Application for EuroProofNet STSM, Regensburg, 2024
Interoperability of Tableaux and Sequent Calculus Proof Systems

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Details of the STSM The applicant is Simon Guilloud, PhD student at EPFL in the group of Pr. Viktor Kunčak. The STSM will be two weeks long, from Monday 25th of March to Friday 6th of April. The applicant will visit the group of Philipp Rümmer in the University of Regensburg, and work mostly with Julie Cailler, postdoctoral researcher[1].The topic is the proof-production and interoperability of analytic tableaux and sequent calculus based proof systems for first order logic.

Goals The goals of the STSM are to facilitate interoperability between proof systems using variations of the Sequent Calculus proof system for first order logic. In particular, we aim at making it easy for ATPs based on the method of analytics tableaux (for example Princess[3], Goéland[1] to export their proof to proof assistants such as Coq, Dedukti and LISA. The primary objectives of this project include establishing standardized steps and ontologies inside TSTP for sequent-calculus and tableaux-style proofs. Subsequently, our focus will be twofold: first, making the LISA[2] proof assistant (developed by the group to which the applicant belongs) able to export and import theorems in this format and secondly using the Princess[3] theorem prover (developed by the group of Philipp Rümmer) to generate proofs in this specialized format. Finally, we hope to integrate Princess as a solver in LISA. The compatibility of these tools with the format defined earlier will also serve as a proof of usability for it.

Working Plan Our first objective is to define a standard proof format, as a specialization of TSTP, suitable for a variety of tableaux and sequent-calculus based ATPs and ITPs. Currently, it can be hard to extract proof from a TSTP file because each proof system can use different proof steps and ontologies, which may be difficult to translate to other systems. We believe that by restricting

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[1]A second STSM proposal, for Julie Cailler to visit EPFL and work on related but disjoint topics and deliverables, is also made.

our attention to a subset of systems for first order logic using closely related formalisms, we will be able to design a standard for export and import of proofs usable by a large category of systems and tools.

We will first make an analysis of existing sequent-calculus style proof formats and systems used by state-of-the art tableaux provers and tools. This will allow us to define the required steps the proof system must have, to include as many systems as possible. Beside the regular proof steps of one-sided and two-sided sequent calculus (see systems G1c and GS3 in [4]), we may have to consider additional, non-theoretically standard steps such as transformation into negation normal form, inner and outer skolemization, reordering of conjuncts and disjunct, substitution of equivalent formulas and more.

We will then implement this format in the LISA proof assistant, as a first use case. LISA's kernel is based on an extension of the traditional sequent calculus for first order logic. We expect that LISA will then be able to both export its library of theorems in this format and import theorems from tableaux-based ATPs made compatible with this format.

Finally, we will work on the proof output of the Princess theorem prove. Currently, Princess's proof production is limited, as completeness is lost when proof production is activated. We will aim at improving this, and make Princess export proofs to the format defined earlier. In the end, we hope to be able to use Princess inside LISA as a proof-producing tactic using the above proof format as intermediate.

Expected Outputs   We will mostly contribute to the objectives of WG1 "Tools for proof systems interoperability" and WG2 "Automated theorem provers". More precisely, our deliverables are the following:

1. Description of a proof format, as a subsystem of TSTP, suitable for sequent calculus and tableaux-based systems.

2. Export, import and certification of proofs in this format from and to the LISA proof assistant.

3. Extension of Princess's proof-producing capabilities.

4. Export of proofs from Princess to the above format.

5. Integration of Princess as a proof-producing tactic for users in LISA.

Those objectives will directly contribute to the MoU of EuroProofNet "Promote the output of detailed, checkable proofs from automated theorem provers."

In the professional and social domain, the applicant and their coworker expect that this STSM will help them build a professional network, establishing productive collaborations and learning from each other's (and their respective supervisors') area of expertize. Moreover, both are junior researchers, respectively PhD student and recently graduated postdoctoral researcher. Hence, this STSM proposal is in accordance with the MoU's "Bring together members of the different communities working on proofs in Europe.", "Create an excellent

and inclusive network of researchers in Europe with lasting collaboration beyond the lifetime of the Action." and "Actively support young researchers, the under-represented gender, and teams from regions with less capacity."

References

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[2] GUILLOUD, S., GAMBHIR, S., AND KUNCAK, V. LISA – A Modern Proof System. In *14th Conference on Interactive Theorem Proving* (Bialystok, 2023), Leibniz International Proceedings in Informatics, Daghstuhl, pp. 17:1–17:19.

[3] RÜMMER, P. A Constraint Sequent Calculus for First-Order Logic with Linear Integer Arithmetic. In *Logic for Programming, Artificial Intelligence, and Reasoning* (Berlin, Heidelberg, 2008), I. Cervesato, H. Veith, and A. Voronkov, Eds., Lecture Notes in Computer Science, Springer, pp. 274–289.

[4] TROELSTRA, A. S., AND SCHWICHTENBERG, H. *Basic Proof Theory*, 2 ed. Cambridge Tracts in Theoretical Computer Science. Cambridge University Press, Cambridge, 2000.