

## Faculty of Science and Engineering

### Profile report: Embedded Systems

- Discipline: Computing Science
- Level: Tenure-track assistant professor with an education profile
- Fte: Full time (0.8-1.0 FTE)

#### 1. Scientific discipline

Embedded Systems is the field of designing specialised computing systems that are built into larger technical systems used to implement a dedicated function and determine specific functionality, control and enhance the operation of the overall system. The discipline of embedded systems involves different aspects: analysis and design techniques, tools and methodologies, and application domain requirements. The National Science Foundation (NSF) defines an embedded system as follows:

*“An embedded system is an application-specific computing system found inside products such as home appliances, mobile handheld personal systems (e.g., cellphones, health monitors, assistive devices, cameras, electronic games), instrumentation, automobiles, aircraft, missiles, satellites, and nuclear power plants. Embedded systems are distinguished from general-purpose computing systems by their well-defined functionalities and stringent design constraints. Embedded systems encompass all of the four fundamental operational capabilities required to interface with the world at large—sensing, computing, control, and communication—, which can now be integrated with single-chip multiprocessors. The ability to combine operational capabilities in this way has opened up new possibilities for application-specific computing”.*

#### 2. Vacancy

This position is opened by the Board of the Faculty (ref: PT/gl/22/00181) and will be embedded in the Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence, basic unit Computer Architecture. The criteria and conditions pertaining to the position are described in the document [‘Assistant professor with an education profile’](#).

#### 3. Selection committee (BAC)

Prof. dr. N. Taatgen (chair)	Professor of Artificial Intelligence, Bernoulli Institute Research Director
Prof. dr. ir. G. Gaydadjiev	Professor of Innovative Computer Architectures
Prof. dr. A. Lazovik	Programme and Education Director for Computing Science
Prof. dr. H.H. Hansen	Professor of Formal Modeling
Prof. dr. ir. R. Verstappen	Education Director for Mathematics
Dr. ir. M. Taouil	External member, Dependable Computing Systems TU Delft, the Netherlands
Niels Bügel	Student member

#### *HR advisor:*

M. Laning, MSc

#### *Advisors:*

Dr. A. Rastogi

A.G. Gringhuis, MSc

Assistant Professor in Software Engineering

Policy Officer Bernoulli Institute

#### **4. Area of expertise**

The topic of Embedded Systems is an essential part of any modern computing science programme and brings together all fundamental and specialised topics in computer science due to its cross-cutting nature and impact. Moreover, designing embedded systems requires specific skills needed to identify the relevant properties of the application domain and translate them into clear specifications. The recent developments in IT and computing systems have resulted into a prominent role for embedded systems and devices. These systems require better understanding of the embedded systems hardware and pose very specific requirements on the way software is developed. As a consequence, in the focus areas of the Bernoulli Institute of Data Science, Machine Learning and Software (within the sector plan for Computer Science in the Netherlands) we acknowledge the need to place more emphasis on the topic of Embedded Systems.

Embedded Systems has not been taught in our Computer Science Programs (bachelor or master). This is a clear disadvantage in our current curriculum that is not in line with the advances of computing technology. Our students have also indicated the same on several occasions. The role of embedded systems is prominent and becoming more and more challenging (embedded devices are heavily interconnected, computation, memory and data storage requirements are very tight, there is a continuous push for more and more functionality and these trends are accelerating), while at the same time educational needs have not been adequately addressed. Moreover, we believe that the topic of Embedded Systems will be a very good motivation for high school students to decide for a study in Computing Science at our university. Given the widely recognized importance of Embedded Systems and the increasing intake of students in computer science educational programs, the institute needs to strengthen both its teaching activities and research on that topic.

In addition to teaching basic and advanced courses on Embedded Systems, the candidate will coordinate the development of a consistent learning trajectory in Embedded Systems across the related courses on relevant topics, including the introduction of novel teaching methods for learning embedded systems, real-time systems, operating systems and energy efficient computing systems.

#### **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 centres 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 research groups, seven computer science groups, and four groups in the field of artificial intelligence. The constituting research groups 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 aims to strengthen the current research portfolio in Mathematics, Computer Science and Artificial Intelligence by expanding both in fundamental areas that have a prominent role in education as well as in directions that are essential for new technological and societal developments.

The Bernoulli Institute has a leading role in the recently established cross-disciplinary research theme on Data Science and Systems Complexity (DSSC) within the Faculty of

Mathematics and Natural Sciences. This concerns a research cluster of 60+ researchers in a number of basic disciplines (mathematics, computer science, artificial intelligence, systems & control, engineering, astronomy) and various scientific application domains. The ambition is to understand and solve big data problems by exploiting the joint perspectives from both data science and complexity science. The institute is also heavily involved in the Groningen Cognitive Systems and Materials Center (CogniGron), which is a joint venture between the Bernoulli Institute and the Zernike Institute for Advanced Materials. It comprises researchers from materials science, physics, chemistry, mathematics, computer science and artificial intelligence. The centre provides structure, coherence, and visibility for a joint research program in the direction of cognitive systems and materials.

