POLITECNICO DI MILANO

PhD in INGEGNERIA DELL'INFORMAZIONE / INFORMATION TECHNOLOGY - 41st cycle

Research Area n. 1 - Computer Science and Engineering

THEMATIC Research Field: HARDWARE-SOFTWARE CO-DESIGN FPGA-BASED SYSTEMS: FROM EFFICIENT TUMOR DIGITAL TWIN TO SPACE SYSTEMS

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	Hardware capabilities are increasingly shaping the direction of scientific progress, leading to the phenomenon known as the “hardware lottery.” This term refers to the tendency of research ideas to gain prominence not necessarily because of their intrinsic scientific merit, but due to their alignment with the capabilities and constraints of existing hardware platforms. Novel hardware–software co-design methodologies offer a promising path to overcoming this limitation. By enabling fast and iterative design-space exploration of potential microarchitectural solutions, they make it possible to decouple innovation from specific hardware constraints. Moreover, rapid algorithmic evolution can drive equally agile hardware adaptation, fostering systems that can efficiently respond to new or unforeseen computational demands. The primary objective of this research is to explore hardware–software co-design approaches for tailoring heterogeneous applications to complex and adaptable computing systems. Field-Programmable Gate Arrays (FPGAs) will serve as the core enabling technology, supporting fast iteration cycles and domain-specific specialization across diverse application areas. Two application domains will guide experimental and

	methodological development: 1. Biomedical systems: The research will investigate a co-designed toolchain for heterogeneous FPGA-based systems aimed at developing a tumor microenvironment (TME) digital twin simulator for cancer treatment planning. The focus will be on optimizing both computational performance and resource utilization to achieve a balance between computing power and cost efficiency. 2. Space systems: Many computational patterns found in numerical TME simulations—such as matrix operations and iterative solvers—also appear in spacecraft computing, particularly in interplanetary guidance and vision-based Earth observation. The research will thus explore how the proposed methodological framework can be adapted to similar computational kernels operating in distinct domains, enabling reusability and adaptability across biomedical and aerospace applications.
Methods and techniques that will be developed and used to carry out the research	The research will involve the study of specialized domains within biomedical and aerospace computing systems, where FPGA technology serves as the common foundation. The methodology will focus on system-level performance modeling to identify and analyze bottlenecks in the target applications of interest. Building on this analysis, the candidate will develop an automation toolchain to maximize hardware–software co-design opportunities, identify key performance indicators, and rapidly iterate over alternative architectural designs. FPGA-based heterogeneous systems will constitute the core enabling technology. The computing platform will integrate techniques for developing specialized systems through the use of High-Level Synthesis (HLS), Hardware Description Languages (HDLs), Domain-Specific Languages (DSLs), and system-level software.
Educational objectives	1) Gain expertise in theoretical and practical understanding of modern computing systems, their design methodologies, especially with reconfigurable platforms such as FPGAs. 2) Collaborate in interdisciplinary teams, integrating knowledge and contributions from biomedical, computer, and aerospace engineering.

	3) Develop analytical and experimental skills to evaluate system performance, reliability, and energy efficiency 4) Training in scientific communication and collaboration, enabling participation in international research projects and dissemination of results through high-impact publications.
Job opportunities	FPGA and Computing Systems experts are among the most growing in-demand jobs in the computer science and engineering field. They have the unique capabilities of conjugate hardware and software expertise, that make their figure invaluable in across the whole world.
Composition of the research group	1 Full Professors 0 Associated Professors 1 Assistant Professors 3 PhD Students
Name of the research directors	Prof. Davide Conficconi, Marco D. Santambrogio

Contacts
davide.conficconi@polimi.it

Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents	--

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
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. 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:
1st year: Yes
2nd year: Yes
3rd year: Yes

CancerScan/ GA 101186829