Offer #2025-08798

Post-Doctoral Research Visit F/M Task-based Cardiac Electrophysiology Simulation on multi-GPU Heterogeneous Clusters

Contract type : Fixed-term contract

Level of qualifications required : PhD or equivalent

Fonction : Post-Doctoral Research Visit

Level of experience : From 3 to 5 years

About the research centre or Inria department

The Inria center at the University of Bordeaux is one of the nine Inria centers in France and has about twenty research teams.. The Inria centre is a major and recognized player in the field of digital sciences. It is at the heart of a rich R&D and innovation ecosystem: highly innovative SMEs, large industrial groups, competitiveness clusters, research and higher education players, laboratories of excellence, technological research institute...

Context

International Relation Department Postdoctoral Position

Every year Inria International Relations Department has a few postdoctoral positions in order to support Inria international collaborations. The postdoctoral contract, within the context of the agreement signed between Inria and Simula Research Laboratory in Oslo, Norway, will have a duration of 24 months. The default start date is November 1st, 2025 and not later than January, 1st 2026. The

postdoctoral fellow will be recruited by the Inria Research Center at the University of Bordeaux in France, but it is recommended that the time is shared between France and Norway (please note that the postdoctoral fellow has to start his/her contract being in France and that the visits have to respect Inria rules for missions)

Task-based Cell-level Cardiac Electrophysiology Simulation

Simulating cardiac electrophysiology at the resolution of individual cells is a key challenge, as coarser-grained and cell-averaged simulations fail to capture the effects of pathological or aging cardiac tissues with sufficient realism. Cell-resolved simulation at such a fine-grained level necessitates the efficient exploitation of the computing power of contemporaneous HPC platforms equipped with accelerators. However, doing so comes with computer science challenges for HPC application developers such as deciding when and how to map application kernels onto these heterogeneous computing resources, handling data transfers, replication and consistency management between discrete accelerator memory spaces, between distributed nodes or ensuring the overlapped progression of data transfers in concurrence with computations. To address these issues, task-based parallel programming models, together with their associated runtime systems, such as the StarPU runtime system developed by Inria Team STORM, have shown the benefits of their ability at performance portability on HPC platforms.

The HPC Department of Simula has recently developed a primitive version of a new cell-resolved simulator of cardiac electrophysiology, named DEMI. This new simulator advances Simula's previous parallel cell-based simulation software, which was based on regular computational meshes and the finite difference numerical method. The new DEMI simulator adopts the finite element numerical method and can thus model realistic geometries of irregular shapes. To efficiently handle huge-scale computations that are required by cell-based simulations of cardiac electrophysiology, there is an urgent need to port the DEMI simulator to cluster platforms of multiple GPU nodes. A standard CPU-to-GPU code porting will pose a major programming challenge. Thus, the task-based parallelization and runtime system StarPU is expected to provide a considerably more programmer-friendly approach.

Ongoing Collaboration

Simula’s HPC Department and Inria Team STORM are jointly involved in the European project MICROCARD-2 CoE (2025 - 2027, 30-month) in which they work on the OpenCARP cardiac electrophysiology simulation code, together with other partners of the project. In this respect, relevant scientific findings and experiences from this post-doc would be transferable to the MICROCARD-2 Project. The Post-doc researcher will be well posed to interact and collaborate with other consortium members of the MICROCARD-2 CoE, who are working on related research topics.

This current collaboration follows the joint participation of Simula and STORM to the MICROCARD Project (2020-2024) and to the associate team MAELSTROM. In consequence, Simula's HPC department will provide support in supervising and collaborating with the Post-doctoral researcher.

Assignment

Recruitement Guidelines

Candidates for International Relation Department postdoctoral positions are recruited after the end of their Ph.D. or after a first post-doctoral period: for the candidates who obtained their PhD in the Northern hemisphere, the date of the Ph.D. defense shall be later than September 1, 2022; in the Southern hemisphere, later than April 1, 2022. In order to encourage mobility, the postdoctoral position must take place in a scientific environment that is truly different from the one of the Ph.D. (and, if applicable, from the position held since the Ph.D.); particular attention is thus paid to French or international candidates who obtained their doctorate abroad.

Objectives of the Post-doctoral Position

This post-doctoral position aims at integrating the StarPU task-based runtime system as the scheduling and execution engine of the DEMI cardiac electrophysiology simulation code, to enable and optimise its execution on GPU-accelerated computing nodes. The original DEMI simulator follows a regular fork-join node-level execution scheme based on OpenMP parallel loops coupled to a MPI based distributed execution. Instead, task-based runtime systems such as StarPU take advantage of asynchronism to avoid idle times and overlap operations such as data transfers with computations. In order to maximally benefit from this asynchronism, care will have to be taken to express the entire flow of the application through data dependencies all along the simulation, without resorting to barriers. An important challenge of integrating StarPU as DEMI’s execution engine will thus be to delineate individual tasks carefully, with a sufficient computational grain to enable the efficient use of GPU accelerators, but small enough to ensure good load balancing, and to partition data structures inside DEMI to maximize parallelism and latency hiding in complex cardiac cells simulation layouts.

StarPU ships with a collection of scheduling algorithms with a variety of trade-offs between the scheduling capabilities and costs, to match distinct application characteristics. Another challenge will therefore be to select and fine-tune StarPU's scheduling algorithm to take into account, and take advantage of the potential specificities of cardiac electrophysiology simulations with DEMI, in terms of priorities, data access patterns and transfer volumes.

Main activities

- Bibliographical study on related works.
- Port of DEMI on top of StarPU to target heterogeneous computing clusters of multi-GPU nodes.

- Performance evaluation and tuning on synthetic meshes, on local computing clusters (PlaFRIM in Bordeaux).
- Experimentations on national supercomputing resources such as GENCI and SLICES resources in France and the EX3 platform at Simula.
- Publications on the findings of this work in selected conferences and journals.

Skills

- Language C programming on Linux systems
- Parallel and distributed programming for HPC
- Applied mathematics and scientific simulation programming
- Development with Git / Gitlab / GitHub environments
- Fluency in written and spoken English

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 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

The monthly salary will be 2927€ (before social security contributions and monthly witholding tax).

General Information

- **Theme/Domain :** Distributed and High Performance Computing
- **Town/city :** Talence
- **Inria Center :** Centre Inria de l'université de Bordeaux
- **Starting date :** 2025-10-01

- **Duration of contract :** 2 years
- **Deadline to apply :** 2025-06-01

Contacts

- **Inria Team :** STORM
- **Recruiter :**
  Aumage Olivier / Olivier.Aumage@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

Key profile characteristics to succeed in the proposed mission

- Appetence to work in a team as part of an international collaboration.
- Enthusiasm to conduct research works at the convergence of multiple disciplines such as HPC, applied mathematics and medical science.
- Proactivity in building experiments, analyzing results and suggesting optimization directions.
- Mobility for extended collaboration visits at Simula.

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

If you are interested by this job, please could you apply on website jobs.inria wth the following documents :

- cv
- cover letter

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.