Offer #2024-07962

Post-Doctoral Research Visit F/M Source-to-Source Optimization of OCaml Programs

**Contract type**: Fixed-term contract

**Level of qualifications required**: PhD or equivalent

**Fonction**: Post-Doctoral Research Visit

**Context**

The work is conducted as part of the ANR OptiTrust project.

**Assignment**

The OCaml programming language encourages development with a high degree of modularity and abstraction. It therefore leads to higher productivity, higher code reuse, and fewer bugs. Moreover, thanks to its simple semantics, OCaml code lends itself better to formal verification.

The downside of programming at a high level of modularity and abstraction is that these aspects generally hinder code optimization. The OCaml compiler extension called "F-lambda" performs a number of inlining steps in order to facilitate further optimizations. Yet, it is guided by heuristics, and falls short of performing advanced optimizations. Besides, the C++ approach of using templates for static code specialization is associated with numerous limitations, such as complexity in the source code, blow-up in the size of the generated code and its compilation time, and issues with understandability of error messages.

We would like to devise an approach that allows programmer to explicitly guide the application of series of advanced optimizations. This approach would allow refining high-level code down to high-performance code. Concretely, each optimization would take the form of a source-to-source transformation. At each step, the programmer would get feedback in the form of human-readable code.

This approach of user-guided source-to-source transformations is already implemented as part of the OptiTrust framework, which currently applies only to C code, but internally relies on an imperative lambda-calculus very close to OCaml. For certain optimizations, their correctness is verified by means of lightweight Separation Logic assertions, which accompany the code.

The aim of this project is to generalize the OptiTrust framework to operate on OCaml code, and to extend the framework with transformations relevant for ML-style programs. A possible extension to the project consists of developing refinements from OCaml functions down to optimized C implementations of these functions.

**Main activities**

The concrete plan for the postdoc is as follows.

1. Extend OptiTrust to input and output OCaml syntax.

2. Implement source-to-source transformations relevant for optimizing OCaml programs, such as inlining, specialization, simplification of pattern matching, elimination of avoidable allocations, removing of indirections on records, refinement of data constructors e.g. to generalize from unary to n-ary list cells.
3. Apply the approach to case studies, such as optimization of the buckets of a hashtable, compilation of higher-order iterators into tight loop nests, specialization of the ‘Sek’ sequence data structure.

4. Demonstrate the possibility to refine allocation-free OCaml functions down to C code, with generation of C-bindings. Demonstrate the possibility of producing high-performance vectorized C code, e.g. for loops processing numeric data. An interesting case study would be the compilation of code from the Catala DSL, via OCaml, down to optimized C code.

**Skills**

The candidate must:
- be fluent in OCaml programming;
- be familiar with the notions of AST, and of semantics;
- be familiar with programs logics, in particular logical invariants;
- have knowledge of C programming.

**Benefits package**

- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking (after 6 months of employment) and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage

**Remuneration**

2788 € gross/month

**General Information**

- **Theme/Domain**: Architecture, Languages and Compilation
- **Software engineering** (BAP E)
- **Town/city**: Strasbourg
- **Inria Center**: Centre Inria de l'Université de Lorraine
- **Starting date**: 2024-10-01
- **Duration of contract**: 1 year
- **Deadline to apply**: 2024-08-10

**Contacts**

- **Inria Team**: CAMUS
- **Recruiter**: Charguéraud Arthur / Arthur.Chargueraud@inria.fr

**About Inria**

Inria is the French national research institute dedicated to digital science and technology. It employs 2,600 people. Its 200 agile project teams, generally run jointly with academic partners, include more than 3,500 scientists and engineers working to meet the challenges of digital technology, often at the interface with other disciplines. The Institute also employs numerous talents in over forty different professions. 900 research support staff contribute to the preparation and development of scientific and entrepreneurial projects that have a worldwide impact.

**The keys to success**

There you can provide a “broad outline” of the collaborator you are looking for what you consider to be necessary and sufficient, and which may combine:

- tastes and appetencies,
- area of excellence,
- personality or character traits,
- cross-disciplinary knowledge and expertise...

This section enables the more formal list of skills to be completed and ‘lightened’ (reduced):

- “Essential qualities in order to fulfil this assignment are feeling at ease in an environment of scientific dynamics and wanting to learn and listen.”
- “Passionate about innovation, with expertise in Ruby on Rails development and strong influencing...
Concretely, the candidate will contribute to the OptiTrust code base, which is implemented in OCaml. The work should lead to the writing and presentation of research papers on the work produced.

**Warning**: you must enter your e-mail address in order to save your application to Inria. Applications must be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.

**Instruction to apply**

**Defence Security**:
This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST). Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

**Recruitment Policy**:
As part of its diversity policy, all Inria positions are accessible to people with disabilities.