Design Space Exploration for Accuracy-aware Computing

Basic information:
Applications are invited for 15 full-time PhD student positions (called Early Stage Researchers or ESR) for PhD degrees for 36 months. The positions are offered within the Approximate Computing for Power and Energy Optimisation (APROPOS) International Training Network action of the highly appreciated EU-funded Marie Skłodowska Curie grants. The positions are fully funded for a 36-month period. You can choose your position in one of 14 top-level universities and companies in Europe and complement your experience within periods from 3 to 9 months of cross-sector secondments by working with the highly committed industrial partners of the action. You are encouraged to apply for up to three positions within APROPOS network if you believe your profile is suitable for multiple topics. A separate application is needed for each position in case you apply for multiple positions.

APROPOS is an international, multidisciplinary and multi-sectorial training network programme on approximate computing. APROPOS is funded by the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska Curie grant agreement No. 956090.

The ESR-specific project is described below. Please read the description carefully before applying. We recommend you choose the position you apply for based on your technical profile and desired technical expertise, rather than based on the hosting location, as all positions involve high-level research mobility.

Project information:
APROPOS will train 15 Early Stage Researchers to tackle the challenges of future embedded and high-performance computing by using disruptive methodologies. Following the current trend, by 2040 computers will need more electricity than the world energy resources can generate. On the communications side, energy consumption in mobile broadband networks is comparable to datacentres. To make things worse, Internet-of-Things will soon connect 20 to 50 billion devices through wireless networks to the cloud.
APROPOS aims at decreasing energy consumption in both distributed computing and communications for cloud-based cyber-physical systems. We propose adaptive Approximate Computing to optimize energy-accuracy trade-offs. Luckily, in many parts of the global data acquisition, transfer, computation, and storage systems there exists the possibility to trade off accuracy to either less power or less time consumed – or both. As examples, numerous sensors are measuring noisy or inexact inputs; the algorithms processing the acquired signals can be stochastic; the applications using the data may be satisfied with an "acceptable" accuracy instead of exact and absolutely correct results; the system may be resilient against occasional errors; and a coarse classification or finding the most probable matches may be enough for a data mining system. By introducing a new dimension, accuracy, to the design optimization, the energy efficiency can even be improved by a factor of 10x-50x.
APROPOS will train the spearheads of the future generation to cope with the technologies, methodologies, and tools for successfully applying Approximate Computing to power and energy saving. The training, in this first ever ITN addressing approximate computing, is to a large extent done by researching energy-accuracy trade-offs on circuit, architecture,

software, and system-level solutions, bringing together world leading experts from European organizations. In addition, we will provide network-wide and local trainings on the substance and on the complementary skills needed in both industrial and academic work life.

ESR Host Unit: Ecole Centrale de Lyon – Institute of Nanotechnology of Lyon (ECL-INL), France

ESR 6 Description:

Existing Approximate Computing techniques can be applied either at component (e.g., functional approximation) or application level (e.g., loop perforation, precision reduction). When a component is approximate, the impact of the approximation, i.e., accuracy loss, is only considered at local level and it is not trivial how to determine its effect at application-level. On the other hand, the approximation implemented at application-level does not consider the knowledge about the HW architecture. This may lead to sub- optimal solutions.

The goal of this PhD thesis is to design and implement **a design space exploration framework** able to automatically explore the impact of different approximate operators on a given application described in C/C++ and to select the best one accordingly to the required level of accuracy and the available HW architecture. The work is divided in three main tasks:

1) AxC operators modelling. This task has to model the Approximate Operators (existing ones from the literature and/or developing new ones). The operators models will compose a library. A source-to-source compiler will be implemented in order to generate a mutated version of the source code by adding the available approximate operators.
2) Search Engine. This task aims at identifying the "best" configuration of the approximate operators added in the mutated source code (e.g., for the loop perforation it has to identify the maximum number of skipped iterations). Clearly the search space will be very huge, thus it will be not possible to use an exact algorithm to identify the best solution. We thus propose to use heuristics, and we forecast to investigate the use of evolutionary algorithms.
3) Workload Independency. Each time that a configuration for an AxC operator is identified, the impact on the application precision has to be checked (i.e., avoid to degrade too much the application precision). The problem is which workload should be used for the evaluation. The critical point will be how to identify a meaningful workload (i.e., that correctly mimic the real workloads) and how to characterize it.

ESR 6 Objectives:
  • Define and Implement a Design Space Exploration (DES) framework for accuracy-aware computing
  • Support the benchmarking activities

ESR Expected Results:
Proof-of-concept implementation of DSE framework, completion of the PhD at the hosting unit withing 36 months.

Planned secondment(s): CERICT, supervisor Prof. Antonino Mazzeo, M24, 6 months to work on the optimizer for the DSE with the industrial partner, and for industrial practice.

