Gesellschaft für Operations Research e.V.

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GOR-AG: Praxis der Mathematischen Optimierung
Dr. Jens Schulz
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Herewith, we invite you to the 104th meeting of the GOR working group "Real World Optimization" jointly organized with DLR. This meeting is held as a virtual event with the topic

Quantum Computing and Mathematical Optimization

The workshop takes place on March 18th & 19th, 2021 on Thursday and Friday.

The working language will be preferably English and this will be a fully virtual event.
For now, we are looking for speakers, and will open registration in January.

Note that the participation in a GOR-AG-Workshop for non-members is subject to a registration fee, unless you are a speaker or a host.

The registration will be possible from January 2020 until beginning of March 2021. The latest information on the meeting is available on the homepage of the GOR (http://www.gor-ev.de/arbeitsgruppen/praxis-der-mathematischen-optimierung).

Yours sincerely,

Jens Schulz, Julia Kallrath, Josef Kallrath (GOR AG)

Elisabeth Lobe (DLR)

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Quantum Computing and Mathematical Optimization

Specific aims

This virtual event is intended to be a forum to learn and exchange about Quantum Computing methods for Mathematical Optimization problems, and can be seen as a follow on to our working group meeting held in 2017 at DLR Braunschweig.

A computer works by manipulating bits and bytes where each can be set to either 0 or 1. In contrast, a quantum computer employs quantum bits (qubits) that can be both 0 and 1 at the same time. As it is able to contain multiple states simultaneously, it exploits an inherent parallelism which has the potential to be millions of times more powerful than today's most powerful bit-based supercomputers.
Huge investments of large companies into quantum computing show the underlying long-term hope for practical use cases. Recent advances in Adiabatic Quantum Computing and first commercial adiabatic quantum computers being able to handle 5,000 qubits, show the tremendous progress in that area. What will be the role of quantum computing technology in the upcoming years, what is the role of mathematical optimization techniques in the light of quantum computing, will hybrid approaches of these enable us to solve even larger real-world problems – possibly in real-time applications? What are the challenges ahead?

The first day of this workshop is devoted to the foundations of quantum computing and adiabatic quantum computing. It provides the basics and insights for those not yet familiar with the new technology. Day 2 covers examples from industry and research how (adiabatic) quantum computing can be used in conjunction with mathematical optimization or other techniques to solve mathematical optimization problems. We will hold open discussion forums and a plenary round table.

In talks of 25+5min, 40+5min or 50+10min duration, experts from practice and research will share their knowledge and learnings.

If you are willing to contribute a talk, please feel free to contact one of the organizers.

Jens Schulz (schulz-gor ‘at’ gmx.net)

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The following speakers are confirmed:

David E. Bernal (Carnegie Mellon University) - 45min
Modern Computational Approaches to Nonlinear Discrete Optimization

Kerstin Dächert (Fraunhofer ITWM Kaiserslautern)

Bettina Just (FH Mittelhessen)

Matthias Koch (DB Systel) & William Steadman (DB Netz AG) (30min)
Quantum optimization for the train timetable problem

Wolfgang Lechner (University Innsbruck, ParityQC)

Martin Leib (Volkswagen AG)

Elisabeth Lobe (DLR)

Tobias Stollenberg (DLR)

Marika Svensson (Jeppesen)

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Speaker

David E. Bernal is a Ph.D. Candidate at Carnegie Mellon University working in nonlinear discrete optimization. His research has been related to the development and implementation of algorithms to solve these optimization problems. During his Ph.D. he was awarded the Feynman Quantum Academy Fellowhip from the University Space Research Association (USRA) to work on the NASA Quantum and Artificial Intelligence Laboratory. He designed a brand new course on Quantum Integer Programming at CMU together with Prof. Sridhar Tayur and Dr. Davide Venturelli.

Matthias Koch obtained his Diploma in Physics at Freie Universität Berlin in 2009 and received his PhD in 2013 at Fritz-Haber-Institut der Max-Planck-Gesellschaft about „Growth and characterization of single molecular wires on metal surfaces". He has been PostDoc at University of New South Wales (Sydney) from 2014 onwards focused on "Process development for 3D device fabrication for scalable ph-silicon quantum computers". After 2017 he has been group leader at Fritz-Haber-Institute der Max-Planck-Gesellschaft: „Multiprobe experiments on nano-objects". In 2020, he joined DB Systel as Research Engineer in the project „Evaluating the use of quantum algorithms inside the Deutsche Bahn".

William Steadman holds a B.S in Mathematics at MIT in Cambridge, USA (2012). From 2014-2016 he worked as Algorithm Developer at Kiwigrd GmbH in Dresden where he scheduled EV charging using Viterbi algorithm and ML forecasts of photovoltaic production. From 2016-2018 he has been Data Team Co-Lead at Spire Global Inc in Boulder, USA where he developed multi-objective mixed integer model for scheduling satellite and ground-station network. Since 2020 he is Operations Research Expert at DB Netz in Berlin developing a mixed integer moving-block timetabling model and evaluating integrating quantum algorithms.

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Abstracts

Title: Modern Computational Approaches to Nonlinear Discrete Optimization

Speaker: David E. Bernal

Optimization problems arise in different areas of Process Systems Engineering (PSE), and solving these problems efficiently is essential for addressing important industrial applications.

Quantum computers have the potential to efficiently solve challenging nonlinear and combinatorial problems. However, available quantum computers cannot solve practical problems; they are limited to small sizes, and do not handle constraints well. In this talk, we propose hybrid classical-quantum algorithms to solve mixed integer nonlinear problems (MINLP) and apply decomposition strategies to break down MINLPs into Quadratic Unconstrained Binary Optimization (QUBO) subproblems that can be solved by quantum computers. We will also cover different approaches to solving Quadratic Unconstrained Binary Optimization (QUBO) problems through unconventional computation methods, including but not limited to Quantum algorithms, and discuss how these approaches lead to algorithms able to outperform classical solution approaches.

Title: “Quantum optimization for the train timetable problem”

Speaker: Matthias Koch & William Steadman

The need of optimization in railway industry is tremendous, which also reflects in the active research community. Here, we focus on timetable problems, i.e. the assignment of trains to times and routes through the track infrastructure while respecting all operational and capacity constraints. We use a path-based formulation to formulate this as a quadratic unconstrained binary optimization (QUBO) model and examine techniques to improve the problem structure for embedding on NISQ quantum devices. We will discuss upcoming plans to integrate with the dual prices from a mixed integer model or formulating the problem as a more general Ising spin glass model.