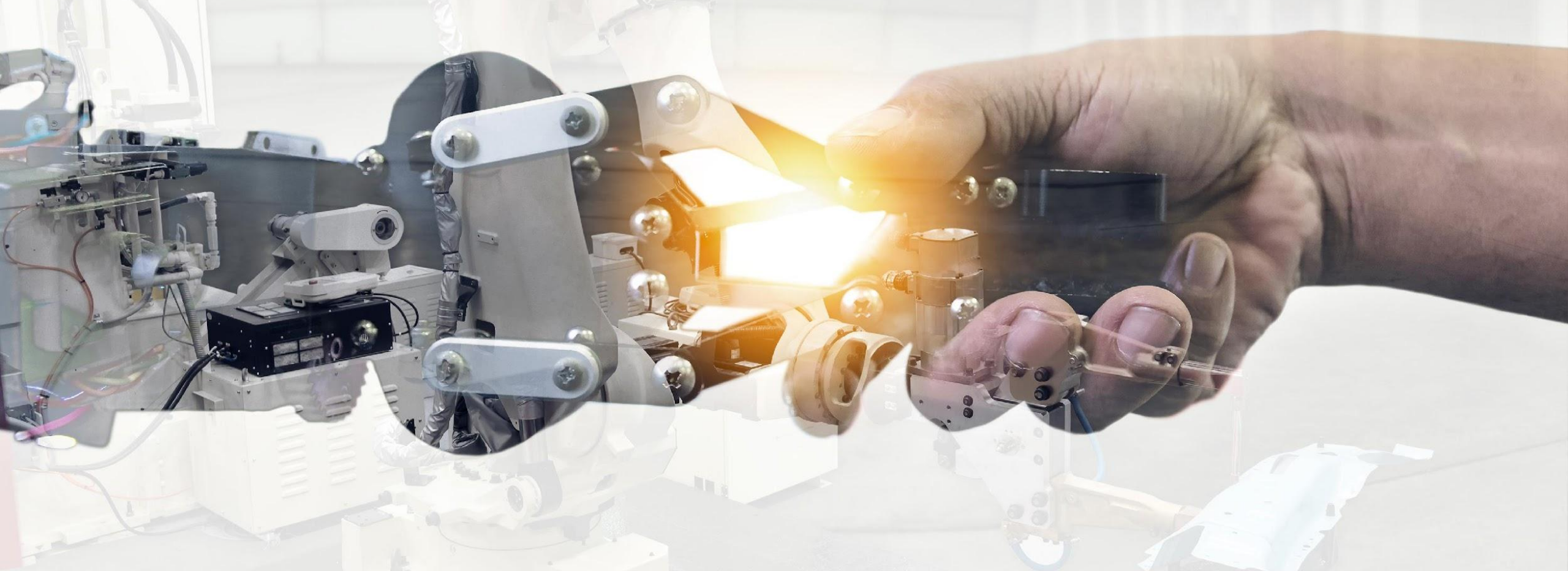

THANK YOU FOR YOUR ATTENTION!

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