University of St Andrews

School of Computer Science

DISTINGUISHED LECTURE SERIES 2004/05

The Unreasonable Effectiveness of Logic

By

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2nd Year Laboratory
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Biography

Philip Wadler likes to introduce theory into practice, and practice into theory. Two examples of theory into practice: GJ, the basis for Sun's new version of Java with generics, derives from quantifiers in second-order logic. His work on XQuery marks one of the first efforts to apply mathematics to formulate an industrial standard. An example of practice into theory: Featherweight Java specifies the core of Java in less than one page of rules. He is a principal designer of the Haskell programming language, and he co-authored Introduction to Functional Programming, which has been translated into Dutch, German, and Japanese. He appears in position 67 of Citeseer's list of most-cited authors in Computer Science.

Wadler is Professor of Theoretical Computer Science at the University of Edinburgh, and holds a Royal Society-Wolfson Research Merit Fellowship. Previously, he worked or studied at Avaya Labs, Bell Labs, Glasgow, Chalmers, Oxford, CMU, Xerox Parc, and Stanford, and lectured as a guest professor in Paris, Sydney, and Copenhagen. He served as Editor in Chief of the Journal of Functional Programming, published by Cambridge University Press, and sits on the Executive Committee of the ACM Special Interest Group on Programming Languages. He has been invited to speak in Aizu, Buenos Aires, Copenhagen, Denver, Edinburgh, Florham Park, Gdansk, London, Montreal, New Delhi, Oxford, Portland, Rome, Santa Fe, Sydney, Talinn, Ullapool, Victoria, Williamstown, Yorktown Heights, and Zurich.

Programme

10.00 – 11.00 **The unreasonable effectiveness of logic**

People might be forgiven for thinking that computing is not so much a science as an industry. Ask someone to name a prominent computer scientist and you are more likely to hear the name Bill Gates than Alan Turing. In fact, computing is both a science and an industry, each stimulating the other.

Everyone knows that logic and computing have something to do with each other, but few understand the remarkable correspondence that links them. A model of logic and a model of computing, each published at the dawn of the computer era, turned out, half a century later, to coincide exactly. We will follow this correspondence through three strands of work, connecting three varieties of logic, three researchers at Edinburgh's Laboratory for the Foundations of Computer Science, and three applications to web technology.

11.00 – 11.30 ***Coffee***

11.30 – 12.30 **Call-by-value is dual to call-by-name**

The rules of classical logic may be formulated in pairs corresponding to De Morgan duals: rules about "and" are dual to rules about "or". A line of work, including that of Filinski (1989), Griffin (1990), Parigot (1992), Danos, Joinet, and Schellinx (1995), Selinger (1998,2001), and Curien and Herbelin (2000), has led to the startling conclusion that call-by-value is the de Morgan dual of call-by-name.

This lecture presents a dual calculus that corresponds to the classical sequent calculus of Gentzen (1935) in the same way that the lambda calculus of Church (1932,1940) corresponds to the intuitionistic natural deduction of Gentzen (1935). It includes crisp formulations of call-by-value and call-by-name that are obviously dual; no similar formulations appear in the literature. The paper gives a CPS translation and its inverse, and shows that the translation is both sound and complete, strengthening a result in Curien and Herbelin (2000).

14.15 – 15.15 **The Girard-Reynolds isomorphism (second edition)**

proved a Representation Theorem: every function on natural numbers that can be proved total in second-order intuitionistic predicate logic, P2, can be represented in F2. Reynolds additionally proved an Abstraction Theorem: every term in F2 satisfies a suitable notion of logical relation; and formulated a notion of parametricity satisfied by well-behaved models.

We observe that the essence of Girard's result is a projection from P2 into F2, and that the essence of Reynolds's result is an embedding of F2 into P2, and that the Reynolds embedding followed by the Girard projection is the identity. We show that the inductive naturals are exactly those values of type natural that satisfy Reynolds's notion of parametricity, and as a consequence characterize situations in which the Girard projection followed by the Reynolds embedding is also the identity.

An earlier version of this work used a logic over untyped terms. This version uses a logic over typed term, similar to ones considered by Abadi and Plotkin and Takeuti, which better clarifies the relationship between F2 and P2.