Embedded Systems is a cross-cutting topic integrating many research topics in the field of computer science and as such the Computer Science department has positioned the topic of Embedded Systems in its Computer Architecture group, which has prominent research and education activities in computer architecture, parallel computing and application specific computing. Therefore, this position will be embedded in the Computer Architecture group.

## **6. Local and (inter)national position**

At the national level the Bernoulli Institute participates in the Dutch computer science research schools Advanced School for Computing and Imaging (ASCI), Dutch Research School in Logic (OZSL), the School for Information and Knowledge Systems (SIKS), and the Dutch Research School in Programming and Algorithmics (IPA), the first being the most relevant for the position. At the international level the BI is involved in several EU research projects (e.g., Human Brain Project, Smart Homes, Visual Analytics), has established collaborations with major companies (Philips Research, IBM) and technological institutes (Astron, TNO, NLR, ECN), and has cooperation and exchange programmes with many universities (e.g., Rome, Leipzig, Birmingham, Barcelona, Ghent, ESIEE-Paris, Tampere).

In Computer Science, the BI has a strong position (as evidenced by participation in NWO and EU projects, publications in renowned journals and conferences, memberships of editorial boards and program committees, conference chairing, etc.). Its expertise lies in intelligent systems (biologically inspired computational modelling, machine learning, morphological image processing); pervasive middleware and energy distribution infrastructures; architecting of software-intensive systems and object-oriented software design; adaptive information systems, middleware, enterprise, services and cloud computing and autonomous process performance improvement; computer architecture, microarchitecture and reconfigurable computing; data and information visualisation, and visual analytics.

At the national level, there are groups with explicit focus on the broader topic of embedded systems at the [TU Delft](#), at the Eindhoven University of Technology (TU/e) (three different laboratories: [1](#), [2](#), [3](#)), at the [University of Twente](#), at the [University of Amsterdam](#), and at the [University of Leiden](#). The Eindhoven University of Technology hosts the [Embedded Systems Institute](#) (ESI). ESI closely collaborates with ASML, Philips, Vanderlande, itec, Thales, Canon and many other industrial leaders in the Netherlands. In addition, ESI has a strong partnership with TNO on the very same the topic of Embedded Systems.

Even though BI has no specialised research focus on Embedded Systems yet, this field is extremely important. This education TT position will allow us to strengthen our expertise in education on a very relevant topic, close the existing gap in our educational programmes and as a result meet the need to provide up-to-date education to our students.

### **7. Expected contributions to teaching**

The impact of Computing Systems on our modern society is unquestionable, and there is a huge demand from industry for more and more engineers and researchers in the field of Embedded Systems and in particular with focus on highly distributed information systems that integrate mobile devices and systems for various purposes. The candidate is expected to contribute to teaching courses with focus on Embedded Systems, real-time systems and energy efficient computing systems, as well as related courses on broader topics. E.g. computer architecture, security and privacy and different types of application domains for Embedded Systems (mobile and wearable devices, IoT, Cloud and Edge Computing), and other practical applications of embedded systems. As such, various labs have to be developed and implemented.

The candidate is expected to take the roles as courses coordinator, lecturer, and examiner. Furthermore, the candidate is required to ensure the high quality of education on the Embedded Systems topic within the CS programs by overlooking all the related education activities. The selected candidate is expected to contribute to both extending the CS curriculum with courses, lectures and student projects to teach those important skills as well as to develop new teaching methods for CS education with focus on the profile topics of this position. To foster educational developments, the candidate will apply for grants that support teaching innovation.

In order to facilitate the connection between high school students and the Computing Science programmes, the candidate is expected to organise activities to raise the awareness of prospective students from high schools, e.g., by engaging in dedicated educational activities at the high school level and the organisation of introductory events for high school students.

### **8. Expected contributions to research**

The candidate is expected to contribute to the ongoing research activities of the Computer Architecture research group with focus on Embedded Systems. There is room for various research directions, and the specific direction will depend on the profile of the candidate. The co-supervision of PhD students will be a concrete mechanism for contributing to the group's research efforts. Additionally, the candidate will carry out research in the field of education, and develop and adopt novel didactic methods used in teaching of Embedded Systems.

### **9. Expected contributions to the organisation**

The candidate is expected to have an active interest and to provide a positive contribution to the management and organisational tasks of the institute. At the level of FSE, the candidate will contribute to the organisation of the faculty, for example by participating in working groups and committees in the area of education. The candidate will participate in relevant national and international organisations.