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# SICSA Distinguished Visitor Report

Prof. Lenore Mullin 01-14/02/2010

The following document reports on the activities and outcomes taking place and arising from the visit by SICSA Distinguished Visiting Fellow, Prof. Lenore Mullin, University at Albany, State University of New York. Prof. Mullin's visit took place during the first two weeks of February 2010 and was hosted by the University of Glasgow. Her visit was sponsored and coordinated by Dr. Paul Cockshott and his student Paul Keir.

## Overview

Lenore Mullin is a leading expert in array-based High Performance Scientific Computing. Her main contributions to the field include the development of an array formalism known as the Mathematics of Arrays (MoA), and later Conformal Computing; theoretical tools to aid in the reasoning and efficient manipulation of array-based computations. These developments have subsequently been applied through numerous collaborations involving problems from the computing, physical, and mathematical sciences.

## Array and Tensor Mini-Course

Lenore kindly agreed to provide a short course on her area of specialism; the mathematics of arrays; the psi calculus; and its application to array and tensor-based scientific computation. The course ran over three consecutive days within the Alwyn Williams Building at Glasgow University. The course was advertised through relevant mailing lists including the

useful SICSA address, [sga-admin@sicsa.ac.uk](mailto:sga-admin@sicsa.ac.uk). The course was attended by around ten people on each day, and was well delivered and received. In addition, after the suggestion of a reader at Oxford University, all three lectures were recorded on video, and will subsequently be made available to a wider audience.

## SPLS Seminar

Fortunate timing allowed the visit to coincide with the February meeting of the SPLS seminar. The meeting was hosted by Heriot Watt University, and took place at ICMS in Edinburgh. Lenore presented an overview of tensor-based scientific programming based on her recent experience as program director at the American National Science Foundation (NSF). See <http://www.macs.hw.ac.uk/~pm175/spls-02102010.shtml> for more details.

## Cakes Talk

Cakes Talks occur at 4pm on Fridays during term time, where invited speakers can present on topics relevant to computing science in an less formal setting; and with cakes. Lenore presented an engaging and personal overview of the evolution of array programming languages, from Kenneth Iverson's APL to the array languages of today. The talk was particularly interesting as Lenore was one of the original implementers of APL, and worked alongside Ken Iverson for many years.

## Research Students at Glasgow

Lenore was introduced to the Computer Vision and Graphics Group on her first Monday and gave an overview of her background which was observed to fit well within the group's objectives. Meetings and discussions were subsequently organized between Dr. Paul Siebert, Lenore, and his Ph.D. student Susanne Oehler.

Dr. Paul Cockshott's Ph.D. student, Paul Keir, whose research involves compilation of array languages for heterogeneous parallel architectures, was particularly

well-placed to take advantage of Prof. Mullin's expertise. Together they were able to validate Paul Keir's Haskell implementation of the MoA algebra; and add the Kronecker product to it. The early implementation stages of a psi-reduction compiler were also undertaken, guided by detailed and useful discussions.

### Internal Meetings

Lenore Mullin and Paul Keir met twice with Dr. John O'Donnell of the Embedded Networked and Distributed Systems (ENDS) group to discuss MoA; emerging machine abstraction methods; FPGAs; parallel models; and High Performance Computing (HPC).

Lenore and Paul Keir met with Prof. David Watt. Discussions concerned MoA; array languages and their efficient implementation; and shape inference.

Lenore also met with Dr. John Patterson.

Paul Cockshott, Lenore Mullin, and Paul Keir met frequently together throughout the two week visit.

### External Meetings

Lenore Mullin and Paul Keir met with Dr. Murray Cole of the Institute for Computing Systems Architecture at the Edinburgh Informatics Forum, University of Edinburgh. Discussion covered emerging machine abstraction methods; algorithmic skeletons; template meta-programming; and common interests in the Centre for Numerical Algorithms and Intelligent Software (NAIS).

Lenore Mullin, Paul Cockshott and Paul Keir also met in Edinburgh with Dr. Ben Leimkuhler, the director of NAIS. Topics discussed included progress on the pending written report for the 2009 National Science Foundation (NSF)/NAIS workshop on Intelligent Software. New project ideas were also discussed.

Lenore Mullin and Paul Keir also visited Heriot-Watt University, meeting with Dr. Hans-Wolfgang Loidl;

Prof. Dugald Duncan; Prof. Philip Trinder, and his student Mustafa Khalifa Aswad. Discussions covered MoA; NAIS; the HPC-GAP project; error recovery in HPC; and the SICSA Multi-core Challenge.

Lenore also met with Prof. Greg Michaelson of Heriot-Watt University.

### Outcomes

Discussions between Paul Cockshott, Lenore Mullin and Paul Keir on the subject of a compiler intermediate language supporting abstract machine descriptions were developed into a working prototype. The intention is to fuse this work with a psi-reduction compiler and develop the concept towards publication.

Lenore Mullin, Paul Cockshott, and Paul Keir are exploring collaborations with industry and addressing how our work can aid in the optimisation of languages such as Matlab and Fortran. A white paper has been prepared which will be input to a proposal with NAIS.

Lenore and Dr. Ben Leimkuhler began to collate a report on the Edinburgh 2009 NSF/NAIS workshop on Intelligent Software. This report will provide input to a further workshop. In this regard, Lenore has also subsequently met with Prof. Tony Kennedy of Edinburgh University in Washington DC.

Paul Keir's Ph.D. research field is concerned with similar issues, regarding HPC compilers, as NAIS. Following the meetings described, Paul Keir has been invited to attend their meetings.

Lenore plans to work with Suzanne and Paul S. to identify "hot spots" in their facial recognition software suitable for optimisation strategies based on MoA and psi calculus.

In summary, Prof. Mullin met and was introduced to many people affiliated to SICSA, the theme of Complex Systems Engineering, and NAIS. Her visit

greatly energized established connections within this group. Lenore enjoyed her visit immensely, and remains interested in further collaborations.