COST Action IC1201
Behavioural Types for Reliable Large-Scale Software Systems
(BETTY)
Final Report

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1   Introduction

This report describes the activities of COST Action IC1201 (Behavioural Types for Reliable Large-Scale Software Systems) during its funded period of 26th October 2012 to 25th October 2016. Most of the information in this report can also be found on the Action's web site at `www.behavioural-types.eu`, along with the complete programmes of the meetings and workshops.

2   Membership and Participation

In the original proposal for the Action, the number of participating countries was 12. This increased to 17 by the time of the kick-off meeting, and to 22 by the end of the first year. During the second year, Argentina joined as a participating international partner country. The email list for the Action has 145 subscribers. The numbers of subscribers to the email lists for each Working Group are: WG1 (Foundations): 69; WG2 (Security): 41; WG3 (Languages): 62; WG4 (Tools & Applications): 46. Most people are members of more than one Working Group. The total number of people who attended at least one WG/MC meeting is 124. The first Training School (2014) had 35 trainees, and the second Training School (2016) had 31 trainees.

3   Working Group and Management Committee Meetings

We held combined WG/MC meetings twice per year. Each meeting included sessions for all four Working Groups. Because of the significant overlap in membership of the Working Groups, we did not run parallel sessions. In general the sessions took the form of mini-workshops for presentation and discussion of recent research. At some meetings there were sessions to discuss progress with the State-of-the-Art Reports or to discuss future research directions. Some meetings were co-located with major conferences for our community.

There was a special Working Group meeting in February 2014, which was held at the COST Office in Brussels, to work on Horizon 2020 proposals.

The list of WG/MC meetings, with dates and locations, is as follows.

- 24th March 2013, co-located with the ETAPS conference in Rome, Italy.

- 25th/26th September 2013, co-located with the SEFM conference in Madrid, Spain.

- 13th April 2014, co-located with the ETAPS conference in Grenoble, France.

- 31st August 2014, co-located with the CONCUR conference in Rome, Italy.

- 17th April 2015, co-located with the ETAPS conference in London, UK.

- 4th September 2015, co-located with the CONCUR conference in Madrid, Spain.

- 17th/18th March 2016, in Valletta, Malta.

- 6th/7th October 2016, in Lisbon, Portugal.

4 Open Workshops

We organised a series of four workshops called BEAT (Behavioural Types). The fourth workshop was combined with the International Workshop on Web Services and Formal Methods (WS-FM), which has been running for several years and involves many Action members. The dates and locations of the BEAT workshops were as follows.

- BEAT 2013: 22nd January 2013, co-located with the POPL conference in Rome, Italy.

- BEAT 2: 23rd/24th September 2014, co-located with the SEFM conference in Madrid, Spain, and with a WG/MC meeting.

- BEAT 2014: 1st Septemeber 2014, co-located with the CONCUR conference in Rome, Italy, and with a WG/MC meeting.

- WS-FM/BEAT 2015: 4th/5th September 2015, co-located with the CONCUR conference in Madrid, Spain, and with a WG/MC meeting.

Action members have also supported the PLACES workshops (Programming Language Approaches to Concurrency- and Communication-cEntric Software), which have been co-located with the ETAPS conferences since 2009. The co-location of the WG/MC meetings with the ETAPS conferences in 2013, 2014 and 2015 made it convenient for Action members to also attend PLACES. This resulted in PLACES being one of the most well-attended workshops at ETAPS.

5 State-of-the-Art Reports (SOARs)

A major goal at the beginning of the Action was for each Working Group to produce a State-of-the-Art Report covering its area. Working Groups 1, 2 and 3 produced survey articles which have been published in journals.

The situation for Working Group 4 (Tools and Applications) is different. At the beginning of the Action, there was very little work on tools and applications based on behavioural types. One of the achievements of the Action has been to encourage more research in this direction, with impressive results. As a Final Action Dissemination output, with a grant from the COST Office, we are producing a book with chapters on all of the software tools developed by Action members during the Action. This book will appear later in 2017, edited by the Action Chair and Vice-Chair. It describes the new state-of-the-art established by the Action.

The list of State-of-the-Art Reports is as follows.

1. Hans Hüttel, Ivan Lanese, Vasco T. Vasconcelos, Luís Caires, Marco Carbone, Pierre-Malo Deniélou, Dimitris Mostrous, Luca Padovani, António Ravara, Emilio Tuosto, Hugo Torres Vieira, Gianluigi Zavattaro. *Foundations of Session Types and Behavioural Contracts*. ACM Computing Surveys 49(1), 2016. doi: 10.1145/2873052

2. Massimo Bartoletti, Ilaria Castellani, Pierre-Malo Deniélou, Mariangiola Dezani-Ciancaglini, Silvia Ghilezan, Jovanka Pantovic, Jorge A. Pérez, Peter Thiemann, Bernardo Toninho, Hugo Torres Vieira. *Combining behavioural types with security analysis*. Journal of Logical and Algebraic Methods in Programming, 2015. doi:10.1016/j.jlamp.2015.09.003

3. Davide Ancona, Viviana Bono, Mario Bravetti, Giuseppe Castagna, Joana Campos, Simon J. Gay, Elena Giachino, Einar Broch Johnsen, Viviana Mascardi, Nicholas Ng, Luca Padovani, Pierre-Malo Deniélou, Nils Gesbert, Raymond Hu, Francisco Martins, Fabrizio Montesi, Rumyana Neykova, Vasco T. Vasconcelos, Nobuko Yoshida. *Behavioral Types in Programming Languages*. Foundations and Trends in Programming Languages 3(2-3):95-230, 2016. doi: 10.1561/2500000031

4. Simon J. Gay and António Ravara (editors). *Behavioural Types: from Theory to Tools*. River Publishers, 2017 (to appear).

