2021-04197 - Internship F/M Using Data Science to derive stochastic models for parallel applications scheduling

Contexte et buts du poste

The project is in the context of the national collaboration between centers in Grenoble, Lyon and Bordeaux. It is focused on a new vision for modeling jobs for the design of supercomputers. Based in Bordeaux within the Inria project-team Tadaam, it will be co-supervised by Guillaume Pallez (Tadaam, https://people.bordeaux.inria.fr/gaupsy/ ) and Fanny Dufossé (Datamove, https://team.inria.fr/datamove/team-members/fanny-ducoss/)

We will be looking for a PhD student to pursue on this topic after this internship on which the intern will be strongly encouraged to apply. The offer of the doctoral contract on this subject is available at this link:

https://jobs.inria.fr/public/classic/fr/offres/2021-04195

Mission confiée

## Context and Motivation

High-Performance Computers (also called supercomputers) are massive infrastructure used to run extremely large parallel applications. These applications come from a wide range of domains, such as material physics, climate modeling/forecast, astronomy etc. Used as a cornerstone to some industrial applications (self-driving cars, drug discovery etc), supercomputing is also one of the pillars of scientific discovery (such as recently the Higgs Boson, supermassive blackholes, etc). With the advent of Big Data and machine learning together with the race to Exascale (a supercomputer able to compute at a peak of $10^{18}$ Flops), an explosion of application domains turned to exploit supercomputer resources

### Scheduling

One of the central problems of computing is the allocation (or scheduling) of jobs with different requirements on the shared computational resources (the computing platform). Research on Resource and Job Management Systems (RJMS) is extremely active. Fundamentally there is a key element at the center of all existing and future algorithmic solutions: user-provided resource needs. So far, most scheduling algorithms rely on this assumption. However this is a well known and documented limitation: user estimates are known to be inaccurate (overestimated). It has been shown that this inaccuracy hurts the performance of the system.

### Research vision

We hypothesize that job resource requirements and temporal variations are in essence stochastic. The variability of their needs is inherent and can be large. Based on this hypothesis, we believe that HPC scheduling algorithms and softwares should embrace the uncertainty of job resources requirements.

**"The idea of this project is to show that we can design job schedulers that do not assume that user needs are deterministic/computable, but that can work with them as soft constraints while knowing that they are unreliable."**

Note that this project is based on some previous work that showed extremely promising results ([2,3]).

### Internship topic

This is the first step of the project where the goal is to design stochastic/statistical models for HPC jobs, based on the analysis of real data. In addition, we will work on constructing models based on partial information using tools such as Bayesian inference.

The challenge of the thesis consists in understanding and describing the variability of resource usage, including its origin and its behavior. We want to be able to present novel formulations to describe the behavior of applications that includes the uncertainty. Important questions have to be answered such as:

1. How can we account for the variability in application needs?
2. What are the sources of variability and their impact on application performance?
3. How can we abstract this variable behavior?

Variability in application resource needs seems to come from different factors (input data, machine parameters, code performance etc). Finding the right modelization is an important factor to the design of algorithmic solutions (which will also be an important part of the thesis).

(a)(b) Application walltime variation for various inputs.

(https://fett.roflcopter.fr/pics/mlSTKV-B0L3yvd.jpg =340x180) (b)(d) Correlation between size of input and walltime)

**Data from a neuroscience application running with inputs from two different datasets:**

(a) Application walltime variation for various inputs. (b) Correlation between size of input and walltime**

In preliminary work we have been able to demonstrate that for specific neuroscience applications running in complete isolation the behavior was strongly input-dependent and could be modeled through high variance statistical distribution ([1], see Figures. Here our goal is many-fold: (i) try to see if we can generalize the observations at a much higher scale (trace-based analysis); (ii) as a second step, we hypothesize that an application behavior is the consequence of a compositional rules between application behaviors and machine interference, hence by studying combined one of the two applications and the complete trace, we want to try to guess the machine impact (and hence the function used in this compositional rule). (iii) Once this is done, we plan to verify on the second

Informations générales

- **Thème/Domaine**: Calcul distribué et à haute performance
- **Statistiques**: (Big data) (BAP E)
- **Ville**: Talence
- **Centre Inria**: CRI Bordeaux - Sud-Ouest
- **Date de prise de fonction souhaitée**: 2022-03-01
- **Durée de contrat**: 5 mois
- **Date limite pour postuler**: 2022-01-31

Contacts

- **Equipe Inria** : TADAAM
- **Recruteur** :
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  - Dufossé Fanny : fanny-dufoss@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 200 équipes-projets agiles, en général communnes avec des partenaires académiques, impliquent plus de 3500 scientifiques pour révéler 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 180 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.

Consignes pour postuler

Thank you to send these documents:

- CV
- cover letter
- the syllabus of the classes you took during your Master 1/Master 2 + the grades obtained when available
- transcript of marks at licence and Master level
- any document that you consider interesting to transmit to the recruiter

Sécurité défense :

Ce poste est susceptible d’être affecté dans une zone à régime restreint (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.

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Le traitement des candidatures adressées par d’autres canaux n’est pas garanti.
application the compositionality of the rules and predict its behavior.

Then, we will work on proposing modelization for complex workflows for specific applications (including the varying level of parallelism). In parallel these models will be tested against the design of scheduling algorithms to verify their manipulability.

This new strategy to create application performance models will provide in the future a completely new directions to submitting information to the resource arbitration mechanism which seems necessary to the upcoming application challenges of high-performance computing.

[1] https://hal.inria.fr/hal-02921487/

Principales activités

The main activities include: literature reading, data processing, reporting, paper writing.

Compétences

- advanced knowledge in statistics (such as bayesian optimization, active learning)
- good knowledge in probability theory
- Knowledge in a scripting language for data science (R, python)
- some knowledge and interest in algorithmic design
- good level in english (written)

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 partial 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

Rémunération

Monthly gross salary of 1 589,50 €.