# I/O magazine

ICT RESEARCH PLATFORM NEDERLAND

ICT-ONDERZOEK
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**PAUL KLINT**

# Towards a flexible research workforce

**How should we respond to the growing confidence gap between Europe and the US?**

The US undermines the 80-year-long partnership with Europe. Data of the Dutch government resides on servers of US tech firms. The Dutch government cuts university budgets and hundreds of researchers are being fired. Mario Draghi warns that Europe is losing the worldwide competition and should innovate. Are start-up funding and creating European tech giants the answer to all of this?

I don't think so. We should indeed become more resilient and self-supporting, but how? It is common wisdom that many good ideas originate in Europe, but their commercialisation happens in the US; at a high price for social security, the natural environment, and democracy, as we are currently witnessing.

Let's focus on a Dutch solution that could also serve as a model for Europe. Every year, we waste hundreds of talented researchers because they cannot find a job in academia after completing their PhD. In addition to this, the Dutch government almost exclusively focuses on research that is co-funded by industry, but in many cases, industry is not interested, and as a result, many promising research projects have not even started.

Here is my proposal: give – after a basic screening – every researcher with a completed PhD a permanent position as a research associate at a university or research institute for a fair salary. But there is a catch: it is only guaranteed that you can do research for 2-3 days a week. The other 3-2 days, you may be asked to perform other duties like helping out on research projects outside your specific expertise, teaching at all levels (including primary and secondary education), or working on government projects. You are also – under certain conditions – encouraged to create a start-up.

The benefits are considerable: no talent is wasted, we create a flexible research workforce, automatic knowledge transfer to society is guaranteed, and start-ups can be created without extra bureaucracy. The government gets access to more expertise and can make better policy choices. The pressure on senior researchers to write research proposals (with a very low acceptance rate) is reduced. Since the salary is fair but not spectacular, this scheme provides the opportunity for intrinsically motivated researchers to keep contributing to the public benefit.

What do you think: what are realistic conditions for creating such a flexible research workforce?

# TAPPING INTO A LARGER POOL OF TALENT

**The IPN working group Equity, Diversity, Inclusion (EDI) supports diversity and inclusion in computer science by raising awareness, open discussions and sharing experiences.**

**By Bennie Mols**
Images iStock, Ivar Pel, Tilburg University, University of Twente

**DIVERSITY IN ICT TRACK AT NWO ICT.OPEN**

Since 2022, the annual NWO ICT.OPEN conference has had a session on Diversity in ICT. This features invited talks that showcase achievements, explore opportunities and address ongoing challenges to promote greater equity and diversity in ICT. Additionally, a poster session highlights national and local initiatives to promote ICT diversity.

The Diversity and Inclusion session at ICT.OPEN 2023 celebrated the achievements of historical LGBTIQ+ pioneers such as computer visionary Alan Turing and game designer Danielle Berry. It also gave the stage to the new generation of ICT researchers who shared their experiences from within the LGBTIQ+ community in academia. The 2024 edition of the Diversity and Inclusion session at ICT.OPEN  included a talk by Shirley de Wit (TU Delft) on gender diversity and by Sylvia Stuurman (Open University) on neurodiversity.

This year, there will be four oral presentations by Mairieli Wessel, Anne Arzberger, Emeralda Sesari and Mae Sosto, and some posters.

'Not that long ago, ICT conferences with almost exclusively men were not that unusual', says Tanja Vos, professor in Software Engineering at Open University. 'But that is changing thanks to collective efforts', she says. 'People at such conferences were unaware of the lack of women and simply needed the matter to be pointed out to them.'

**Tanja Vos**

'People simply needed the matter to be pointed out to them'

A good example of this shift is the Bits&Chips Event in Eindhoven. When Vos was invited to join the programme committee, she noticed that efforts to improve gender diversity were already underway. Tijs van der Storm and Jurgen Vinju from VERSEN (VEReniging Software Engineering Nederland) had taken the initiative to make the speaker lineup more balanced, and they specifically reached out to her because of her role as chair of the IPN working group on Equity, Diversity and Inclusion (EDI).

**Ana Varbanescu**

'Hiring more diverse people does not equate to hiring those who deserve it less'

Together, they worked to include as many women as possible in the programme, an effort that highlights how concrete actions can drive meaningful change. 'The more people get used to seeing women in these positions, the closer we get to making diversity the norm rather than the exception', Vos emphasises.

## EDI achievements

The EDI working group meets four times per year and includes representatives from all Dutch universities as well as CWI and NWO. Vos shares chairing the EDI working group with Ana Varbanescu, associate professor at the University of Twente and affiliated with the University of

Amsterdam. 'One of the first initiatives', states Varbanescu, 'was to write a report with guidelines on how to increase the number of women in computer science.'

There is still a world to be gained in this regard. For instance, in 2022, the proportion of women in computer science education at universities was 25 percent, and in higher vocational education only 9 percent. 'And the higher up the career ladder you go, the lower the proportion of women becomes', Vos adds. A second concrete result was the creation of a booklet with successful stories of women who have done a PhD in computer science. Varbanescu: 'What inspired them to do a PhD? How do they look back on it? The report and the booklet are available on the working group's website.' The third major achievement of the EDI working group is the setting up of the EDI session at the annual NWO ICT.OPEN conference. Varbanescu: 'These sessions are well attended and well received.'

In the near future, the EDI working group plans to revisit their discussions with heads of departments on how to increase the proportion of women. However, this time round, the discussions will be expanded to cover LGBTQI+ and neurodiversity as well. Varbanescu: 'What is the present status for different groups? What are best practices? What are the problems underrepresented groups encounter? We really want to ensure that we get a good overview of what is happening and then collect the best practices in a document we will publish.'