6 Short-Term Scientific Missions (STSMs)

Participants in the Action have enthusiastically taken advantage of the funding for Short-Term Scientific Missions (STSMs). This was expected, as an established style of collaboration in our community is to make one or more short visits and follow up with online communication. Some people have undertaken more than one STSM; some people have hosted more than one STSM; some people have been both host and visitor in different STSMs; there have been some "multi-party" STSMs involving two or more simultaneous visits to the same host.

A complete list of STSMs appears on the Action website. There were 89 in total.

7 Training Schools

The Action organised two Training Schools. In each case the Action Chair, Simon Gay, was the director and there was a local organiser who was a member of the Management Committee. The Action Chair consulted the Vice-Chair and the Working Group chairs on the selection of topics and lecturers. A brief summary of each Training School follows.

The first Training School took place in Lovran, Croatia, from 30th June to 4th July 2014. Nine lecturers covered a range of topics on the theory and applications of behavioural types. There were 35 trainees, of whom 32 were funded by the Action and 3 attended at their own expense. The tutorial material has been published on the Training School website: `summerschool2014.behavioural-types.eu`.

The second Training School took place in Limassol, Cyprus, from 27th June to 1st July 2016. Seven lecturers covered a range of topics on the theory and applications of behavioural types. There were 31 trainees, of whom 30 were funded by the Action and 1 attended at her own expense. The tutorial material has been published on the Training School website: `summerschool2016.behavioural-types.eu`.

8 Funding Applications

Action members have obtained funding for national and EU projects. There is a list on the Action web site at `www.behavioural-type.eu/projects`. A total of three applications were submitted to Horizon calls in 2014, 2015 and 2016 but were not funded. Several Action members are involved in forthcoming RISE proposals.

9 Gender Balance, Early-Career Researchers, and Inclusiveness

The Action membership includes just over 20% female participants, which is slightly higher than typical faculty membership in computer science. Female members have been well represented in all of the Action activities.

Early-career researchers and PhD students have also been actively involved, participating in STSMs and presenting their research at Working Group meetings. Almost 50% of STSMs have involved early-career researchers. Almost all of the trainees at the Training Schools were early-career researchers.

The Action organised events in several inclusiveness target countries: Croatia, Cyprus, Malta and Portugal. The WG/MC meetings in other countries (France, Italy twice, Spain twice, UK) were because of our decision to co-locate the meetings with major conferences, whose locations had already been decided.

10   Publications and Other Dissemination

Action members have produced a large number of workshop, conference and journal publications. A list appears on the Action website. It is not yet complete for 2016. Publications continue to appear as research started during STSMs is completed and works its way through the publication process.

Action members have presented tutorials at conferences and summer schools. For example, Professor Nobuko Yoshida (WG3 Vice-Chair) and Professor Vasco Vasconcelos (WG1 Co-Chair) gave a tutorial at the POPL conference in January 2014. Dr Ornela Dardha lectured at the SICSA Summer School on Practical Types in St Andrews, UK, in August 2015.

Dr Davide Ancona was funded to present an overview of the Action at the ECOOP conference in June 2013.

Professor Simon Gay was an invited speaker at the workshop on Trends in Concurrency in September 2014. His lecture covered topics related to the Action, and included an overview of the work of the Action.

Professor Vasco Vasconcelos (WG1 Co-Chair) was an invited speaker at the CONCUR conference in 2014.

Dr Fabrizio Montesi (WG4 Vice-Chair) was funded to give a keynote lecture at the Workshop on Web Services and Formal Methods in September 2014. His lecture covered topics related to the Action, and included an overview of the work of the Action.

Professor Simon Gay was an invited speaker at the TYPES conference in May 2016. His lecture included an overview of the work of the Action, and helped to generate interest in behavioural types among members of the more general community in type theory.

11   Follow-on Activities

A new COST Action, EUTypes (CA15123), has been established by the community who run the TYPES conferences. The invitation to Professor Gay, the Chair of IC1201, to speak at the TYPES conference in 2016, which was also the first WG/MC meeting of CA15123, enabled him to establish contact with that Action. Several MC members from IC1201 are also involved in CA15123 as MC members. The next WG/MC meeting of CA15123 was co-located with the final meeting of IC1201, in Lisbon, Portugal in October 2016, and included a joint session. Members of IC1201 will be able to attend future meetings of CA15123 and apply for funding for STSMs.

A Dagstuhl Seminar on Theory and Applications of Behavioural Types took place from 30th January to 3rd February 2017. It was organised by Professor Simon Gay (Action Chair), Professor Nobuko Yoshida (WG3 Vice-Chair), Professor Vasco Vasconcelos (WG1 Co-Chair) and Professor Philip Wadler. The participants included many of the most active Action members, as well as researchers from neighbouring research areas. The seminar was successful and we plan to organise another one in 2018 or 2019.

The web domain `www.behavioural-types.eu` will be redeveloped as a site for the community more generally, now that the Action has finished. The current content of the web site will be archived within the new site as a record of the activities of the Action.

12   Conclusion

The Action has been successful in consolidating and expanding the European research community on behavioural types. There have been productive scientific meetings, a large number of STSMs, and many publications in international conferences and workshops. State-of-the-art reports have been produced in the areas of Working Groups 1, 2 and 3, and a book is forthcoming in the area of Working Group 4. These will be valuable resources for researchers within and outside the field. Two Training Schools introduced a total of around 60 participants to the topics of the Action, and provided them with opportunities to make professional contacts. Finally, the activities of the community are continuing, and events such as the Dagstuhl Seminar are expanding the scope to include researchers in other relevant areas.