Reductions and Causality

Jean-Jacques Lévy, INRIA

Church's lambda-calculus is a kernel language for the design of programming languages and the study of their properties. The lambda-calculus is more directly connected to functional languages (Lisp, Scheme, SML, Ocaml, Haskell), but its type theory inspired many other languages (Java, C#, F#, Scala). The lambda calculus has also many implications in mathematical logic. One of the most impressive results is the proof of the consistency of second-order arithmetic by Girard, through Howard correspondance. Another consequence is the formalization of mathematics or the verification of software and hardware in higher-order logics.

This course will follow my 2009 course on Lambda-Calculus, but does not need it as perequisite. It is more oriented toward the causality or independence of reductions steps in any calculus. It has impact in the proof of optimisation or models of weak memory models for multicore architectures (see Alglave, Maranget, Sewell, Zappa Nardelli, Boudol, Petri recent works). All classes will correspond to exercices. This course might motivate students to the theory of programming languages and to verification with formal methods.

Reductions	
Monday 10/31 13:00-14:30 FIT 1-small lecture hall	Causality and Independence in computations. Sequential vs parallel processes in functional languages. Permutations of reads-writes w.r.t (weak) memory models
Friday 11/04 13:00-14:30 FIT 1-small lecture hall	Lambda-calculus: finite developments theorem. Parallel moves. Cube lemma. Residuals of reductions. Equivalence by permutations.
Monday 11/10 13:00-14:30 FIT 1-small lecture hall	The lattice of reductions. Canonical reductions.
Redexes	
Friday 11/11 13:00-14:30 FIT 1-small lecture hall	Redexes and their history. Redex families. Generalized finite development theorem. Infinite reductions and infinite families.
Monday 11/16 13:00-14:30 FIT 1-small lecture hall	Decidability of redex families. Labeled lambda-calculi.
Friday 11/18 13:00-14:30 FIT 1-small lecture hall	Reductions and Winskel's event structures. Causality. Other calculi.

Books on the lambda-calculus:

- Barendregt, Henk; The Lambda Calculus. Its Syntax and Semantics, 1984. Elsevier, 2nd edition, 1997.
- Barendregt, Henk; Lambda calculi with types, Handbook of logic in comp. science, Oxford, 1991.
- Barendregt, Henk; Dekkers, W. J. M.; Statman, Rick; Lambda calculus with types, Perspectives in Logic, Cambridge University Press, 2011.
- Church, Alonzo; The calculi of Lambda-Conversion, Princeton University Press, 1941.
- Curry, Haskell; Feys, R.; Combinatory logic. Volume 1. North Holland. 1958.
- Hindley, Roger; Seldin, Jonathan; Introduction to Combinators and Lambda-Calculus. Cambridge University Press. 1986.
- Girard, Jean-Yves; Taylor, Paul; Lafont, Yves; Proofs and Types. Cambridge University Press, 1989.
- Lévy, J.-J., École Polytechnique, 2005, `http://moscova.inria.fr/~levy/courses/X/M1/lambda`