

CoCo: Communication-Based Computation

Revised plan and budget for SICSA-funded activity

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Computation increasingly depends on communication: in distributed systems, in the cloud, in multi-threaded applications, in mobile applications, in parallel supercomputers, and within many-core architectures. The rise of communication-based computation is presenting new challenges for: programming languages and abstractions for parallelism and communication; compilation techniques; computer architecture; algorithm design; software engineering; testing and verification. While there is a great deal of activity within SICSA in many of these areas, we do not have a coherent, unified approach to the whole field. SICSA funding for meetings on Communication-Based Computation will enable us to bring together researchers with different perspectives, for mutual benefit and potential new collaboration.

The proposers, Prof. Wadler and Dr Gay, are internationally leading researchers in programming languages and have an excellent record of organising and coordinating activities in the research community. Through their recently-awarded EPSRC Programme Grant, and COST Action (European research network) IC1201, they are highly active in the emerging field of communication-based computation. Their SICSA colleagues, listed below as participants, include recognised research leaders in all aspects of parallel and distributed computing, programming languages, and computer architecture.

1 Participants (faculty members) *and expertise*

- Prof. Philip Wadler, University of Edinburgh *programming languages, web programming*
- Dr Simon Gay, University of Glasgow *programming languages for structured communication*
- Dr Murray Cole, University of Edinburgh *structured parallel programming for portability*
- Dr Christophe Dubach, University of Edinburgh *energy-efficient computing*
- Prof. Kevin Hammond, University of St Andrews *parallel programming, performance analysis*
- Dr Ekaterina Komendantskaya, University of Dundee *parallel logic programming*
- Dr Hugh Leather, University of Edinburgh *compiler optimisation, parallelisation*
- Dr Hans-Wolfgang Loidl, Heriot-Watt University *high-level parallel programming, symbolic computation*
- Dr Conor McBride, University of Strathclyde *languages for parametric programming*
- Prof. Greg Michaelson, Heriot-Watt University *programming languages, embedded systems*
- Dr Vijay Nagarajan, University of Edinburgh *architectural support for communication*
- Prof. Michael O’Boyle, University of Edinburgh *compiling for high-performance architectures*
- Dr Rik Sarkar, University of Edinburgh *algorithms, distributed computation, sensor networks*
- Prof. Sven-Bodo Scholz, Heriot-Watt University *programming languages, compiler technology*
- Dr Jeremy Singer, University of Glasgow *programming languages, anyscale computing*
- Dr Ian Stark, University of Edinburgh *programming languages, security*
- Prof. Phil Trinder, University of Glasgow *parallel and distributed programming languages*
- Dr Wim Vanderbauwhede, University of Glasgow *many-core architectures and programming*

2 Current funded projects

- EPSRC (Programme Grant): *From Data Types to Session Types: A Basis for Concurrency and Distribution* Wadler, Gay; also Imperial College London
- EPSRC (SADEA): *AnyScale Applications* Singer, Sventek, Nagarajan, O’Boyle; also Manchester
- EPSRC (SADEA): *Adaptive Just-In-Time Parallelisation* Trinder
- EPSRC (SADEA): *Abstraction-Level Energy Accounting and Optimisation in Many-core Programming Languages* O’Boyle, Leather; also Queen’s University Belfast
- EPSRC (SADEA): *Exploiting Parallelism through Type Transformations for Hybrid Manycore Systems* Vanderbauwhede, Gay, Scholz; also Imperial College London
- EPSRC: *HPC-GAP: High Performance Computational Algebra and Discrete Mathematics* Hammond, Trinder, Loidl; also Aberdeen, Edinburgh Parallel Computing Centre
- EPSRC: *Rathlin: Programmable embedded platforms for remote and compute intensive image processing applications* Michaelson; also Queen’s University Belfast
- EPSRC: *Centre for Numerical Algorithms and Intelligent Software* Cole, Nagarajan, O’Boyle; also Heriot-Watt, Strathclyde

