

Short-Term Scientific Mission Grant - APPLICATION FORM¹ -

Action number: CA20111

Applicant name: Dragana Milovancevic

Details of the STSM

Title: Termination Checking of Real-World Programs Using Term Rewriting Systems

Start and end date: 10/03/2023 to 27/03/2023

Goals of the STSM

Purpose and summary of the STSM.

(max.200 word)

The applicant will combine her work on automated equivalence checking of programming assignments with the expertise of the host on automated termination checking, equivalence checking, and term rewriting systems (TRSs).

Existing approaches to automated equivalence checking suffer from a fundamental limitation: termination checking. Approaches that omit termination checks can result in unsound equivalence proofs, leading to incorrect conclusions, which is unacceptable in practice. On the other hand, approaches that do check for termination, typically fail to do so systematically. As a result, such tools often need a large amount of user input, reducing their applicability.

To address these limitations, we propose the use of term rewriting systems as an intermediate representation for proving termination of real-world functional programs. The purpose of this STSM is to explore the applicability of TRSs and tools for automated termination checking, such as AProVE and Ctrl, on real-world functional programs, such as the ones that arise in a programming course. As a long-term goal, we plan on further integrating the outputs of this STSM into the Stainless verifier and its equivalence checker.

Working Plan

Description of the work to be carried out by the applicant.

(max.500 word)

The plan of this STSM is to explore termination checking techniques for functional programs, in order to allow sound and automated equivalence proofs of real-world examples. We split the proposed work into three main objectives:

- The applicant will study variants of TRSs, such as LTRSs and ITRSs. The applicant will translate a selection of challenging real-world Scala programs to TRSs, connecting the Scala

¹ This form is part of the application for a grant to visit a host organisation located in a different country than the country of affiliation. It is submitted to the COST Action MC via e-COST. The Grant Awarding Coordinator coordinates the evaluation on behalf of the Action MC and informs the Grant Holder of the result of the evaluation for issuing the Grant Letter.

programming language semantics to the abstract formalism of rewriting systems. In the process, the applicant will identify challenging language constructs (e.g., higher-order functions), as well as propose a strategy for an automated translation between Scala and TRSs.

- The applicant will evaluate tools for termination checking operating on TRSs, such as AProVE (for ITRSs) and Ctrl (for ITRSs and LCTRSs). The applicant will additionally compare the results of this evaluation to results of the Stainless verifier on the original Scala programs. We already tested those tools on a few representative examples and observed promising result improvements. Challenging examples may also be beneficial for future joint work on termination proving techniques.
- The applicant will identify and summarize challenges and next steps towards the automated translation between Scala and TRSs. As future work goals, we plan to build an automated translator and integrate this translation into the Stainless verifier, and, consequently, into its equivalence checker. As a reference implementation, the applicant will study the c2lctrs tool for C programs.

Expected outputs and contribution to the Action MoU objectives and deliverables.

Main expected results and their contribution to the progress towards the Action objectives (either research coordination and/or capacity building objectives) and deliverables.

(max.500 words)

The main expected results of this STSM are:

- Translations of challenging (with respect to termination checking) Scala submissions from a functional programming course, both as LCTRSs and ITRSs
- Termination checking results for Ctrl and AProVE on those examples, and comparison of the two tools on those examples, as well as comparison to the current results of the Stainless tool on the original Scala programs
- A summary of the main challenges and the next steps to automated translation between Scala and TRSs

The results of this proposal are beneficial to the applicant's doctoral project and contribute towards the aims of WG3. On a small scale, this project is key to demonstrating the practical value of the applicant's work for real-world applications in automated grading, and contributes to the applicant's thesis as the next pending milestone. On a larger scale, this project provides a rigorous and practical solution towards the overarching goal of automated grading. Furthermore, it opens doors to promising avenues of future work across disciplines such as high performance computing, code optimization, and software evolution. The expected results of this project thus directly aim at making techniques for program verification more effective and more accessible, which is among the main research coordination objectives. In terms of capacity building objectives, this proposal is only a stepping stone into a long lasting collaboration, thus creating an excellent network with lasting collaboration beyond the lifetime of the Action. In particular, we identified two crucial activities that are right next in our long term collaboration goals. First, manual translations to TRSs open doors to designing and building automated translators between Scala and TRSs. Second, future work implies connecting this work on termination checking with the existing work on equivalence checking.