

Report on the outcomes of a Short-Term Scientific Mission¹

Action number: CA20111

Grantee name: Melanie Taprogge

Details of the STSM

Title: Computer-Assisted Proof Verification for Higher-Order Automated Reasoning within the Dedukti Framework

Start and end date: 25/03/2024 to 07/04/2024

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.

The STSM was carried out to cooperate with Frédéric Blanqui on the ongoing extension of the higher order logic automated theorem prover Leo-III with the aim of adding an option to directly output proof certificates in Lambdapi syntax that can easily be verified.

Prior to the start of the STSM, a foundation for the work has already been laid: An encoding of the underlying logic as a Lambdapi theory was decided on, the inference rules used in Leo-III were encoded and proven, strategies for the encoding of different steps in the reasoning process were developed and parts of the automation of the process were implemented. The encoding of Leo-III rules only affecting substructures of clauses as well as the encoding of the specific polymorphism that Leo-III implements proved to be the major challenges.

The STSM offered the opportunity to discuss and refine the work that has already been completed and work on solutions for the encountered challenges in cooperation with Frédéric, who was able to provide valuable insight on the Lambdapi encoding of the underlying logic as well as the strategies followed to encode proofs. As a result of these discussions, better approaches for the encoding were developed and implemented during the STSM. The implementation was completely revised accordingly and work on the automation of the encoding was continued for further inference rules.

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

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.

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.

The STSM was immensely helpful in the extension of Leo-III, as the cooperation with Frédéric has led to several major improvements, the main ones being:

- The representation of polymorphisms in the theory defined to encode Leo-III reasoning was refined to accurately reflect the restrictions of the polymorphism present in Leo-III
- After discussing advantages and disadvantages of representing proofs as either lambda-terms or proof scripts, the latter were chosen instead of the terms that have been used in the preliminary work. This not only resulted in more readable output but also made it possible to take advantage of Lambdapi tactics, which facilitated the encoding of some rules significantly, especially in the case of rules operating on substructures of clauses.

The STSM and the cooperation with Frédéric have thus been an integral resource in the ongoing extension of Leo-III. Once completed, this project will contribute directly to Research Coordination Objectives 1 (Express new proof systems in the Dedukti logical framework) and 2 (Promote the output of detailed, checkable proofs from automated theorem provers) as well as deliverable D9 (Software for translating proof formats used by automated theorem provers to Dedukti). The publication of the results of the ongoing project is planned.

Frédéric will continue to be an advisor and provide insight and feedback to this project. Furthermore, The STSM made potential overlap of the challenges encountered in the Verification of HOL ATP systems and SMT solvers apparent, which might open the door to cooperations between projects with these focus points.