The first step before a quantum leap

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Quantum computing can significantly reduce processing times. With the Quantum Computing for Shipping and Maritime Logistics project, funded by the City of Hamburg, the Fraunhofer Center for Maritime Logistics and Services CML is investigating the potential of this future technology.

Most of the real-world problems in maritime logistics – such as network optimization, load planning, weather routing, staff scheduling for medium and large fleets, as well as crane optimization, berth allocation, and how yards run – are inherently difficult to solve but highly relevant for daily port & shipping operations. In most cases, these challenges are tackled manually, which entangles the workforce in long processes that cannot deliver a solution on the fly. In addition, the final answer, though workable, doesn't necessarily have to be the best one.

Decision support systems can boost operational efficiency by providing fast – and sound, if not optimal – solutions. One of the main steps towards smooth troubleshooting is the formalization and analysis of the to-be-solved optimization problems. The next challenge lies in the development of methods that can deliver a sound solution for such complex issues – and do it naturally within a reasonable time frame.

Quantum computing promises to accelerate optimization problem-solving. To assess the possible advantages of this technology, Fraunhofer CML is formalizing relevant problems from operational practice to evaluate whether quantum computers can offer an advantage over not only pen & paper methods but also standard computers.

The travelling bulker problem

To that end, we've developed a demonstrator that presents practical use cases in the maritime sector and enables the comparison of classical and quantum solutions with one mouse click. Real-world issues are modelled as mathematical optimization problems and tailored to suit specific computing systems and algorithms. The application is user-friendly, and the solutions are clearly visualized.

Benchmarking, in which the solution performance of a quantum vs a standard computer is compared, will be more than informative in respect of the proposed goal. Fraunhofer CML is making such a comparison for the so-called maritime inventory routing problem (MIRP). Specifically, it involves efficient route planning for bulk carriers to supply different locations with limited storage capacities.

The solution to a given MIRP is a plan that includes which ship is at what port and when, whether loading slots are available, and how much cargo it loads or unloads at a port in any given unit of time – all of these parameters can be optimized. Various constraints for ports (e.g., handling

Fig. 1. Illustration of the maritime inventory routing problem

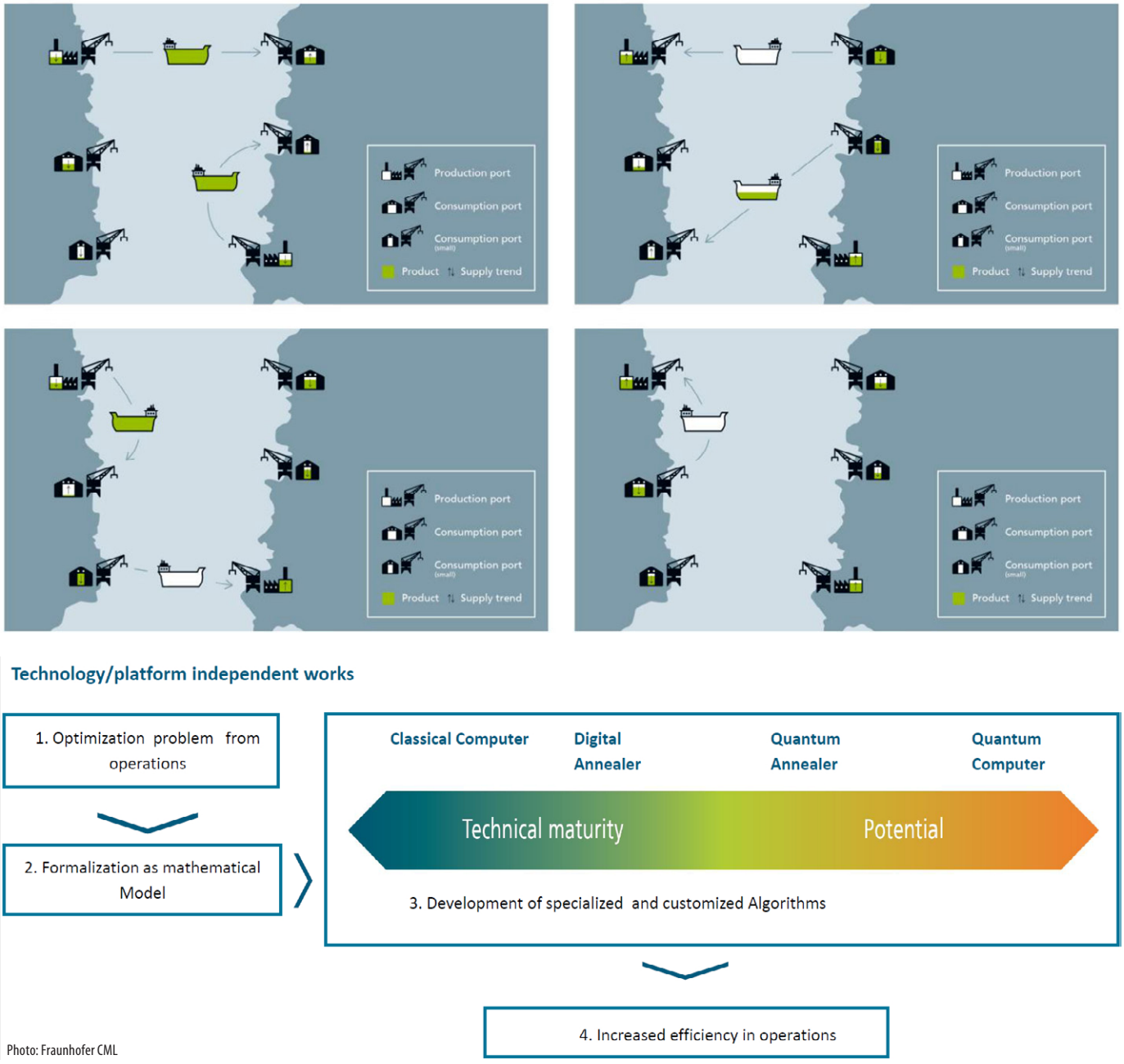


Photo: Fraunhofer CML

capacity) and compatibility requirements between ships and ports are considered. Additionally, restrictions regarding the loading can also be taken into account, e.g., when some shipments cannot be transported together on the same carrier or without a cleaning in between. The problem is characterized by a very large number of possible solutions that grows exponentially with the number of inputs (ships, time frame, ports, etc.).

Quantum annealing is used to run the calculations. This intermediate technology is currently more technologically mature than universal quantum computers. Quantum annealers are special-purpose machines that can only solve a specific class of combinatorial optimization problems. In comparison to gate-based universal quantum computers that are characterized by a small number of useful qubits, quantum annealers are more powerful, but only for particular purposes (not all kinds of problems can be mapped to fit into the requested structure of the quantum annealers).

The MIRP demonstrator is a starting point for the development of customer-specific solutions for any routing and network optimization. The Fraunhofer CML thus offers low-threshold access to quantum computers and facilitates the assessment of the potential of this technology for the maritime & shipping industries. ■

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