2021-03424 - PhD Position F/M Dynamic Steady-State Scheduling for Inference and Training in Deep Neural Networks on Heterogeneous Resource

Informations générales

- Thème/Domaine : Calcul distribué et à haute performance
- Ville : Talence
- Centre Inria : CR Bordeaux - Sud-Ouest
- Date de prise de fonction souhaitée : 2021-09-01
- Durée de contrat : 3 ans
- Date limite pour postuler : 2021-07-31

A propos du centre ou de la direction fonctionnelle

HiPACs is a joint project-team with Bordeaux INP, Bordeaux University and CNRS (LaBRI UMR 5800). It has been created on the first of January 2010 and is led by Luc Giraud.

An important force which has continued to drive HPC has been to focus on frontier milestones which consist in technical goals that symbolize the next stage of progress in the field. In the 1990s, the HPC community sought to achieve computing at a teraflop rate and we are able to compute on the first leading architectures at a petaflop rate. Generalist petaflop supercomputers are available and some communities are already in the early stages of thinking about what computing at the exaflop level would be like early 2020. For application codes to sustain a petaflop and more in the next few years, hundreds of thousands of processor cores or more will be needed, regardless of processor technology. Currently, a few HPC simulation codes easily scale to this regime, and major code development efforts are critical to achieve the potential of these new systems. Scaling to a petaflop and more will involve improving physical models, mathematical modelling, super scalable algorithms that will require paying particular attention to acquisition, management and visualization of huge amounts of scientific data.

In this context, the purpose of the HiPACs project is to perform efficiently frontier simulations arising from challenging research and industrial multiscale applications. The solution of these challenging problems require a multidisciplinary approach involving applied mathematics, computational and computer sciences. In applied mathematics, it essentially involves advanced numerical schemes. In computational science, it involves massively parallel computing and the design of highly scalable algorithms and codes to be executed on future petaflop (and beyond) platforms. Through this approach, HiPACs intends to contribute to all steps that go from the design of new high-performance more scalable, robust and more accurate numerical schemes to the optimized implementations of the associated algorithms and codes on very high performance supercomputers.

Contexte et atouts du poste

The PhD thesis is funded by the European H2020 EuroHPC project TEXTAROSSA: to achieve high performance and high energy efficiency on near-future exascale computing systems, a technology gap needs to be bridged: increase efficiency of computation with extreme efficiency in HW and new arithmetics, as well as providing methods and tools for seamless integration of reconfigurable accelerators in heterogeneous HPC multi-node platforms. TEXTAROSSA aims at tackling this gap through a co-design approach to heterogeneous HPC solutions, for HPC, AI and HPDA applications.

In the framework of the project TEXTAROSSA, a few visits (3-5) of relatively short duration (1 to 2 weeks) will be possible between Bordeaux and the partners of the project (in Italy, Spain, Germany and Poland). Travel and accommodation costs will be covered.

Mission confiée

The training phase and the inference in deep neural networks induce increasing needs in the use of computing resources. Today, learning is classically performed on GPU clusters, relying essentially on data parallelism [1], which requires the realization of costly collective communications that limit scalability [2]. Inference is usually performed on a CPU or the processor of an embedded device such as a phone. However, the use of more complex and deeper networks and the need to obtain real-time results may also require the use of more parallel resources and more sophisticated algorithms.

From a scheduling point of view, the inference problem comes back to a steady state scheduling problem [3,4], but with new constraints related to the "in-order" execution of tasks. The training problem is also a steady state scheduling problem, but the particular form of the dependencies (between the forward and the backward phases) induces complex memory management problems [5,6,7]. A first algorithmic contribution of the PhD thesis is therefore to adapt steady-state scheduling algorithms to the specific context of training and inference in deep neural networks.

In the field of parallelism, for linear algebra and numerical simulation applications mainly, an approach based on dynamic (runtime) scheduling has been proposed [8,9]. Indeed, because it is difficult to reliably predict the execution duration of the different tasks, point-to-point communications and collective communications, it is difficult to rely on a static assignment of computational tasks to parallel resources and a pre-calculated schedule. In contrast, the idea of dynamic strategies is to make placement and scheduling decisions at runtime, based on simpler (and cheaper) policies and algorithms but with a clear knowledge of the state of the resources and of the algorithm. A second contribution of the thesis is therefore to adapt dynamic schedulers such as StarPU to the application context of learning and to interface them with frameworks such as PyTorch and TensorFlow, based on the RoToR [10] and StarPU [11] software.

Work Plan

This thesis is funded by the European H2020 project TEXTAROSSA. First, we will carry out a state of the art study, both on steady-state scheduling techniques and on dynamic runtimes. In a second step, we will focus on the inference problem, by identifying a suitable application framework, with the design...
of static and dynamic scheduling strategies and the realization of a dynamic scheduler prototype on heterogeneous resources. Finally, in a third step, we will consider the case of the learning phase to extend the previous prototype.

Requirements

The candidate should have a very good mathematical and algorithmic background, with good understanding of Deep Learning and parallelism, as well as programming skills in Python (and C and/or C++).

References

[10] RoToR https://gitlab.inria.fr/hiepacs/rotor

Principales activités

- Design and analysis of algorithms
- Solving combinatorial optimization problems
- Integration into deep learning frameworks
- Integration in StarPU

Compétences

Technical skills and level required:

Languages: Python

Other valued appreciated: good knowledge of Pytorch and/or Tensorflow, C/C++

Avantages

- Subsidized meals
- Partial reimbursement of public transport costs
- 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

Rémunération

- 1882€ / month (before taxes) during the first 2 years
- 2085€ / month (before taxes) during the third year