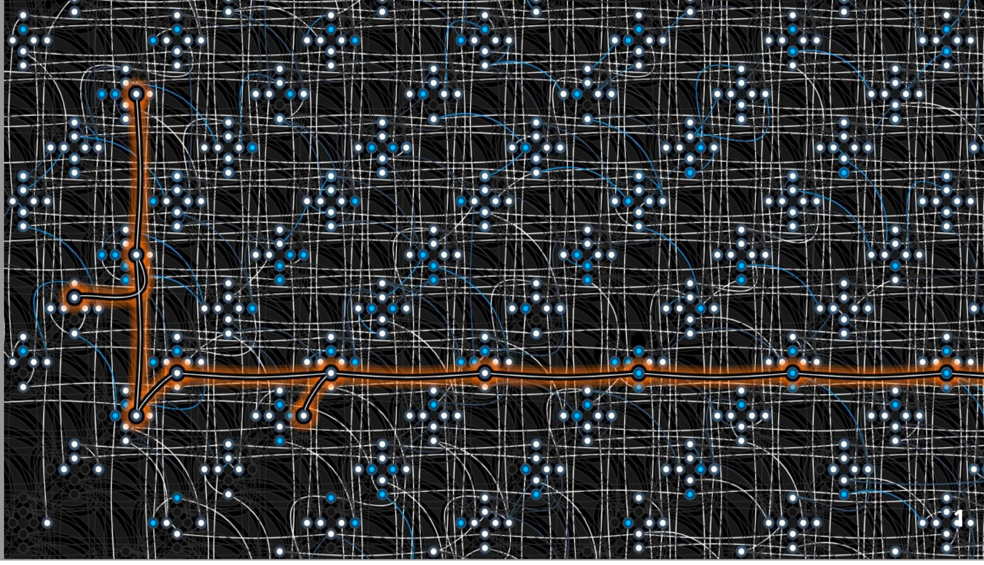

Subject to alterations in specifications and other technical information. 06/2022.

QUANTUM COMPUTING IN PHOTONICS

Task

In the field of photonics, there is a multitude of different optimization problems with a large number of degrees of freedom. According to the current state of the art, such problems can only be solved approximately by means of classical, CPU- and GPU-based optimization processes. As a result, research cannot fully exploit the potential of the underlying photonic technologies. In the future, this problem could be solved by the ongoing development of quantum computers and annealers. Especially for discrete, combinatorial optimization problems, using quantum computers and annealers promises to shorten the required runtime and to increase the quality of the obtained solution. In order for quantum computers to solve photonics problems, however, these problems have to be transformed into a special mathematical formulation (quadratic unconstrained binary optimization, QUBO).

Method

The Chair for Technology of Optical Systems (TOS), in cooperation with Fraunhofer ILT is working out the transformations and validating the resulting advantages using state-of-the-art quantum computers. In addition, it is analyzing how to scale up optimization problems on future generations of quantum computers. In the context of preliminary investigations, the institute has identified various use cases from photonics for this purpose, cases that are particularly suitable, due to their problem structure, for the use of quantum computers and annealers. These use cases are expressed in the form of a QUBO problem, solved on a D-Wave Advantage quantum annealer, and the TOS is investigating the optimization quality for different problem sizes.

Results

Scientists at TOS have verified the correct QUBO formulations for the two use cases “Combinatorial selection of catalog lenses for automated design of optical systems” and “Design of free-form optical systems” using sample problems. They were able to identify the limitations of current generation quantum annealers and to formulate resulting requirements for suitable problems (among others avoiding densely populated QUBO matrices).

Applications

The investigations presented here make it possible to systematically assess the advantages of using quantum computers in optimization problems in photonics, such as optical design and industrial laser-based manufacturing (e.g., LPBF).

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1 Topography of a quantum annealer.

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