

### 3 ESR (PhD) positions in Horizon 2020 Marie Skłodowska Curie

**Position:** PhD-student

**Departments:** Department of Electrical Engineering

**FTE:** 1,0

**Date off:** 24/04/2016

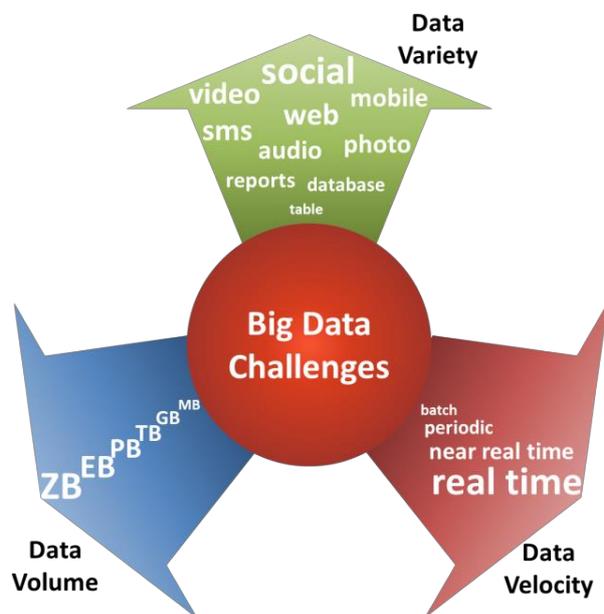
**Reference number:** V36.2535

#### Job description

**3 ESR (PhD) positions in Horizon 2020 Marie Skłodowska Curie European Industrial Doctorate**

**NeMeCo: Near-Memory Computing - Scaling Big-Data Processing into the Next Decade.**

The emerging knowledge economy relies increasingly on **Big-data** applications to extract value out of huge amounts of data by searching for correlations that can be used to predict business trends, find the best medical treatment for diseases, perform financial risk management, determine the best locations to drill for oil and gas, fight crime, and for many other purposes. Big-data applications are very different from traditional workloads and put extremely high demands on the High Performance Computing (HPC) systems that are used to execute them. One of the key challenges in designing new generations of HPC systems that can keep up with the ever-growing data volumes, is that current technological trends prevent large amounts of data to be transferred at acceptable power dissipation costs. Reducing expensive data transfers by “bringing computation closer to the data”, also known as **near-memory computing**, has emerged as a very promising solution to address this scaling issue in HPC systems in order to realize the **Exascale** computing systems that are required for handling future Big-data workloads. Near-memory computing, however, is still in its infancy, and many challenges have to be addressed before it can be established as an integral component of HPC systems.



**NeMeCo** is an ambitious Marie Skłodowska-Curie European Industrial Doctorates (EID) Innovative Training Network (ITN) programme, which addresses several of the above challenges. In particular, NeMeCo is an interdisciplinary training and research project aimed at developing **power-efficient HPC systems for Big-data processing** based on the exploitation of near-memory computing capabilities, and, in this way, making the world a better place by enabling important innovations in, for example, healthcare, energy consumption, traffic congestion and safety.

NeMeCo involves a three-partner network comprising the **Eindhoven University of Technology** in the Netherlands, **IBM Research GmbH** in Switzerland, and the Netherlands Institute for Radio Astronomy, **ASTRON**. These partners provide a unique combination of academic and industrial expertise of Big-data applications, compilers, memory and processor technology, and high-performance computer architecture. NeMeCo offers early stage researchers (ESRs) an excellent multidisciplinary training

program at the cross roads of hardware and software design, where complex trade-offs have to be made between performance, programmability and energy efficiency. A board of 8 experienced supervisors will work together across disciplines and sectors to train and mentor the ESRs who will have access to superb research facilities at all locations. A total of three individual PhD projects are available

**ESR1: Run-time optimization**

**ESR2: Compiler technology**

**ESR3: Near-memory processor design**

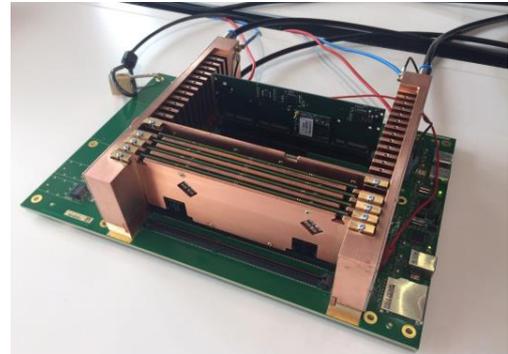
These three projects complement each other to cover the wide spectrum of aspects related to the following research objectives that build upon each other:

