

## Short-Term Scientific Mission Grant - APPLICATION FORM<sup>1</sup> -

Action number: CA20111

Applicant name: Benedikt Ahrens

### **Details of the STSM**

Title: Initial semantics for polymorphic type systems

Start and end date: 2025-01-26 to 2025-02-01

Detail of the cost in EUROS:

As reference, you can use the daily allowances by country for ITCGs (<https://europroofnet.github.io/itcg-daily-allowance/>) and the associated Excel sheet (<https://europroofnet.github.io/pages/grant.xlsx>).

- Transport (upload screen capture): EUR 228
- Hotel/day (upload screen capture): EUR 86 per night
- Food/day: EUR 50 per day

TOTAL: EUR 1348 according to the spreadsheet

### **Goals of the STSM**

Purpose and summary of the STSM.

*(max.200 word)*

During this STSM, we aim to work towards the goals of WG6.

The goal of this STSM is to develop initial semantics for polymorphic type systems. This means:

- Develop a notion of signature for polymorphic type systems
- Associate to any signature a category of models
- Identify sufficient conditions for signatures to admit an initial model
- Study the expressivity of the recursion principle stemming from initiality; in particular, what are the translations of languages that can be defined by recursion?

This STSM is a continuation of a previous STSM (February 2024).

### **Working Plan**

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

*(max.500 word)*

There are many works on initial semantics for untyped and simply-typed programming

<sup>1</sup> 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.

languages (e.g., PCF), but only a few extended abstracts without proofs for polymorphic type systems. Yet, polymorphic type systems present an important stepping stone from simply-typed to dependently-typed languages, which are the ultimate topic of WG6. The difficulty of polymorphic type systems, compared to simply-typed ones, is the varying type-level context, indicating the possibility of binding type-variables by, for instance, a type-level universal quantification (think as the type of the polymorphic identity function as forall X, X -> X). In this STSM, we will follow an initial sketch developed by Benedikt Ahrens and Thomas Lamiaux during Lamiaux's internship with Ahrens in 2022/23. Specifically, we aim to study the transfer of typed signatures and their models across a translation of types, in the style of a Grothendieck fibration. We anticipate that through this "pullback" construction, we can handle the varying type contexts which make polymorphism difficult to capture mathematically.

During a first STSM in February 2024 of Ahrens to Lafont, we developed a notion of model for System F such that the language of System F forms the initial such model. We presented our results in a talk at the WG6 meeting in Leuven in April 2024.

In the next STSM, we aim to develop a notion of signature, and the companion notion of model of a signature, for polymorphic type systems. The notion of signature should be broad enough to encompass the prime example of System F, but also extensions of System F by type and term formers. We then aim to construct, for any signature, an initial model: the syntax generated by the signature.

As in previous work with Hirschowitz and Maggesi (see below), our notion of signature should consist of a functor from a category of monads (over some base category) to a total category of modules over monads; however, this time the base category has to be chosen in a more sophisticated way, to account for variable-binding not only on the level of **terms**, but also on the level of **types**.

[Benedikt Ahrens](#), [André Hirschowitz](#), [Ambroise Lafont](#), Marco Maggesi: Presentable signatures and initial semantics. [Log. Methods Comput. Sci. 17\(2\)](#) (2021)

[Benedikt Ahrens](#), [André Hirschowitz](#), [Ambroise Lafont](#), Marco Maggesi: Reduction monads and their signatures. [Proc. ACM Program. Lang. 4\(POPL\)](#): 31:1-31:29 (2020)

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

Main expected results and their contribution to the progress towards the Action objectives (<https://europroofnet.github.io/objectives/>) and deliverables (<https://europroofnet.github.io/deliverables/>).

Working groups to which this mission contributes:

*(max.500 words)*

The goals of the STSM are in line with the objectives of WG6 "Type theory". We aim for the following results:

- A paper on initial semantics for polymorphic type systems (Deliverable: "Definition of a mathematical framework for modular reasoning about type theories and their extensions."). Specifically, we aim to submit a paper to a conference with a deadline in February.

- Possibly a computer formalization (which would go some way towards a prototype implementation, Deliverable "Prototype implementation of the mathematical framework")