From Computing Science to Politics or From Apodictic Logic to Persuasive Logic

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LFCS30 Edinburgh 13 04 2016

HAPPY 30th ANNIVERSARY, LFCS !


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Theoretical Computer Science in Edinburgh: THE MYTH

The myth started in the late 60's and gathered momentum in the 70's. (I am still in awe to this day):

- **Rod Burstall** - a true Founding Father, just take a look at his CV;
- **Robin Milner** - an inspirational leader and true King Midas, *e.g.* Types in ML;
- **Gordon Plotkin** - a true Artist of Mathematical Sciences, from astonishing complexity to bewildering simplicity, *e.g.* "Universal Generators and the failure of the ω-rule in λ-calculus", "Strong Normalization for Dependent Types (LF)".

They were the Demiurge, the makers of the conceptual Universe of Theoretical Computer Science, introducing and advocating for:

- λ-calculus and the higher order functional paradigm whereby functions are first-class citizens: POP2 (1969);
- categories;
- computer assisted proof development: 1978 M. Gordon, R.Milner, C. Wadsworth: Edinburgh LCF: A Mechanized Logic of Computation;
- new programming and specification languages: HOPE, LCF, ML;
- crucial notions and concepts: type soundness, full abstraction, compositionality, institutions, *etc.*

My question to Gordon Plotkin: or how I was involved

- Symposium on Semantics of Data Types, July 1984, Sophia-Antipolis, France.
- Are Scott-continuous functions *adequate* for modeling λ-calculus?
- Is there an **exact** model of the pure β-theory in the Category of Domains and contionuous functions? Or are there equations which are forced upon us by Scott Topology?
  - The answer is **YES** for a conjunction of an inequality and an equality. "On the completeness of order-theoretic models of the λ-calculus" (Honsell-Plotkin I.C. 2009).
  - The conjecture is NO for pure equations. It is still unsettled to this day!
- In december 1985 I was invited for an interview in Edinburgh, which was held in early February 1986.
- In March 1986, I was hired as an RA at the LFCS (actually I think I was the first to be hired on the LFCS grants). It was a **turning point** in my life.

Why did Don ask me to speak on this occasion?

- Born in Genoa '58, therefore I am 58 years old!
- grew up in Genoa, Palermo, Malta, Trieste;
- 1980 Degree in Mathematics Pisa University;
- 1983 Perfezionamento in Matematica Scuola Normale di Pisa;
- 1983 Assistant Professor in Informatics, Torino University;
- **February 1986 - April 1988 Research Fellow at LFCS**;
- 1991 Udine University - Full Professor in Informatics;
- **October 1998 - October 1999 Visiting Professor at LFCS**;
- 2001-2008 Principal/V.C./Rector of Udine University;
- from 2008 Mayor of the city of Udine (independent, left);
- Mayors are elected by the people in Italy, stay in office for 5 yrs, and can be re-elected at most once.
- Ballots are terrible experiences!

My logical experience prior to LFCS

- Pisa 1982: **Non well-founded Set Theory** - Together with M. Forti we introduced the Antifoundation Axiom X_1, whereby extensional equality is a Maximal Fixed point. We anticipated Co-induction and bisimualtions, which we called *admissible relations*.
- Torino 1983: Semantics of Intersection Types, (related to Abramsky's Domain Theory in Logical Form).

My arrival in Utopia (Brobdingnag?) and Meeting the Utopians

- Robin Milner offerd me to stay at his place while I found an accomodation in Edinburgh. I was overwhelmed in seeing this hospitality towards such a junior person;
- Met many unbelievable people, like David Park who also stayed at the Milners and was building a music performer enhancer on a PC;
- Don Sannella, Colin Stirling, Stuart Anderson;
- Bob Harper;
- Arnon Avron ("Furio, tell me WHAT IS COMPUTER SCIENCE????");
- Ian Mason;
- Tim Griffin: The Synthesizer Generator;
- Eugenio Moggi, Tatsuya Hagino, Brian Ritchie;
- Randy Pollack: LEGO proof asssitant;
- George Cleland, Hugh Stabler, Morna Findlay, Eleanor Kerse, Monika Lekuse.

