Report on the outcomes of a Short-Term Scientific Mission[1]

Action number: CA20111

Grantee name: Andreia Mordido

Details of the STSM

Title: Algebraic Session Types

Start and end date: 30/05/2022 to 04/06/2022

Description of the work carried out during the STSM

Description of the activities carried out during the STSM. Any deviations from the initial working plan shall also be described in this section.

(max. 500 words)

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During the STSM we have drafted our proposal of algebraic session types, a theory of session types defined by means of datatype-like definitions. Inspired by the expressivity of context-free session types in the specification of communication protocols characterized by non-regular languages, but also aware of the limitations on the complexity of type equivalence, we have pursued a nominal interpretation of types. During the STSM, we have developed the type system, the metatheory and examples of protocols specified with algebraic session types.

In this work, we have extended the notion of datatypes to sessions and specified the type system for the theory of algebraic session types. We have defined a normalization function for types, that reduced type equivalence to syntactic equality and led to a polynomial-time algorithm for type equivalence – a significant enhancement over the previous doubly-exponential algorithm for context-free session types [2]. We have developed the metatheory, including an operational semantics relying on a labelled transition system governed by internal synchronization actions (as used, e.g. by Fowler et al. [4]).

We have devoted some time analysing the distinctions between algebraic session types and context-free session types (in their different variants – first-order [5], higher-order [3], polymorphic [1]). We crafted a translation of types, expressions and processes.

[1] This report is submitted by the grantee to the Action MC for approval and for claiming payment of the awarded grant. The Grant Awarding Coordinator coordinates the evaluation of this report on behalf of the Action MC and instructs the GH for payment of the Grant.

Throughout this mission we have designed several applications that take advantage of algebraic session types to define protocols in a modular, composable, way. The modularization of session types and their definition by means of datatypes promotes code reutilization, and favours an easier specification of protocol definitions, in a syntax more familiar to the programmers.

There were no deviations from the initial working plan; the visit was very fruitful and resulted in significant progress in the proposed research. The duration of the visit had to be slightly adapted due to unexpected budget restrictions: the visit took place from May 30 to June 4 because the flight ended up being more expensive than initially estimated. The return trip could not be supported by the COST Action because all the other costs in Freiburg (flight Lisbon-Frankfurt + train Frankfurt-Freiburg + hotel + meals + local transports) were already slightly more expensive than 1200 euros. In summary, the expenses "to Freiburg" and "in Freiburg" were supported by the 1200 euros budget approved by the Cost Action.

References:

[1] Bernardo Almeida, Andreia Mordido, Peter Thiemann and Vasco T. Vasconcelos. "Polymorphic Context-free Session Types". arXiv preprint arXiv:2106.06658. Submitted for publication. 2021.

[2] Bernardo Almeida, Andreia Mordido and Vasco T. Vasconcelos. "Deciding the bisimilarity of context-free session types". International Conference on Tools and Algorithms for the Construction and Analysis of Systems. Springer, Cham, 2020.

[3] Diana Costa, Andreia Mordido, Diogo Poças and Vasco T. Vasconcelos. "Higher-order context-free session types in System F". PLACES. 2022.

[4] Simon Fowler, Wen Kokke, Ornela Dardha, Sam Lindley and J. Garrett Morris. "Separating Sessions Smoothly". arXiv preprint arXiv:2105.08996. 2021.

[5] Peter Thiemann and Vasco T. Vasconcelos. "Context-free session types". Proceedings of the 21st ACM SIGPLAN International Conference on Functional Programming. 2016.

Description of the STSM main achievements and planned follow-up activities

Description and assessment of whether the STSM achieved its planned goals and expected outcomes, including specific contribution to Action objective and deliverables, or publications resulting from the STSM. Agreed plans for future follow-up collaborations shall also be described in this section.

(max. 500 words)

Grantee enters max 500 word summary here.

In this STSM we achieved our planned goals: we have successfully designed the theory of algebraic session types, developed a normalization of types that provide a polynomial-time reduction of type equivalence to syntactic equality, designed the metatheory and drafted the comparison with context-free session types.

Our work provided some contributions to several goals of the Cost Action and of WG3:

- *By endowing our theory with an extension of datatype definitions to communication protocols, we are enabling techniques for program verification to be more accessible to all stakeholders. Datatypes are greatly appreciated by programmers, so this theory will allow bringing session types closer to the programmer's interests.*

- *By significantly reducing the complexity of type equivalence (compared to counterpart types with comparable expressivity), we are lowering the computational complexity of the compiler and thus making techniques for program verification more effective.*

As result of this action, we expect the following outcomes:

- *A theory of algebraic session types endowed with an extension of datatypes to define communication protocol*
- *A polynomial-time algorithm to verify the equivalence of algebraic session types*
- *A term language and its static and semantics, as well as results of type preservation and progress.*
- *A functional programming language incorporating algebraic session types.*
- *Agda proofs for some results.*

As result of this STSM, we plan to have the following publications:

- *A paper presenting the theory of algebraic session types and its metatheory*
- *An artifact composed of a prototype language incorporating algebraic session types*
- *An artifact containing AGDA proofs for some results.*

Ongoing activities:

Currently, we are proving the main results, including preservation and progress and the complexity analysis of the algorithm for type equivalence. We are writing one article, that is expected to be submitted to POPL'23.

Future work:

In the near future, we plan to incorporate a notion of subtyping in our theory, which will enable more programs to be considered as well-typed.