Simon Cooksey

sjc205@kent.ac.uk

Research

I study modern multi-processor computers to understand the behaviours admitted by their complex micro-architectural designs. My research has focussed particularly on so-called *weak memory behaviours*, which are exhibited on machines that allow out-of-order execution and caching.

These intricate behaviours present challenges for programmer reasoning. Formal models help to clarify precisely what is allowed, and my tools bridge the gap between mathematical formalisation and programmer intuition about computer behaviour. My tools make these formal models executable. This informs the development of the model by allowing quick refinement of definitions, and also permits a programmer to probe the behaviour of a model to grasp the precise meaning of a given program.

These models stand as cutting edge specifications for verification of concurrent programs executing on modern high-performance hardware.

MRD and MRDer *Modular Relaxed Dependencies* (MRD) is a denotational semantics for weak memory consistency in C and C++. As well as helping to define the denotation, I built an evaluation tool (MRDer) in OCaml to enable fast calculation of the semantics against a corpus of litmus tests. Further, I proved meta-theoretic properties about the semantics with respect to industry standard models of C/C++. *To appear, ESOP 2020.*

Through the looking-glass An extension of NVIDIA's PTX ISA to support mixing load and store operations that target different *views* of memory. This gives well defined semantics to programs with both, for example, constant loads and generic stores to the same address. The memory model extension was built in the relational model checking tool, Alloy. Mechanical proofs in Coq validate our extension, showing that this model is a sound and complete with respect to the existing industrial model. *Under submission for PLDI 2020.*

PrideMM PrideMM is a tool written in OCaml which provides an API for building Second Order logical formulae and uses this API to express memory models. We use cutting edge *Quantified Boolean Formulae* (QBF) solvers to efficiently simulate a new class of memory model which solve the thin-air problem. We encode the problems in a high-level second order logic giving us flexibility in problem expression. This then gets translated into a QBF model checking problem for a solver to efficiently execute. *Appears in the post-proceedings of TAPAS 2019.*

Education

The University of Kent — Canterbury
Computer Science PhD Candidate — Sept. 2016 – Present
Computer Science with a Year in Industry BSc (Hons), *First class* — Sept. 2012 – Jul. 2016

Internships & Employment

The University of Kent — Canterbury, United Kingdom
Assistant Lecturer — Sept. 2016 – Present
I participate in teaching a selection of modules. This involves content delivery in seminars and terminals, as well as marking and providing feedback on student work.

NVIDIA — Santa Clara, California
Research Intern — Jul. 2018 – Dec. 2018
As an intern at NVIDIA I extended the Memory Consistency Model for NVIDIA's virtual instruction set (PTX) to support "memory views". This enables writing well defined programs which mix generic load and store operations with specialised load and store operations for texture, surface and constant accesses.

XMOS — Bristol, United Kingdom
Development Intern — Aug. 2014 – Aug. 2015
At XMOS I built tools, libraries, and test infrastructure for the xCORE series of multi-core processors.

Skills

- **OCaml.** Using OCaml to implement mathematical artefacts for mechanised evaluation.
- **C/C++ concurrency semantics.** Constructing concurrency semantics for the C family of programming languages.
- **Formal Hardware Specification.** Using internal hardware specificaitons and design manuals to capture a mathematical abstraction of machine behaviour, using *Alloy*.
- **Proof assistants.** Mechanical proof of model meta-theory, used to validate mathematical design choices.

References

Dr. Mark Batty
SW109 Cornwallis
The University of Kent
Canterbury
CT2 7NF
United Kingdom

Dr. Daniel Lustig
NVIDIA
2 Technology Park Drive
Floor 3
Westford, MA 01886
United States of America

Dr. Henk Muller
XMOS Ltd.
33-35 Queen Square
Bristol
BS1 4LU
United Kingdom

Publications

- *Modular Relaxed Dependencies in Weak Memory Concurrency*: To appear at the 29th European Symposium on Programming, 2020. *Marco Paviotti, Simon Cooksey, Anouk Paradis, Daniel Wright, Scott Owens, Mark Batty*
- *P1780 Modular Relaxed Dependencies: A new approach to the Out-Of-Thin-Air Problem*: ISO C/C++ Standards Committee meeting, Cologne, 2019. *Mark Batty, Simon Cooksey, Scott Owens, Anouk Paradis, Marco Paviotti, Daniel Wright*
- *PrideMM: Second Order Model Checking for Memory Consistency Models*: 10th Workshop on Tools for Automatic Program Analysis, 2019. *Simon Cooksey, Sarah Harris, Mark Batty, Radu Grigore, and Mikoláš Janota*

Conference Attendance

- **ISO C++ Standards Committee**: Demonstrating a compositional semantics for C/C++ concurrency which avoids the out-of-thin-air problem to the C++ standards committee.
  - Cologne, 2019
  - Belfast, 2019
- **Aarhus Concurrency Workshop**: Explained the issues surrounding simulating the latest memory models and presented an early version of PrideMM.
- **PLMW / POPL 2017**: Attended the Programming Languages Mentoring Workshop at POPL'17 in Paris with a grant from the ACM.