- EU FP7: *ParaPhrase (Parallel Patterns for Heterogenous Multicore Architectures)* Hammond; consortium of 7 academic and 3 industrial organisations
- EU FP7: *ADVANCE (Asynchronous and Dynamic Virtualisation through performance ANalysis to support Concurrency Engineering)* Hammond, Scholz; consortium of 6 academic and 4 industrial organisations
- EU FP7: *RELEASE (A High-Level Paradigm for Reliable Large-Scale Server Software)* Trinder; consortium of 4 academic and 3 industrial organisations
- COST Action IC1201: *Behavioural Types for Reliable Large-Scale Software Systems (BETTY)* chaired by Gay; 22 countries
- COST Action IC1202: *Timing Analysis on Code-Level (TACLe)* Hammond; 17 countries

3 What will be done?

We will hold an initial one-day meeting at a suitable conference venue in Scotland. The cost, including lunch for 30 people and expenses for an invited speaker, is estimated at £1500 (based on a quote from Cameron House at Loch Lomond). An optional evening meal, not funded, will facilitate further discussion in an informal setting. Holding the meeting in a location away from our universities will enable the participants to focus exclusively on the topics of discussion. The programme of the meeting will be oriented around reaching a common understanding of key problems and working on collaborative approaches which may lead to joint publications or funding applications. Rather than spending a day giving talks, we will organise dedicated sessions that discuss and contrast the role of communication from various angles.

We will follow up with two one-day meetings based in SICSA departments, during which participants will report on ongoing collaboration resulting from the initial meeting. These meetings will be open to members of our wider research communities, as well as SICSA members. One meeting will focus on the important domain of mathematical applications, building on connections with the Centre for Numerical Algorithms and Intelligent Software and projects such as HPC-GAP. The cost of each meeting is estimated at £250 with university catering for 30 people.

Most of the expected participants have funding from grants in related areas and will be able to use that funding for travel to the meetings. The SICSA funding will be used to enable us to hold the first meeting at an external venue. We expect that some of the participants' established collaborators from outside SICSA may also attend with their own funding, and we will investigate the possibility of inviting distinguished external participants by combining their visits with university seminars or by using research grant funding.

Potential distinguished invited participants Prof. Peter Thiemann, University of Freiburg; Dr Manuel Fähndrich, Microsoft Research; Prof. Martin Hofmann, LMU Munich; Dr Tim Harris, Oracle Labs; Dr Jost Berthold, University of Copenhagen; Prof. Torsten Hoefler, ETH Zurich; Prof. Paul Kelly, Imperial College London; Prof. Keshav Pingali, University of Texas, Austin; Dr Brad Chamberlain, Cray Research; collaborators in our EPSRC, FP7 and COST projects.

4 Why now?

The increasing importance of communication-based computing is widely recognised, for example by the EPSRC MACDES (Many-core Architectures and Concurrency in Distributed and Embedded Systems) priority. This is an area in which SICSA researchers are establishing a leading position, as shown for example by the EPSRC and EU projects listed above. In EPSRC's recent SADEA (System Approaches to Distributed and Embedded Architectures) call within the MACDES topic, 4 out of the 5 funded projects involve SICSA researchers. The SICSA Multi-Core Challenge, organised by participants in this proposal, was effective in stimulating activity and collaboration in multi-core programming, and led to a special journal issue. SICSA funding will enable us to explore connections between all of our current activities and funded projects. This is less likely otherwise, as each project will have a natural tendency to focus on its own work programme.

5 Outcomes

As well as identifying opportunities for new collaboration and joint publications, we expect the following specific outcomes: (1) an extended publication containing insights gained from the meetings; (2) funding applications to EPSRC and EU Horizon 2020; (3) strengthening the leading role of SICSA departments in communication based computation; (4) a series of annual workshops.