Massivizing Computer Systems: VU on the Science, Design, and Engineering of Distributed Systems and Ecosystems*

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1 EXTENDED ABSTRACT

Wherever we look, our society is turning digital. Science and engineering, business-critical and economic operations, and online education and gaming rely increasingly on the effective digitalization of their processes. For digitalization to succeed, societal processes must leverage efficient computer systems, effectively and efficiently integrated into larger ecosystems, managed primarily without application developer and even client input. However successful until now, we cannot take these ecosystems for granted: the core does not yet rely on sound principles of science and design, and there are warning signs about the scalability, dependability, and sustainability of engineered operations. This is the challenge of massivizing computer systems.

In this talk, inspired by this challenge and by our experience with distributed computer systems for over 15 years, we focus on understanding, deploying, scaling, and evolving computer ecosystems successfully. We posit we can achieve this through an ambitious, comprehensive research program, which starts from the idea that we can address the grand, fundamental challenge by focusing on computer ecosystems rather than merely on (individual, small-scale) computer systems. To this end, we define (distributed) computer ecosystems and differentiate them from (distributed) computer systems. We formulate principles and introduce a reference architecture for computer ecosystems supporting diverse workloads - AI/ML, big data and graph processing, online gaming and metaverse, and business-critical and serverless - and diverse resources and back-end services across the computing continuum. We synthesize a framework of resource management and scheduling (RM&S) techniques, which we argue should be explored systematically in the next decade. We show early results obtained experimentally, through controlled real-world experiments, long-term observation, and what-if analysis of short- and long-term scenarios using the OpenDC digital twin for datacenters.

This vision aligns with the Manifesto on Computer Systems and Networking Research in the Netherlands (Iosup et al., 2022), which the speaker co-leads. Many of our examples come from real-world prototyping and experimentation, grand experiments in computer systems, and/or benchmarking and performance analysis work conducted with the Cloud group of SPEC RG (SPEC RG Cloud Group, 2020).

This is a call to the entire community: there is much to discover and achieve, and to get meaningful, long-lasting results we need to form a community spanning distributed systems, performance engineering, software engineering, and more. We also need to train the next generation of ethical professionals.

BRIEF BIOGRAPHY

Dr.ir. Alexandru Iosup is a full professor at Vrije Universiteit Amsterdam (VU), a high-quality research university in the Netherlands. He chairs the Massivizing Computer Systems research group at the VU and is a visiting researcher at TU Delft. He is also elected chair of the SPEC-RG Cloud Group. His work in distributed systems and ecosystems led to high scientific impact, with applications in cloud computing, big data, scientific and business-critical computing, and

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online gaming and the metaverse. His research has received prestigious recognition, including membership in the (Young) Royal Academy of Arts and Sciences of the Netherlands, the Netherlands ICT Researcher of the Year award, and a Ph.D. from TU Delft. His leadership and innovation in education led to various awards, including the prestigious Netherlands Higher Education Teacher of the Year. He received a knighthood for cultural and scientific merits.

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