2018-00620 - PhD - Performance Modelling and Simulation of OpenMP Applications

**Level of qualifications required**: Graduate degree or equivalent

**Function**: PhD Position

**Context**

- **Presentation of the Teams**:

  The AVALON Research Team in Lyon, France, is a joint group between INRIA, CNRS, ENS Lyon, the University Claude Bernard Lyon 1, and the University of Lyon. The long term goal of the Avalon team is to contribute to the design of programming models supporting a lot of architecture kinds, to implement it by mastering the various algorithmic issues involved, and by studying the impact on application-level algorithms. Ideally, an application should be written once; the complexity is to determine the adequate level of abstraction to provide a simple programming model to the developer while enabling efficient execution on a wide range of architectures.

  The STORM Research Team at Inria and LaBRI Laboratory in Bordeaux, France, works on the topic of High Performance Parallel Computing. As emphasized by initiatives such as the European Exascale Software Initiative, the European Technology Platform for High Performance Computing, or the International Exascale Software Initiative, the HPC community needs new programming APIs and languages for expressing heterogeneous massive parallelism in a way that provides an abstraction of the system architecture and promotes high performance and efficiency. In this context, Team STORM designs code optimizing techniques for the whole programming tool chain, at the compiler level, at the runtime system level, and at the execution analyser level, with a focus on heterogeneous platforms.

**Assignment**

The Inria Project Lab HAC SPECIS gathers several Inria teams on the thematics performance studies and correctness in simulating high performance computing (HPC) applications and machines. The SimGrid platform designed by some of the participating teams enables simulating large scale distributed, accelerated platforms and applications running on them. Such simulations are used for multiple purpose, from anticipating the behaviour of applications on large supercomputers to the study and design of algorithms (task scheduling, load balancing, etc.) in a controlled environment and reproducible setup.

A key missing capability of SimGrid, however, is the ability to simulate OpenMP codes. The polymorphic characteristic of its programming model, from fork-join parallel loops to dependent tasks and recursive tasks, blending control and computation work in a free form fashion, makes the modelling and simulation of OpenMP particularly challenging.

Inria's team AVALON in Lyon and STORM in Bordeaux have a long background on designing runtime systems for parallelism and on working with the OpenMP parallel language. Both teams have jointly designed the KStar OpenMP compiler, and AVALON is also working on extensions to the LLVM's open source OpenMP runtime system. Inria is also part of the OpenMP Architecture Review Board in charge of the evolution of the OpenMP Specification. The objective of this PhD thesis is to build on this expertise and the expertise of HAC SPECIS members to design and implement an OpenMP modelling and simulation subsystem for the SimGrid framework.

This work will therefore involve several complementary steps.

First, data will have to be collected from real application runs to build performance models for various OpenMP constructs, possibly leveraging the OpenMP Tool API (OMPT) specification.

Second, mechanisms will have to be designed, at the runtime system level and/or at the language level to delineate computation parts that could be simulated, from control parts that would still have to be fully executed for application correctness and simulation realism, from mixed parts that would dynamically be sampled for a few iterations and subsequently simulated.

Third, replay mechanisms will have to be designed, where relevant, to accurately simulate the execution of corresponding OpenMP constructs (parallel loops, task parallelism), potentially taking into account different policies commonly adopted in OpenMP runtime systems.

**General Information**

- **Theme/Domain**: Distributed and High Performance Computing
- **Scientific computing (BAP E)**
- **Town/city**: TO BE DECIDED (Lyon or Bordeaux)
- **Inria Center**: CRI Bordeaux - Sud-Ouest
- **Starting date**: 2018-10-01
- **Duration of contract**: 3 years
- **Deadline to apply**: 2018-05-24

**Contacts**

- **Inria Team**: STORM
- **Recruiter**: Aumage Olivier / olivier.aumage@inria.fr

**About Inria**

Inria, the French National Institute for computer science and applied mathematics, promotes "scientific excellence for technology transfer and society". Graduates from the world's top universities, Inria's 2,700 employees rise to the challenges of digital sciences. With its open, agile model, Inria is able to explore original approaches with its partners in industry and academia and provide an efficient response to the multidisciplinary and application challenges of the digital transformation. Inria is the source of many innovations that add value and create jobs.

**Conditions for application**

**Advisors**: Olivier AUMAGE (STORM) / Thierry GAUTIER (AVALON)

**Thank you to send**:

- Copy of master thesis diploma
- Master marks and ranking
- 2 pages CV
- Cover letter
- Support letter(s)

**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.
Fourth, longer term objectives would include the integrated simulation of distributed + shared-memory applications, such as the MPI+OpenMP pattern frequently adopted in HPC.

**Main activities**

**Key-words**: High performance computing, parallelism, simulation, modelling, runtime system, tracing

**Links**:
- Team AVALON: https://www.inria.fr/en/teams/avalon
- Team STORM: https://www.inria.fr/en/teams/storm
- IPL HAC SPECIS: http://hacspecis.gforge.inria.fr/
- SimGrid: http://simgrid.gforge.inria.fr/
- OpenMP: http://www.openmp.org/

**Skills**
- Mastering software development under UNIX-like operating systems
- Good level in C/C++ language programming, system programming and parallel programming
- Mastering technical and scientific English
- Good writing skills
- Additional Appreciated Skills: Knowledge of OpenMP parallel programming language, SimGrid, Fortran, MPI

**Benefits package**
- Subsidised catering service
- Partially-reimbursed public transport

**Remuneration**
1982€ / month (before taxes) during the first 2 years, 2085€ / month (before taxes) during the third year.

**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.