My first assignment by Robin

- R.Milner told me: "Experiment on how to put/implement a logic on a machine!" and he gave me two papers:
- R. Milner "The use of machines to assist in rigorous **proof**" *Phil. Trans. R. Soc. Lond.* A **312** 411-422 (1984);
- R. Milner "Is **Computing** Science an Experimental Science" *LFCS Inaugural Lecture 17/1/1986* ECS-LFCS-86-1
  - Is there really a distinction bewtween a "theory of how" (pragmatics) and a "theory of what" (ontology)? *Types* are an example of the latter influencing the former while, *infinite objects* are an example of the former influencing the latter;
- R.Burstall, B. Ritchie, P.Taylor, C. Jones: "Interactive Proofs Editing with the IPE" ECS-LFCS-87-88-61

The LF Logical Framework

A Framework for Defining Logics
R.Harper, F.Honsell, G.Plotkin Journal of the ACM, **40** 1, Jan. 1993, pp 143-184
An extended abstract of the paper was presented in 1987 at the LICS Conference in Cornell and, in 2007 at the ACM/IEEE LICS Symposium, LF received the **Test-of-Time Award**.

- The Judgements-as-types paradigm;
- P. Martin-Löf - Constructive Type Theory, the notion of Judgement:
  - what has been done can be done - introduction rules;
  - put your knowledge into practice - elimination rules;
- LF, a dependently Typed Lambda Calculus as a General Logic, as a Metalogic;
- LF as a decidable metalanguage for proofs;
- an implementation of LF as a computer-assisted proof development environment;
- recurrent mantras at the time: "LF is normative", "Implementing a logic form scratch is a daunting task".

LF relatives, cognates and descendants and Implementations

LF triggered a number of reactions on how to use existing theorem provers as General Logical Frameworks.

- Boyer Moore Theorem Prover;
- B.Constable: NuPRL;
- S. Feferman: Finitary inductively presented logics, in Logic Colloquium '88, pp. 191-220, North Holland, Amsterdam, 1989; reprinted in What is a Logical System? (D. S. Gabbay, ed.), Clarendon Press, Oxford (1994), 297-328;
- G. Huet, T. Coquand *et al.*: Coq;
- F. Pfenning *et al.*: Elf, CLF;
- R. Pollack: LEGO
- Coquand: Agda

De Bruijn and the Eindhoven AUTOMATH Project

- Started in the '60's this was the first project ever of machine-checking Mathematics.
- Its most remarkable result was the complete proof checking of Landau's Mathematical Analysis;
- In his first visit to Edinburgh De Bruijn, among other topics, proposed the riffle-shuffle problem. (And he showed us that it was related to the Gilbreath Principle, quasicrystals, non-periodic tilings, Mandelbrot Set, etc.)

Some philosophical issues

- What is a proof?
- What does it buy you? or "Solving Sudoku without erasers", (by the way, Rod worked on *word sum puzzles*: R.M. Burstall. A program for solving word sum puzzles. Computer Journal 12(1):4851 (1969).);
- theorem proving vs proof checking vs proof assisting;
- decidability of proofs.

The adequacy problem: trying to break the system

There are are many features/peculiarities of logics that need to be accomodated. Sometimes these are taken care of by some feature of the metalanguages itself, sometimes the task can be accomplished only indirectly. This is the issue of *deep* and *shallow* encodings of a logic. The following are problmematic:

- rules of proof (admissible rules) vs derivable rules;
- substructural Logics and (Lght) Linear Logic;
- Program Logics;
- diagrams, and proofs without words, physical analogies;
- Non apodictic arguments;

To deal uniformly with the problems arising from different *proof cultures* and hence the need for *plugging in* different systems we introduced *locked-types*: F. Honsell, L. Liquori, P. Maksimovic, I. Scagnetto *LLFP: A Logical Framework for modeling External Evidence, Side Conditions, and Proof Irrelevance using Monads.* accepted for publication Logical Methods in Computer Science, preliminary version available at http://www.dimi.uniud.it/scagnett/ LLFP_LMCS.pdf, 2016.

Must proofs be decidable objects?

- Extensions of *Fitch Prawitz Set Theory*, where proofs are acceptable only if *normalizable*.

How LFCS affected my career

- Wonderful colleagues and friends for life;
- reputation;
- methodology;
- a quality standard in research;
- learning the pervasive role of Computing Science and Informatics.

A personal Bildungsroman: my coming-to-age story.

