Quantum Software Engineering Group

Mini-course

Quantum λ-calculus

Benoit Valiron

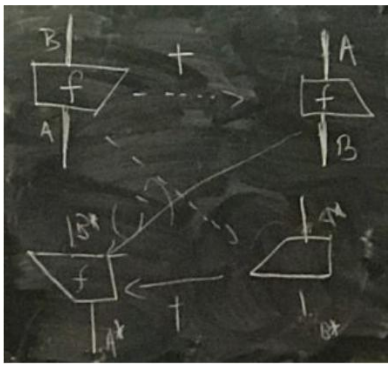
LRI - Laboratoire de Recherche en Informatique
Université Paris-Saclay

5 November 2019

10.30 - 12:30 and 14.30 - 16.30

UMinho, Room A2, Dep. Informatics, Gualtar

Organisation



The **Quantum Software Engineering Group** at INL is devoted to the development of foundations and rigorous, mathematical methods for Quantum Computer Science and Software Engineering and its application in strategic problem-areas emerging in the context, but not exclusively, of the QuantaLab partnership and the IBM Q Hub.

The group research is structured around three main topics unavoidable in any roadmap for a Software Engineering discipline meeting rigorous scientific standards: i) how quantum software systems are modelled, designed and developed; ii) how models are composed at different levels of abstraction, and finally, iii) how properties of their behaviours are anticipated, expressed and verified.

Arca — **Software Architecture & Design Calculi Group** is a research team on formal approaches to programming based on program calculi of processes, algorithms, etc. and on software quality, focusing on components, architectures, coordination, and variability.

This team is part of the HASLab group, which is a software laboratory at University of Minho associated to INESC TEC.

Abstract

In this tutorial, we shall discuss higher-order in quantum computation. First we shall briefly present the general concept of quantum computation and expose the problems arising while mixing quantum data with higher-order. We shall present the various attempts and their possible shortcomings. We will then present a lambda-calculus for quantum computation with classical control. We shall discuss its operational semantics, its expressivity and develop a type system based on linear logic, enforcing safety properties.
In a second step, we shall investigate denotational semantics of quantum higher-order based on completely positive maps. We shall consider the case of strictly linear programs (i.e. without duplication) and, as an example, discuss the interpretation of Bell's inequality in this context. We will then turn to the question of extending the semantics to support the interpretation of duplicable objects. Finally, if time permits, we shall sketch the direction taken by recent advances in quantum programming languages, with the development of circuit-description languages, and the problem of quantum control.

Benoit Valiron

Benoit Valiron is assistant professor at the engineering school CentraleSupélec. Attached to the computer science laboratory (LRI) of Université Paris Saclay in Orsay, France, his research interests include semantics of programming languages, quantum computation and formal methods. His main contributions are in the field of higher-order quantum computation. On the theoretical side, Benoit Valiron focuses on the semantics of quantum lambda-calculi, and analyzes the interplay between quantum and classical control. He is also a contributor to the practical applications of quantum computation: He is one of the main developers of the quantum programming language Quipper, and some of his recent works concern the development of quantum circuit-synthesis methods.

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