1. **Analysis** of Big data workloads, their key algorithms, their complexity in terms of memory, compute and I/O operations, their data locality, their parallelization potential, their mappings to various platforms, possible algorithmic optimizations, etc. The purpose is to obtain a detailed understanding of their characteristics, and their static and dynamic processing requirements (ESR1+2+3).
2. **Modelling** of selected Big data workloads, modelling of conventional computer architectures and of potential novel architectures based on near-memory computing, and modelling of the mapping of the workloads on those architectures. Objective is to enable a huge design space exploration, but still with sufficient detail based on accurate predictions of power consumption and performance (ESR1+2+3).
3. **Development** of techniques for partitioning, mapping, and compiling Big data workloads on a hybrid HPC system combining conventional processing elements with near-memory computing capabilities (ESR2). Development of techniques for run-time optimization of the performance and power consumption (ESR1). Development of a system-level and accelerator level architecture for a near-memory computing device integrated into a hybrid HPC system (ESR3).
4. **Realization** of a near-memory computing tool set and ecosystem including compiler, debugger, performance analysis, and run-time optimization tools (ESR1+2), and a near-memory computing device implementation in a hardware description language (ESR3).
5. **Translation** of the expertise, models, tools and architecture, into a small-scale demonstrator of a computing system supporting near-memory computing (ESR1+2+3). This demonstrator will be integrated into an emerging ecosystem for HPC technologies, which increases the commercial relevance of the developed near-memory computing tool set and architecture while, at the same time, allowing evaluation of its application to a wide range of real-world problems. The latter is a key element of the proposed cutting-edge research program and will be instrumental for realizing break-through innovations.

The training is structured individually for each ESR based on a personal career development plan which covers scientific, personal and transferable skills. The ESRs will be employed for an initial period of three years by the Eindhoven University of Technology in the Netherlands, which will also award the PhD degrees. If successful, the employment will be extended by a **fourth year**. Each ESR will do secondments

at IBM Research GmbH in Switzerland (for about 20 months) and at ASTRON in the Netherlands (for about 4 months).

As part of the NeMeCo project, the three ESRs will have access to an exceptionally wide range of state-of-the-art server and supercomputing technologies, including an on-site BlueGene BG/Q system, a collection of OpenPOWER hardware, various commercial GPUs, FPGAs, and DSPs, as well as technologies that are not on the market yet, such as the world's first hot water cooled 64-bit microserver<sup>1</sup> and an accelerator platform that is based on the direct attachment of FPGAs to the memory interconnect of a commercial server processor<sup>2</sup>.



*Hot water cooled 64-bit microserver*

In addition, the **DOME** project<sup>3</sup>, in which ASTRON and IBM jointly perform fundamental research on large-scale green Exascale computing for the Square Kilometre Array (SKA) radio telescope, offers the ESRs a unique opportunity to get experience with an “extremely Big”-data application, involving the processing of **Exabytes** of astronomical data collected by hundreds of thousands of antennas and dishes for exploring the universe. The SKA will become the biggest radio telescope on earth requiring enormous compute power when it becomes operational in the next decade.



*Artist's impression of the Square Kilometre Array (SKA) radio telescope*

**Image credits: Swinburne Astronomy Productions for SKA Project**

### **Job requirements**

We are looking for highly motivated candidates having a master's degree with excellent grades in a relevant field (e.g. Computer Science, Electrical Engineering). Also required are solid programming skills (e.g., in C or C++) and good English proficiency. According to the Marie-Curie regulations, candidates shall, at the time of recruitment, be in the first four years of their research careers, and have not been awarded a doctoral degree. They also must not have resided or carried out their main activity (work, studies, etc.) in the Netherlands for more than 12 months in the 3 years immediately preceding the time of recruitment.

### **Conditions of employment**

- a challenging job in a dynamic and ambitious university and a stimulating internationally renowned research environment;

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<sup>1</sup> <http://www.research.ibm.com/labs/zurich/microserver>

<sup>2</sup> <http://openpowerfoundation.org/presentations/near-memory-acceleration-on-the-contutto-card>

<sup>3</sup> <http://www.dome-exascale.nl>

- full-time temporary appointment for 3 years, which will be extended with one year if it is successful;
- gross salary between € 2.125,00 and € 2.717,00;
- an extensive package of fringe benefits (e.g. excellent technical infrastructure, the possibility of child care and excellent sports facilities);
- On top of the normal conditions you will receive the Marie Curie benefits.

### **Information and application**

#### *Information:*

- For more information about the project and any informal enquiries, please contact dr.ir. J. van Lunteren (jvl@zurich.ibm.com), ir. J. van Daltsen (J.v.Dalsten@tue.nl) or prof.dr. H. Corporaal (H.Corporaal@tue.nl).
- For information concerning employment conditions you can contact Mrs. W.W.K. van Eck - de Vries (W.W.K.v.Eck@tue.nl.)
- More information on employment conditions can be found here: <http://www.tue.nl/en/university/working-at-tue/working-conditions/>.

#### *Application:*

If interested, please use 'apply now'-button at the top of this page. You should upload the following:

- a detailed curriculum vitae, a letter of motivation and portfolio with relevant work;
- a cover letter explaining your motivation and suitability for the position;
- a detailed Curriculum Vitae (including a list of publications and key achievements in research project(s));
- contact information of two references;
- copies of diplomas with course grades;

Candidates will be selected based on graduation mark and proficiency at university including consideration of the reputation of the university, relevant experience and skills, writing skills and publications, work experience as well as performance in relevant modeling exercises and interviews. Applications from women, who are currently under-represented in this area, will be particularly welcome. If male and female candidates have the same qualifications, preference will be given to female candidates.

Please note that applications for all three projects are allowed. Please list the projects in order of interest in your application.

Please keep in mind; you can upload only 5 documents up to 2 MB each!

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