Project QAIS

A Research Workshop celebrating the

IBM Scientific Prize 2010

awarded to Alexandra Silva

HASLAB (*High Assurance Software Laboratory*)

Universidade do Minho, Dep. Informática, Braga

17 October, 2011

Venue:
DI Meeting room
Departamento de Informática
Campus de Gualtar
Universidade do Minho

Context & Objectives

This Research Workshop has a double objective. First it constitutes an opportunity to celebrate the awarding of the IBM Scientific Prize 2010 to Alexandra Silva. As an undergraduate, Alexandra studied *Mathematics and Computer Science*, a joint degree offered by the Departments of Informatics and Mathematics at Minho. At present she is a lecturer at the University of Nijmegan, Holland, and holds a post-doc research position at HASLAB, the *High-Assurance Software Laboratory* at Minho University.

A second objective is to launch QAIS, a new research project at HASLAB, recently approved by FCT, coordinated by Alexandra Silva. The project is devoted to quantitative analysis of interacting systems, its foundations and algorithms.

Schedule

11.00	**Opening** (Luís S. Barbosa, HASLAB, Universidade do Minho) **The QAIS project** (Alexandra Silva, Nijmegen University & HASLAB)
11.30	**Towards bialgebraic semantics based on quasi-final coalgebras** (Luís Monteiro, Universidade Nova de Lisboa)
12.00	**On structured Kripke frames** (Manuel A. Martins, Universidade de Aveiro)
12.30	*Lunch*
14.00	**Sound and complete axiomatization of trace semantics for probabilistic transition systems** (Ana Sokolova, University of Salzburg)
14.30	**A look at the (Linear) Algebra of probabilistic functions** (José Nuno Oliveira, HASLAB, Universidade do Minho)
15.00	**When data goes quantitative, relations follow!** (Hugo Macedo, HASLAB, Universidade do Minho)
15.30	**Some remarks on dualities connecting topology and logic** (Dirk Hoffman , Universidade de Aveiro)
16.00	**On Moessner's theorem** (Alexandra Silva, Nijmegen University & HASLAB)
16.30	**Bigraphical modelling of architectural patterns** (Alejandro Sanchez, Universidad Nacional de San Luis & HASLAB)
17.00	*Closing discussion*

ABSTRACTS

11.30 **Towards bialgebraic semantics based on quasi-final coalgebras**
(Luís Monteiro, Universidade Nova de Lisboa)

Abstract
The standard way to characterize behaviours in a coalgebraic setting is as elements of final coalgebras. Many kinds of behaviours, however, have been proposed that do not fit into this pattern. The reason is that final coalgebras are unique up to isomorphism, and so can not describe more than one kind of behaviour for any given type of systems. To deal with this problem I introduced before the notion of "quasi-final" object of a concrete category. Quasi-final objects are defined by weakening some of the requirements that final objects must satisfy in the main category by relegating them to the underlying category. Well-known kinds of behaviours in van Glabbeek's linear time – branching time spectrum, like traces, ready traces, failures and synchronization trees, have been shown to give rise to quasi-final coalgebras. In this talk I seek to extend Turi and Plotkin's bialgebraic semantics using quasi-final coalgebras instead of final coalgebras. I will present a preliminary result and discuss possible ways in which it can be generalized.

12.00 **On structured Kripke frames**
(Manuel A. Martins, Universidade de Aveiro)

Abstract
A structured Kripke frame is a Kripke frame with each node endowed with a mathematical structure (e.g. an algebra or a first-order structure). We will show how structured Kripke frames have been used to define natural semantics for first order modal logic and first-order hybrid logic. In this talk we will also discuss the notion of bisimulation between these structures. This is a joint work with Luís Barbosa and Alexandre Madeira.

