POLITECNICO DI MILANO

PhD in INGEGNERIA DELL'INFORMAZIONE / INFORMATION TECHNOLOGY - 38th cycle

Research Area n. 1 - Computer Science and Engineering

PARTENARIATO PNRR Research Field: ON HOW TO ENABLE FUTURE GENOMICS COMPUTATION USING HARDWARE/SOFTWARE CODESIGN METHODOLOGIES FOR QUANTUM COMPUTING INFRASTRUCTURE

Monthly net income of PhDscholarship (max 36 months)
€ 1400.0
In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Quantum computing is one of the major challenges in computer architectures and generally of computer science in the last decade. During the history of computer science, High Performance Computing systems continuously improved in computational power, memory speed and interconnection effectiveness, achieving a level of performance unforeseeable a decade ago. However, we are now reaching a level in which it is much harder to push the limits and to advance beyond the state of the art, by finally breaking the exascale wall. Several research projects throughout the years tried to exploit in turn massive parallelism, distributed software execution, specialized hardware accelerators, reconfigurable computing and heterogeneous computing, which is now the most promising paradigm in the exascale journey. All these efforts have been necessary in the process of advancing the computational power of HPC systems, but the massive amount of resources needed to reach one exaFLOPS demands applications, management software and in general HPC tools that hardly reach completeness and efficiency only at design time. Within this context, it is emerging the need for a fresh new approach to the way systems are designed and used by advancing the state of the art in system software and management for drastically

	more complex node architectures where quantum hardware will be included in computing systems as accelerators wich will not replace classical processing element but they will be coupled with them as it happened, like GPUs and FPGAs.
Methods and techniques that will be developed and used to carry out the research	Recent advancements in genomic research allow to perform multiple analysis on DNA. Ranging from personalized medicine, where the goal is to create drugs that are shaped on the DNA of the individual, to agrigenomics, where it is possible to create more robust plants that can resist as an example, to climate change.In this scenario, where there is a huge amount of data to process and the algorithms are particularly compute intensive, general purpose architectures have demonstrated to be inefficient. The research program aims at creating software/hardware systems that adapts their behavior basing on the working environment where quantum hardware will be included in computing systems as accelerators to enable such complex computation.This scenario will consider quantum processing elements as special-purpose accelerators used to solve specific domain problems. At the beginning the systems will be composed of CPUs paired with a hardware accelerator, in particular an FPGA and GPU devices to simulate quantum processing elements. This will impact several aspects of the computer science, as an example the development of libraries and development frameworks to access quantum accelerators by domain experts knowing where quantum will be useful, as done with GPUs. We have to enable "backend developers" to gain a deeper understanding on how to use quantum computing to accelerate computations, which leads to the development of advanced computational tools focused on measuring performance, profiling applications, co-design quantum-classical systems, etc. Furthermore, we do have also to properly manage the runtime management of such new complex heterogenous quantum-enabled computer architectures.
Educational objectives	The research will be carried out in the NECSTLab.

	Because of the collaborations established through the years, working within this lively and stimulating academic and research environment, the doctoral student will become a skillful system designer, with expertise in both advanced computer architectures and computer science methods.
Job opportunities	The candidate, at the end of his/her PhD will have several job opportunities, just two present two examples: continuing working on the methodology aspects by pursuing a postdoc career, being hired by a company working in the research topic developed during the PhD.
Composition of the research group	0 Full Professors 1 Associated Professors 1 Assistant Professors 1 PhD Students
Name of the research directors	Marco Santambrogio

Contacts
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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
This PhD project meets the programmatic directions of different of the main horizontal pillars of the PNRR-Next Generation Italy, NextGenerationEU, Spoke 10: Quantum Computing and in particular it is coherent with the "HPC National Center on HPC, Big Data and Quantum Computing" Mission 4 Education and Research LIST OF UNIVERSITIES, COMPANIES, AGENCIES AND/OR NATIONAL OR INTERNATIONAL INSTITUTIONS THAT ARE COOPERATING IN THE RESEARCH: MIT; Berkeley; NVIDIA4; AMD-Xilinx

EDUCATIONAL ACTIVITIES (purchase of study books and material, including computers, funding for participation in courses, summer schools, workshops and conferences): financial aid per PhD student
5.707,13 Euro per student

TEACHING ASSISTANTSHIP: (availability of funding in recognition of supporting teaching activities by the PhD student)
There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.

COMPUTER AVAILABILITY: individual use

DESK AVAILABILITY: individual use