Faculty of Science and Engineering

Profile report: Hardware-Software co-design (Hardware-Software co-creatie)

- Discipline: Computer Science
- Level: Tenure-track Assistant Professor or Associate Professor
- Fte: 1,0 fte

1. Scientific discipline
The majority of contemporary software-intensive systems are holistic hardware/software solutions built into devices that are not necessarily recognised as computerised appliances. The tight hardware/software collaboration, however, determines the functionality and the perceived quality of these systems, e.g., cars, home appliances, medical devices. The above applies for individual systems, subsystems, systems of systems, product lines or even entire enterprises. Integrating the design of software and hardware draws on a wide variety of scientific fields such as software engineering, hardware engineering, (embedded) systems design, distributed systems, information systems and fundamental computing science.

2. Vacancy
This position is opened by the Board of the Faculty in the context of the sector plans and will be embedded in the Bernoulli Institute, basic unit Software Engineering or Computer Architecture, depending on the candidate's profile. The position falls within the framework of 'Career Paths in Science 4' ('Bèta's in Banen 4'). Please see link for criteria and conditions.

3. Selection committee (BAC)

Prof. dr. J.B.T.M. Roerdink	Scientific director Bernoulli Institute and Professor Scientific Visualization and Computer Graphics
Prof. dr. A. Lazovik	Program director (BSc) Computer Science
Prof. dr. ir. P. Avgeriou	Professor Software Engineering
Prof. dr. ir. G. Gaydadjiev	Professor Computer Architecture
Prof. dr. R. Carloni	Associate professor Robotics
Prof. dr. A. Koziolek	Karlsruhe Institute of Technology
T. Rangnau	Student member

HR advisor:
N.F. Clemencia-Lokai

4. Research area
The engineering of software-intensive systems is concerned with the overall system organization rather than dealing separately with the software and the hardware sub-systems. This research area has recently experienced substantial growth due to the

emergence of Cyber-Physical Systems, Cloud/Fog/Edge Computing and the Internet of Things. This position is also important in the context of the *Groningen Cognitive Systems and Materials Center* (CogniGron), since designing novel materials for cognitive systems requires a holistic approach that takes both software and hardware into account.

There are various research challenges in engineering software-intensive systems. These types of systems are typically heterogeneous and often have to satisfy real-time constraints. They are minimally comprised of a hardware architecture and embedded code that needs to operate under the constraints of the hardware and the operating system. They are often characterized as critical systems, e.g., safety-critical or mission-critical. High levels of security are also of paramount importance, as many software-intensive systems store and process sensitive data.

The two areas of software and hardware engineering, each having a rich history and body of knowledge, in combination can provide better solutions to the fundamental problem of design, verification and management of software-intensive systems, and taming their complexity. That is the only way to ensure that these systems enable and facilitate our knowledge society that increasingly depends on them. Furthermore, these two areas will reinforce our current offering in undergraduate and graduate curricula in Computer Science. This is not simply a matter of covering a larger part of the Informatics Body of Knowledge. Essentially, it will help meet the demand for skilled ICT professionals in the high-tech industry both regionally and nationally. It will enable us to leverage the opportunity of increasingly growing numbers in student cohorts, by supplying the ICT job market with graduates equipped with both hardware and software skills.

5. Embedding: institute (and base unit)

The Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence is part of the Faculty of Science and Engineering (FSE). The profile of the institute centers around modelling, computation, and cognition with a focus on science and technology, keeping a balanced mix of fundamental and applied aspects. The Bernoulli Institute comprises five mathematics programmes, seven computer science programmes, and four artificial intelligence programmes. The constituting programmes participate in various national research schools and most of the PhD students are enrolled in an educational programme and take part in other activities offered by these schools. The Bernoulli Institute has a leading role in the cross-disciplinary research theme on Data Science and Systems Complexity (DSSC), and in the Groningen Cognitive Systems and Materials Center (CogniGron) within the Faculty of Science and Engineering.

