Report on the ICMS Workshop *Mathematical Theories of Abstraction, Substitution and Naming in Computer Science*

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1 Deviations

The only deviation from the original proposal occurred because one of our three keynote speakers, Robin Milner, had to withdraw at a late stage. Rather than find a replacement, the organisers decided to replace Milner's one-hour slot with two contributed talks, because they already had more offers of interesting talks than would fit into the programme. Milner was to have contributed to the objective of understanding the relationship between nominal/presheaf techniques and work on computational models that take sharing into account, such as term graphs and "bigraphs". However that topic was addressed in the talks by Mackie and Miculan.

2 Description

Mathematical treatments of concrete syntax (using strings, trees and directed graphs) have always been a central concern for that part of computer science to do with symbolic computation, programming language implementation and computer-aided reasoning. However, it has proved much harder to find useful theories of *abstract syntax* which address the structural properties common to all high-level semantics of formal languages—especially those properties that have to do with substituting structures for variables, delimiting the scope of names, and sharing common substructures. The workshop brought together a varied group of 38 researchers, some of whom have recently created new mathematical models for abstract syntax, substitution and naming (using various kinds of category theory, set theory and computational logic) and some of whom are building computer systems for symbolic computation and proof based on those theories.

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3 Detailed Report

3.1 Achievement of objectives

The main objective of the workshop was to bring together researchers who are applying logic, category theory and set theory to the study of the abstract syntax and semantics of computer languages and systems for symbolic computation and proof. We wished to compare various new mathematical approaches and to assess the applications of them that are being made in computer science. The following paragraphs describe some of the ways in which these objectives were met.

Category theory Two recent developments were well represented at the workshop: a mathematical theory of substitution, due to Plotkin, Fiore and Turi, founded upon the properties of various (pre)sheaf categories; and the particular model of binding and α-conversion given by the "nominal sets" model of Gabbay and Pitts. The first was very well exposed in Fiore's tutorial. The second was used in a number of the talks (by Clouston, Gabbay, Mathijssen, Staton, Schöpp and Tzevelkos). Although much of the emphasis of the work with nominal sets has been on using them to model logic and programming languages for names and binders, the category of nominal sets is in particular a sheaf category and so fits within the framework described by Fiore. Category theory, and in particular enriched category theory, provides the tools to compare and unify these developments and Hyland's talk attempted to do that. Schöpp's talk on "categories with binding structure" and part of Staton's (to do with substitution structures for nominal sets) also provided categorical analysis of the nominal sets model that may help to unify it with the Plotkin-Fiore-Turi approach. Finally, Plotkin's stimulating invited talk advocated combining the new categorical algebra of binding and substitution with a somewhat older categorical treatment of dependently typed algebra. He aims to produce second-order meta-theoretic frameworks for logics and type theories that avoid some of the computational drawbacks of the fully higher-order frameworks currently in use, for example, in the popular Twelf system of Pfenning, Harper and Schuermann (the last of whom was at the workshop).

Logic Several speakers described logical systems for specifying and reasoning about operational semantics involving binding and substitution. Two camps were evident. One (typified by Cheney's tutorial on nominal logic and the talks by Clouston, Mathijssen and Gabbay) treats names, for example names of substitutable variables, as an explicit part of the logic. The other (typified by Miller and Tiu's presentations of their higher-order logic for binding and mobility of bindings, and by Jouannaud and van Oostrom's talks about higher-order term rewriting) delegates issues of naming to a meta-level. It seems that the second camp believes the first is being inconveniently concrete, while the first camp believes that the second is side-stepping pragmatically important issues. There was lively discussion of this difference, but it is not clear that any new common ground emerged from the meeting.

Applications One reasonable way to assess the theoretical work described above is to see what software, such as programming languages and theorem-provers, it gives rise to. Such applications were well represented at the meeting. Baelde described the logic programming language Bedwyr that he, Miller and Tiu are developing. Pottier described his static proof system for the FreshML programming language that checks for impure use of fresh names. Cheney in his tutorial described the αProlog logic programming language that has arisen from nominal logic. But perhaps most impressive of all (to judge by the feedback from participants) is the "nominal datatype" package for the Isabelle/HOL theorem prover; this was described and exercise by its creators, Berghofer and Urban, in their talks.

Their work draws on the theoretical work on nominal sets and seems to be a very useful tool for formalising proofs about operational semantics that allows users to retain familiar habits and conventions concerning bound names and their freshness. Berghofer and Urban's nominal datatype package will become part of the official Isabelle software distribution and is already, somewhat surprisingly, the largest package in that distribution.

3.2 Participation

The workshop had 38 participants, 15 of whom are "early career" researchers—PhD students or post-doctoral researchers. 23 participants were from UK universities, 12 from universities in the rest of the EU, 2 from UK industrial laboratories and 1 from an Australian university. The lack of participation from North America partly reflects the meeting's limited budget and duration, but also reflects the fact that most of the recent research on the workshop's topic has been carried out in Europe. We feel that a very high quality group of participants was brought together, with an excellent mix of age and experience. This was also the view of the participants themselves, to judge from their very positive feedback on the academic value of the workshop.

During the three days the meeting lasted, there were 22 talks; two of these (by Jouannaud and Plotkin) were 60 minute keynotes, two (by Cheney and Fiore) were 90 minute tutorials, and the rest were all 30 minute talks, including eight from among our "early career" participants. The feedback from participants indicates that the tutorials and invited talks were very well received. For many participants the tutorials were one of the highlights of the workshop.

The workshop was unique in its focus: the fact that the topic was well defined clearly helped to encourage discussion and collaboration. The organisers did not try to structure discussions between participants as part of the scientific programme, but did try to facilitate them by scheduling long coffee, lunch and tea breaks. The fact that the structure of the programme allowed for discussion time helped make it a real "working" workshop instead of a "talks workshop". The feedback from the participants indicates that this worked well: the informal atmosphere encouraged free discussions and many people were actually working together during the breaks or after the talks.

3.3 Benefit to participants

One of the main goals of the workshop was to stimulate a comparison of different mathematical approaches to names and substitution. The feedback from the participants indicates that this goal was achieved, in part through the presentations during the workshop, but also through the informal discussions between participants. Several participants indicate that they have started collaborations during the workshop. One of the PhD students who spoke at the meeting reports being offered a post-doctoral position by one of the other participants.

Thanks

In conclusion, the organisers would like to thank ICMS for enabling this workshop to take place. The hard work, efficiency and unfailing helpfulness of the ICMS staff made the administrative aspects of organising the meeting almost trivial for us and we thank them all very much for that.