Quantum Programming and Quantum Algorithms

Overview of Quantum Computational Technologies

Quantum Computing is a new and emerging computational paradigm whose main idea is to use quantum mechanical phenomena in order to perform computation. This has resulted in some very impressive algorithms which outperform the fastest known classical algorithms. A major breakthrough was recently achieved by Google which demonstrated quantum computational advantages on existing quantum computers. The development of quantum computing technologies is rapidly accelerating and has recently benefited from major investment from technological companies with dedicated quantum research teams, such as Google, Microsoft, IBM, and many other quantum startup firms.

An important part of the development of quantum technologies is the design of a quantum software stack (quantum programming languages, compilers, etc.) that can bridge the gap between algorithms and hardware.

Description and Objectives

This internship is concerned with the design of a suitable quantum programming language and with the implementation of quantum algorithms within it. Every quantum programming language has to manipulate both classical information (e.g. booleans, integers, etc.) but also quantum information (e.g. quantum bits). The classical part of the language is the Idris programming language. Idris is a very modern (functional) programming language which introduces powerful and elegant programming constructions. We have already designed a suitable set of quantum programming libraries for Idris, called Qimaera, which are type-safe. The internship which we propose has two main objectives: (1) to further extend and/or improve our quantum programming libraries with useful features for quantum programming (e.g. synthesis and optimisation of quantum circuits, support for classical oracles, etc.); and (2) to use the (extended) libraries for the implementation of state-of-the-art quantum algorithms.

By the end of the internship, the intern will acquire new functional programming skills and knowledge of quantum technologies, both of which are becoming very desirable among technological companies.

Skills and Abilities

- *Essential:* Good programming skills. Knowledge of functional programming is a bonus.
- *Not required:* Knowledge of quantum computation is **_not_** required. We will explain the basics.

Research Lab

Lab: Loria - Inria Nancy Grand Est; Team: MOCQUA
Supervisors:
- Vladimir Zamdzhiev, email: vladimir.zamdzhiev@inria.fr
- Emmanuel Jeandel, email: emmanuel.jeandel@loria.fr

Feel free to email us if you are interested or if you have any questions regarding the internship.