The candidate, depending on his/her profile, will work in the group Software Engineering or the group Computer Architecture; both are embedded in the Bernoulli Institute of the Faculty of Science and Engineering. The group leaders are respectively Prof. dr. Avgeriou and Prof. dr. ir. Gaydadjiev. The candidate's research is expected to also connect with the robotics research in the Autonomous Perceptive Systems group and the Systems, Control and Applied Analysis group at the Bernoulli Institute.

6. Local and (inter)national position

Nationally, most universities have strong research efforts in software engineering. In particular, there are strong Software Engineering research groups at all three technical universities, as well as the universities in Amsterdam (both VU and UvA), Utrecht, Nijmegen and Leiden. The Software Engineering group in Groningen is among the leaders in the field of software architecture and empirical software engineering in general. Furthermore, the Software Engineering group participates in the Dutch Research School in Programming and Algorithmics (IPA), which has a strong tradition in Software Engineering, with Avgeriou sitting in the IPA board. In addition the group also participates in the Dutch National Association for Software Engineering (VERSEN), where Avgeriou also sits in the board. At the international level the research group is involved in several EU research projects with the high-tech industry (e.g., VISDOM - Visual diagnosis for DevOps software development, SDK4ED - Software Development toolKit for Energy optimization and technical Debt elimination), has established collaborations with major high-tech companies (Philips Research, ASML, Canon) and technological institutes (Astron, TNO, Software Engineering Institute at Carnegie-Melon University), and has cooperation and exchange programmes with many universities (e.g., Vancouver, Leuven, Linnaeus, Milano, Gothenburg). Finally, the senior members of the group (Avgeriou, van der Storm) act as Editor-in-Chief in top journals in the field, frequently give keynotes and invited talks in international conferences, serve in numerous Program and Steering Committees of international conferences, and receive often Best Paper awards in top conferences.

The Computer Architecture group was started recently in the context of GogniGron with the purpose of researching novel non-von Neuman and non-digital computing systems. In addition, the group will continue the well-established research lines on reconfigurable custom computing accelerators and parallel memory architectures, since both topics remain relevant for designing contemporary computer systems. In the Netherlands, the group collaborates with TU Delft on novel in-memory computing systems and reconfigurable HPC; University of Leiden and UvA on embedded systems design; Erasmus University on large scale brain simulation and implantable systems; SurfSara on reconfigurable acceleration of scientific computing applications; and Nikhef on low latency solutions for scientific experiments. Internationally the group closely collaborates with Imperial College (reconfigurable computing), ETH (advanced memory systems), Stanford (novel substrates for dataflow acceleration), BSC (programmability of reconfigurable HPC systems) and Politechnico di Milano (design tools and methodologies). The group's long-lasting industrial collaboration involves Google, AMD Research, Maxeler Technologies Inc, BitWise Ltd on various topics of computing systems design including hardware/software co-design. Gaydadjiev holds best papers from among others the International Conference on Supercomputing (ICS) and USENIX and was among the founding members of the FP7 Network of Excellence on High Performance and Embedded Architecture and Compilation (HiPEAC) and member of its Steering Committee for many years. He is also a member of the Steering Committees of the IEEE International Conference on

Computer Design (ICCD); and the International Conference on Embedded Computer Systems: Architectures, Modeling and Simulation (SAMOS).

7. Expected contributions to research

The candidate is expected to extend his/her research program in the field of software-intensive systems, acting as a link between the software engineering and hardware engineering perspectives. The research should compete on a worldwide level and lead to publications in top journals. Obtaining substantial external funding for PhD projects is pivotal. Supervision of PhD students is an important part of the envisioned research activities.

8. Expected contributions to teaching

The candidate is expected to contribute to the bachelor and master programs of the faculty, in particular those in Computer Science. He/she will also be actively involved in the development of new courses related to the research area. Furthermore, he/she will supervise final research projects of bachelor and master students.

9. Expected contributions to the organization

The candidate is expected to contribute in an active manner to the management and organizational tasks of the institute. At the level of Faculty of Science and Engineering, he/she will contribute to the organization of the faculty, for example by participating in working groups and committees, in the fields of teaching, research and management. The candidate shall participate in relevant national and international organizations.