14.00 **Sound and complete axiomatization of trace semantics for probabilistic transition systems**
(Ana Sokolova, University of Salzburg)

Abstract
This talk presents joint work with Alexandra Silva. We provide a sound and complete axiomatization of trace semantics for probabilistic transition systems. Our approach is coalgebraic, which opens the door to axiomatize other types of systems. In order to prove soundness and completeness, we employ determinization and show that coalgebraic traces can be recovered via determinization, a result interesting in itself. The approach is also applicable to labelled transition systems, for which we can recover the known axiomatization of trace semantics (work of Rabinovich).

14.30 **A look at the (Linear) Algebra of probabilistic functions**
(José Nuno Oliveira, HASLAB, Universidade do Minho)

Abstract
Probabilistic functions are half way between pure functions and relations. In the same way the allegory of relations offers a basis for developing the algebra of programming, so does a suitable category of matrices for developing the (linear) algebra of probabilistic functions. This talk will show how the basic combinators of functional programming extend probabilistically and how (typed) matrix algebra enables simple pointfree proofs about probabilistic functions, in which polymorphism plays its role, as one would expect. As a side effect, expressing distributions, sets and predicates as typed matrices helps in calculating basic probability theory in the pointfree style, as a number of examples will show (eg. Kolmogorov axioms, Bayes theorem, etc). A glimpse at probabilistic coalgebras and probabilistic bisimulations expressed as matrices will give a feeling of how to calculate about probabilistic automata (eg. reactive, generative). Probabilistic ana-hylomorphisms are just round the corner. Altogether, this suggests typed matrix algebra as the "natural", quantitative device able to extend, in a smooth way, concepts and theories which have been around (qualitatively) for quite some time.

15.00 **When data goes quantitative, relations follow!**
(Hugo Macedo, HASLAB, Universidade do Minho)

Abstract
The bicategory of relations (Rel) is the basis to establish the foundations of data representation and transformation. Enriching Rel over the category of matrices, obtaining matrix representations of relations as morphisms, is the gist for laying a theory of data aggregation on top of a familiar framework: linear algebra. The approach sheds light into a topic usually left to informality and adds a quantitative layer to familiar foundational data theories.

15.30 **Some remarks on dualities connecting topology and logic**
(Dirk Hoffman , Universidade de Aveiro)

Abstract
Motivated by questions in semantics of modal (propositional) logics, over the past years several duality results were established which extend the classical Priestley and Stone dualities. In this talk we will show how the Kleisli construction for monads can simplify their proof and presentation, and also lead to new(?) duality theorems.

16.00 **On Moessner's theorem**
(Alexandra Silva, Nijmegen University & HASLAB)

Abstract
Moessner's theorem describes a procedure for generating a sequence of n integer sequences that lead unexpectedly to the sequence of nth powers 1^n, 2^n, 3^n, $\ldots$. *Paasche's theorem* is a generalization of Moessner's; by varying the parameters of the procedure, one can obtain the sequence of factorials 1!, 2!, 3!, $\ldots$ or the sequence of superfactorials 1!!, 2!!, 3!!, $\ldots$. *Long's theorem* generalizes Moessner's in another direction, providing a procedure to generate the sequence $a \cdot 1^{n-1}, (a+d) \cdot 2^{n-1}, (a+2d) \cdot 3^{n-1}, \ldots$. Proofs of these results in the literature are typically based on combinatorics of binomial coefficients or calculational scans. In this note we give a short and revealing algebraic proof of a general theorem that contains Moessner's, Paasche's, and Long's as special cases. We also prove a generalization that gives new Moessner-type theorems. This is joint work with Dexter Kozen.

16.30 **Bigraphical modelling of architectural patterns**
(Alejandro Sanchez, Universidad Nacional de San Luis & HASLAB)

Abstract
Archery is a language for behavioural and structural modelling of architectural patterns supporting hierarchical composition and a type discipline. Semantics for modelling reconfiguration and constraints of architectural patterns are currently under development. Our approach is to provide a translation to bigraphical reactive systems for the structural dimension and to mCRL2 for the behavioural. We describe progress on the former.