- The goal is maturity: I quit smoking at LFCS;
- My first encounter with Workstations: 3 SUN 2's;
- My PhD course on Logics and Program Logics
- One of the exam questions I proposed to the students: Here are some decidability problems concerning Intersection Types, solve at least 2 out of 3. [Hint: one is still an open problem]
- Question with Arnon: Is every admisible rule in Implication Minimal Logic also derivable?
- Learning and playing snooker and whist, and learning to find cricket exciting;
- First Types Workshop February 1987;
- First EU project BRA;
- First co-directed PhD thesis: David Pym;
- Tuesday Lab Lunch Talks;
- Reading groups:
  - Michael Beeson *Foundations of Constructive Mathematics*, or Eugenio Moggi's Destructive Logic;
  - J.Lambeck and P.J.Scott *Introduction to Higher-Order Categorical* Logic, or Eugenio Moggi's Destructive Logic.

My fruitful sabbatical at the end of the millenium in 1999

4 papers with

- Rod Burstall: Easy Logic, rule induction, plenty of beautiful examples;
- Don Sannella: Prelogical Relations;
- Don Sannella, John Longley, Andrzej Tarlecki: Refinement Logic;
- Martin Hofmann: functor category models of Higher Order Costructive Type Theories.

How/why a Computing Scientist/Mathematician can turn into a politician?

- Love for quantitative analysis of data and skill in disaggregating it;
- Comittment to rigorous logical analysis and rational approach;
- Is this Illuminism? Epistemocracy(?);
- Love for Problem Solving.

Quantitative approach to Politics

Here are some important targets I fixed for myself:

- Covenant of Mayors 202020 - make sure that within the year 2020 your city will: reduce by 20% the CO_2 emissions from fossile fuels, increase by 20% energy supply from renewable sources, increase energy efficiency by 20% ;
- Create the appropriate number of places in nursery-schools;
- Increase by 2 yrs the Healthy Life Expectancy by the year 2020.
- Reach, by the year 2525, a mobility percentage break up of: 25% by cycle, 25% by public transport, 50% by private/shared vehicles.

Logical Approach to politics, some examples

- Make Udine become member, or signatory, of various Covenants and Networks: Healthy cities Network of World Health Organization, Mayors Adapt to Climate Change, Learning Cities Network; currently I am the president of the European Covenant for Demographic Change.
- Measure and assess indicators: *e.g.* Healthy and Active Ageing (Udine has an Old Age Index of 216, Average Age 47, *etc.*).
- Promote healthy lifestyles.
- Promote healthy city planning using GIS health maps and tools.
- Cable the city with a 50 Mbit broad band connectivity, by an optical fiber running along the sewage pipes system;
- Build co-generation and district heating systems;
- Promote participation using web-enabled complaint-intervention reporting tools.

Problem Solving Examples

- Reduce bureaucracy in the time of Recession - The New Football Stadium.
- Optic Fiber through the sewage pipes - FTTC broad band connectivity.
- Since 60% of the energy from the primary source gets wasted in producing electricity in Italy, co-generation and district heating plants need to be built.
- Build a new underground parking lot in the city centre, turning the *problem*, of minimizing the space wasted by ramps, in the *solution* by making the very *ramp* the parking lot.
- Mediate Cultural Heritage restrictions with the needs of energy efficiency - Remote control of radiators.
- Build a hands-on scientific Toy Library in place of a more expensive Science Museum.

Promoting equity in society, combating dysfunctionalities and dystopias

- Compute the Lorenz Curve, Gini Coefficient, "The Spirit Level: Why More Equal Societies Almost Always Do Better" by Richard G. Wilkinson and Kate Pickett;
- Social Inclusion - The Copernican Revolution of disability: it is a poorly designed environment which makes everyone disabled, rather than the disability of individuals which makes them ill-suited for that environment.
- Two very controvertial moral decisions I had to take:
  - Eluana Englaro - a young woman in Permanent Vegetative State was removed from the artificial life-support machine as her father asked, notwithstanding the huge political opposition;
  - two women were married officially in order to advocate for LGBT rights.

Asylum Seekers

- Call them **refugees**, **asylum seekers**, **expatriates**, **economic migrants**, in any case they are **people**;
- We are experiencing in Udine a constant flow of asylum seekers, originally form Afghanistan and Pakistan, which wanted to settle in Northern Europe, but which have been turned back because there they are considered **economic** migrants. This is not so in Italy, and each day a few dozens arrive in Udine. We are providing reasonable reception to them using former abandoned military barracks.