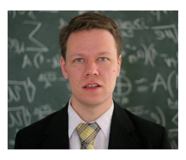
QUANTERA
ERA-NET Cofund in Quantum Technologies

QuantAlgo

Quantum Algorithms and Applications

During the 20th century, the development of information technologies had a huge impact not only on science but also on society as a whole. This unprecedented revolution revealed a need to improve the speed and efficiency of data processing, as well as to strive for better security and privacy. One ultimate limitation of current information processing models is that they assume a simplified representation of physics, relying on classical mechanics. Quantum information technologies promise to break this barrier by achieving the highest security and efficiency allowed by the laws of physics, hence leading to a new revolution in information technologies, in the form of a large-scale network of classical and quantum computing devices able to communicate and process massive amounts of data both efficiently and securely using quantum resources. Despite steady experimental progress, we are still far from this long-term vision, not only due to technological limitations but also to the still-narrow range of applications of current quantum algorithms.
The vision of this project is to combine research on the fundamentals of quantum algorithms with the development of new applications targeted at areas of extreme practical importance and timeliness such as big data and machine learning. The project will complement ongoing experimental efforts in quantum technologies by providing new software tools in order to help lead to a revolution in information technologies, harnessing the power of quantum resources to go well beyond today's capabilities, while maintaining a secure digital society.

Consortium

Institution	Country	Principal Investigator (PI)	Co-investigators
Université Libre de Bruxelles (Coordinator)	Belgium	Jérémie Roland 	Raúl Garcia-Patron Sanchez
University of Bristol	United Kingdom	Ashley Montanaro 	Richard Jozsa, Noah Linden, Sandu Popescu, Tony Short
Centrum Wiskunde & Informatica (CWI)	Netherlands	Ronald de Wolf 	Harry Buhrman, Peter Grünwald
University of Latvia	Latvia	Andris Ambainis 	Aleksandr Belovs, Juris Smotrovs
Université Paris Diderot-Paris 7	France	Miklos Santha 	Sophie Laplante, Iordanis Kerenidis, Frédéric Magniez
University of Copenhagen	Denmark	Matthias Christandl 	
Atos (Bull SAS)	France	Cyril Allouche 	Bertrand Marchand, Simon Martiel, Béatrice Michalak

Work Package 1

Techniques for quantum algorithms

One of the main challenges in quantum information is to find more applications for quantum computers, specifically new algorithms. This would further justify continuing investment into building large quantum computers. This work package aims at new quantum algorithms in several areas, optimizing them for (initially limited) quantum resources, and seeing how limited quantum resources can be aided by classical computers.

Work package Leader:

Ronald de Wolf

Work Package 2

Quantum algorithms for big data

This work package will develop quantum algorithms for tasks which occur in "big data" applications: those where the quantities of data produced are so large that traditional data processing methods are inadequate. We have identified several specific directions where there is good preliminary evidence that quantum algorithms could substantially outperform classical computing. Each models a practically relevant task in sufficient generality to enable quantum speedups that are applicable across many different problems. These are sketching, property testing, and systems of partial differential equations.

Work package Leader:

Ashley Montanaro

Work Package 3

Quantum algorithms for machine learning

Machine learning is one of the most promising applications of quantum algorithms. This area was pioneered by the HHL algorithm that in some cases can solve systems of linear equations exponentially faster than is possible classically. Since then many quantum machine learning applications have appeared, including by consortium members on efficient Recommendation Systems and Gradient Descent. Our aim is to design novel quantum algorithms for machine learning applications and analyse their performance in practice.

Work package Leader:

Cyril Allouche

Work Package 4

Quantum algorithms for interactive computation

Quantum communication has been the most successful aspect of quantum computation in terms of applications and physical implementations. We focus on aspects that have direct impact on the overarching objectives of this proposal. Communication complexity is an indispensable tool for analysing informational bottlenecks in computation (WP1 and WP3). As a transversal theme, we study channel capacities in networks, where our main goal is to establish trade-offs between noise and achievable transmission rates that are practically useful. Finally, we will study how susceptible classical cryptosystems are to quantum attacks.

Work package Leader:

Sophie Laplante