



Offre n°2025-08549

PhD Position F/M Foundation of an HPC Composition Model

Type de contrat : Fixed-term contract

Niveau de diplôme exigé : Graduate degree or equivalent

Fonction : PhD Position

A propos du centre ou de la direction fonctionnelle

The Inria research centre in Lyon is the 9th Inria research centre, formally created in January 2022. It brings together approximately 320 people in 19 research teams and research support services.

Its staff are distributed in Villeurbanne, Lyon Gerland, and Saint-Etienne.

The Lyon centre is active in the fields of software, distributed and high-performance computing, embedded systems, quantum computing and privacy in the digital world, but also in digital health and computational biology.

Contexte et atouts du poste

Numerical simulation is a key technology for many application domains. Thanks to the democratization of high performance computers (HPC), complex physics and more generally complex systems can now be simulated routinely. Numerical simulation is considered as the third pillar of sciences (with experiment and theory) and is critical to gain competitive position.

Though significant efforts have been devoted to the implementation and optimization of several crucial parts of a typical HPC software stack, most HPC experts agree that exascale supercomputers will raise new challenges, mostly because the trend in exascale compute-node hardware is toward heterogeneity and scalability: Compute nodes of future systems will have a combination of regular CPUs and accelerators (typically GPUs), along with a diversity of GPU architectures.

Meeting the needs of complex parallel applications and the requirements of exascale architectures raises numerous challenges which are still left unaddressed. As a result, several parts of the software stack must evolve to better support these architectures. More importantly, the links between these parts must be strengthened to form a coherent, tightly integrated software suite.

The [Exa-Soft](#) project of the PEPR [NumPEX](#) aims at consolidating the exascale software ecosystem by providing a coherent, exascale-ready software stack featuring breakthrough research advances enabled by multidisciplinary collaborations between researchers.

Mission confiée

The particular issue that this PhD shall tackle is to provide a model to compose code development accordingly to various HPC programming paradigms. Software composition is an old [NATO] but still key technique [SZY] to develop complex applications by being able to divide them into manageable code. Though it is common in traditional sequential programming, composition of parallel codes is still challenging. Previous work demonstrated that composition within a parallel programming is possible and does not impact performance [CCA, HLCCM, Comet]. However, we are lacking a model to compose distinct paradigms without mentioning the specific problem of runtime cohabitation in an HPC context.

A particular target of this work could be the Multi-Level Intermediate Representation (MLIR) framework [MLIR], aiming to harness MLIR not only as a unifying compilation target for heterogeneous input Domain Specific Languages (DSLs) but also as a semantic backbone for expressing data flow, and reasoning about scheduling.

Bibliography:

- [NATO] McIlroy, M.D., Mass Produced Software Components. Proceedings of NATO Software Engineering Conference, Garmisch, Germany, October 1968, 138-155.
- [SZY] Clemens Szyperski. Component Software : Beyond Object-Oriented Programming. Addison-Wesley Longman Publishing Co., Inc., 2002.
- [CCA] B. A. Allan, R. Armstrong, D. E. Bernholdt, and al. A component architecture for high-performance scientific computing. International Journal of High Performance Computing Applications, 20(2) :163–202, 2006.
- [HLCCM] Julien Bigot. Du support générique d'opérateurs de composition dans les modèles de composants logiciels, application au calcul scientifique. PhD thesis, INSA de Rennes (France), 2010.
- [COMET] Jérôme Richard. Conception d'un modèle de composants logiciels avec ordonnancement de tâches pour les architectures parallèles multi-cœurs, application au code Gysela. PhD Thesis, Université de Lyon, December 2017.
- [MLIR] C. Lattner *et al.*, "MLIR: Scaling Compiler Infrastructure for Domain Specific Computation," *2021 IEEE/ACM International Symposium on Code Generation and Optimization (CGO)*, Seoul, Korea (South), 2021, pp. 2-14, doi: 10.1109/CGO51591.2021.9370308.

Principales activités

- Study the state-of-the-art of parallel paradigms, parallel programming models, and composition models
- Analyse challenges for incoming parallel applications
- Propose a model that supports composition of selected programming principles
- Implement a proof of concept (POC)
- Conduct evaluation of POC on selected use cases

Compétences

Technical skills and level required :

- knowledge of HPC programming models
- knowledge in (meta-)modeling will be appreciated
- very good programming skills (in particular in C++ but not only)

Avantages

- 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 (90 days / year) and flexible organization of working hours
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage under conditions

Rémunération

1st and 2nd year: 2100 euros gross salary /month

3rd year: 2200 euros gross salary / month

Informations générales

- **Thème/Domaine :** Distributed and High Performance Computing
Software engineering (BAP E)
- **Ville :** Lyon
- **Centre Inria :** [Centre Inria de Lyon](#)
- **Date de prise de fonction souhaitée :** 2025-09-01
- **Durée de contrat :** 3 years
- **Date limite pour postuler :** 2025-08-02

Contacts

- **Équipe Inria :** [AVALON](#)

- **Directeur de thèse :**

Perez Christian / christian.perez@inria.fr

A propos d'Inria

Inria est l'institut national de recherche dédié aux sciences et technologies du numérique. Il emploie 2600 personnes. Ses 215 équipes-projets agiles, en général communes avec des partenaires académiques, impliquent plus de 3900 scientifiques pour relever les défis du numérique, souvent à l'interface d'autres disciplines. L'institut fait appel à de nombreux talents dans plus d'une quarantaine de métiers différents. 900 personnels d'appui à la recherche et à l'innovation contribuent à faire émerger et grandir des projets scientifiques ou entrepreneuriaux qui impactent le monde. Inria travaille avec de nombreuses entreprises et a accompagné la création de plus de 200 start-up. L'institut s'efforce ainsi de répondre aux enjeux de la transformation numérique de la science, de la société et de l'économie.

Attention: Les candidatures doivent être déposées en ligne sur le site Inria. Le traitement des candidatures adressées par d'autres canaux n'est pas garanti.

Consignes pour postuler

Applications must be submitted online via the Inria website. Processing of applications submitted via other channels is not guaranteed.

Sécurité défense :

Ce poste est susceptible d'être affecté dans une zone à régime restrictif (ZRR), telle que définie dans le décret n°2011-1425 relatif à la protection du potentiel scientifique et technique de la nation (PPST). L'autorisation d'accès à une zone est délivrée par le chef d'établissement, après avis ministériel favorable, tel que défini dans l'arrêté du 03 juillet 2012, relatif à la PPST. Un avis ministériel défavorable pour un poste affecté dans une ZRR aurait pour conséquence l'annulation du recrutement.

Politique de recrutement :

Dans le cadre de sa politique diversité, tous les postes Inria sont accessibles aux personnes en situation de handicap.