Supervisory team:
- Prof. Alberto Bosio (ECL-INL), main supervisor
- Prof. Ian O'Connor (ECL-INL), academic co- supervisor
- Prof. Stefano Di Carlo (POLITO), academic co- supervisor
- Prof. Antonino Mazzeo (CERICT), industrial co- supervisor

Enrolment in Doctoral degree: Ecole Centrale de Lyon, France

Target degree: PhD in Doctoral Programme of Electronics, Electrical Engineering, Automatics and Signal Processing (DP EEEA)

Degree details: https://edeea.universite-lyon.fr/ed-160-eea/version-anglaise/

Expected start date: May 2021 (M7 from the beginning of the project)

Approximate gross salary: about 3170 EUR/month for researchers without family, the gross amount includes living and mobility allowances. For reseachers with family responsibilities, the salary would be approximately 3500 EUR/month. Note: for different positions within the same APROPOS network, the salary is country- and unit-dependent.

Duration: 36 months

Researcher Profile: First Stage Researcher (R1)

Research Field: Engineering; Computer science; Technology

Type of contract: Temporary

Job Status: Full-time

Hours per week: 40

Trial period: 6 months

Working and living conditions in the country:

By choosing to work in **France**, you will have the chance to discover a society that is multicultural and open, proud of its history and looking forward to the future. You will discover the art of living *à la française* - an art celebrated around the world. Whether your interests lie in the theatre and music or in fine cuisine, no one leaves disappointed: in France, there's something for everyone. **Lyon** metropole is reputed for its excellence in industry and the life sciences, as well as in cleantech and digital technologies. The area has 600 public and private research laboratories, including 12 LabEx (with the "laboratory of excellence" label). The Lyon metropolitan area is also the second-leading French region for patent applications and is an international hub of innovation.

Read more about France and Lyon
- http://ee.france.fr
- https://www.france.fr/en/auvergne
- https://www.lyoncampus.com/en/welcome/5-good-reasons-to-study-in-lyon

Unit details: The Lyon Institute of Nanotechnology (Institut des Nanotechnologies de Lyon, INL) is a Joint Research Unit (Unité Mixte de Recherche, UMR 5270) involving the CNRS, ECL, INSA, Université Lyon 1 and CPE Lyon. The goal of INL is to encourage world-leading multidisciplinary research in the areas of micro and nanotechnologies and their applications. The pioneering research undertaken at the Institute ranges from materials and technology to devices and systems, thus enabling the emergence of dedicated technologies. The Institute is supported in its work by the Nanolyon Technology Platform. The application areas cover major economic sectors: semiconductor industry, information technologies, healthcare and wellbeing, energy and the environment. The laboratory is located on two leading research campuses at Lyon Ouest-Ecully and LyonTech-La Doua. It has personnel of 200 people including 121 permanent staff. INL is one of the key laboratories of the "Université de Lyon" research and higher education centre.

Read more about ECL-INL:
- https://www.ec-lyon.fr/en
- https://inl.cnrs.fr

Seconding Unit description: The Centro Regionale Information Communication Technology scrl (CeRICT) is a consortium of ten universities and public research centres in the Campania Region, Italy, set up as an outcome of the CRdC ICT project in 2002 by the Campania Region. The CeRICT main mission is to increase the economical and social value of affiliated research institutions matching the medium/long-term research needs of Industry and Public Administrations. CeRICT also provides a lightweight administrative infrastructure simplifying the management of complex research projects, including European projects. More than 200 professors, researchers, and technicians form the virtual staff of CeRICT through its affiliated organizations.

Read more about CERICT at: www.cerict.it

Eligibility criteria: please check carefully that you are eligible; all conditions below are compulsory

Transnational mobility: The researcher must not have resided or carried out their main activity (work, studies, etc.) in the country of the host organization for more than 12 months in the 3 years immediately prior to the start date. Note: the mobility rule applies to the (main) beneficiary where the researcher is recruited, and not to partners to which the researcher is sent or seconded. It is also only determined at one point in time: at the time when the ESR starts working for APROPOS.

Early-Stage Researchers (ESRs)/fresh MSc graduates: All researchers recruited in APROPOS must have less than 4 years since the completion of their first MSc degree and have not been awarded any doctoral degree at the date of the employment.

Background requirements: The applicant must be in possession of Master of Science (MSc) diploma in a relevant field, such as: electrical engineering, communications engineering, computer engineering, software engineering/computer science, signal processing, radio communications, mathematics, physics, aerospace engineering, mechanical engineering, biomedical engineering, etc.

English language requirements: The candidate must be in possession of an English certificate with good level according to the regulations of the university to which the student will be enrolled for the PhD degree – check the degree requirements of the corresponding doctoral program for details.