Vos adds that the working group has also begun exploring neurodiversity and autism as important aspects of diversity. 'Last year at ICT.OPEN', she recalls, 'we had an invited keynote by Sylvia Stuurman, who conducts extensive research on autism. She explained that autistic people perceive the world differently and are constantly processing discrepancies between their expectations and reality. This can lead to increased stress and fatigue due to information overload. Whether they are students, PhD candidates, or colleagues, we should take this into account in our collaboration.'

## Conservative winds

Have Varbanescu and Vos already noticed conservative winds starting to blow in many Western countries? 'Those effects can be seen', says Vos. 'I notice it in my own environment. Some people now feel empowered to criticise diversity efforts, whereas they did not say anything in the past. Everyone is entitled to their opinion. We just need to ensure the discussion is conducted appropriately and respectfully. And then we are back to the diversity issue because that is what it is: respect for other people even if they are different from you in some aspect.'

Varbanescu's experience is similar. 'Some voices can be heard saying that diversity efforts are not meritocratic,

which is completely untrue. For example, I was hired at the University of Amsterdam as a McGillavry fellow [a special recruitment programme for top-level female talent]. There were 250 applicants for five positions. Therefore, this was, beyond doubt, a competitive process to select the best in the field. Everyone hired through this affirmative action has done amazing things, obtained key grants, and made a difference for the University of Amsterdam. I really wish universities would be more open about these successes. Yes, there is a backlash now, but we counter this with the fact that hiring more diverse people does not equate to hiring those who deserve it less. On the contrary, by broadening the spectrum of people we hire, we tap into a larger talent pool.'

## White paper

This year's session on Equity, Diversity and Inclusion at ICT.OPEN is co-chaired by Tim Steenvoorden and Çiçek Güven, assistant professor in the Cognitive Science and Artificial Intelligence (CSAI) department at Tilburg University. Güven says that she has always felt the urge to do something about increasing diversity and inclusion in the computer science community. 'One good way of contributing to diversity and inclusion efforts is to link them to what we do, research. We did that by organising a workshop at our department, bringing together researchers from various disciplines and universities. Following this workshop, we put together a white paper authored by a group of ten scientists from our department, each focusing on their specific area of expertise.'

The paper, entitled 'AI in Support of Diversity and Inclusion', highlights the importance of transparent, socially responsible and context-aware AI technology. It shows both the pitfalls of present AI tools and some case studies of how AI tools can support diversity and inclusion.

The first step in investigating how AI could support diversity and inclusion, explains Güven, is understanding AI's inner workings and limitations. 'For example, widely used large language models rely on existing data, and these data contain a lot of biases. AI algorithms used to hire people can have explicit biases in gender or age, but they can also have implicit biases like years of experience.'

It is also known that gender biases can propagate in language. Güven: 'The automatic translation of a gender-neutral statement might lead to introducing gender in the translation, for example, that beauty is automatically associated with a woman and cleverness with a man.' Irresponsible use of AI can introduce biases, but AI can also be used to detect and mitigate biases. That is also what the authors wanted to show in their white paper. 'One research project looked at the portrayal of migrants by media in ten different EU Member States', says Güven. 'Media reports turned out to be overly focused on asylum seekers and associated them with poverty and risks for

society. And in the portrayal of expats, white faces were overrepresented and Asian faces underrepresented.' A great example of how AI can directly contribute to more inclusion is the SignON project. In this project, AI researchers created an avatar that could translate spoken language into sign language, but also the other way

**Çiçek Güven**

'Widely used large language models rely on existing data, and these data contain a lot of biases'

around: translating sign language into spoken language. In this way, the avatar helps hearing, deaf, and hard-of-hearing people communicate.

Güven herself works together with the Zero Hunger and Zero Poverty Labs at Tilburg University. One of the projects Zero Hunger Lab participates in is called Child Growth Monitor, she explains. 'It involves using AI to detect malnutrition from images of children taken with a mobile phone, intended for regions with limited health-care access. However, the dataset of images of children are small in size, not representative or not publicly available. Therefore, we undertook a data collection initiative in Iraq to collect a more diversified dataset. With AI, we try to find solutions that help underrepresented or disadvantaged communities.'

**MORE INFORMATION**

IPN EDI working group:
**ict-research.nl/edi-working-group**

ICT.OPEN track:
**ictopen.nl/track-diversity-in-ict**

White paper 'AI in Support of Diversity and Inclusion':
**arxiv.org/abs/2501.09534**

# Enhancing leadership among computer scientists

By **Sonja Knols** Image iStock

**Starting this spring, IPN is organising leadership courses for computer scientists in the Netherlands. IPN board members Marieke Huisman and Gerard Barkema explain the ins and outs of this new course programme, which aims to contribute to a well-organised and strongly represented computer science field in our country.**



During a board meeting, the idea arose to organise dedicated leadership courses for computer scientists, Marieke Huisman and Gerard Barkema recollect. 'By the end of 2025, many of the current IPN board members will reach the end of their terms, and we were starting to think about who to replace them with.' 'In addition to that: we had noticed before that in many of the important policy bodies, both at a national and at a university level, computer science is underrepresented', Barkema adds, 'and that is a missed opportunity. By providing dedicated training to the computer science community, we hope to increase the visibility and influence of the field as a whole.'

## TWO CURRICULA

The course programme comprises two distinct curricula: one at a senior level, aimed at potential or new department heads, potential or new IPN board members, and professors who either possess or aspire to gain national influence. The other curriculum is aimed at juniors who are expected to be able to develop into academic leaders in the future: ambitious assistant professors with at least several years of experience, novice associate professors, and tenure trackers. The senior course takes place from March to June 2025 and includes four meetings focusing on key themes such as strategic HR policy, managerial craftsmanship, partnerships and organisational dynamics. The junior training course will start in spring 2026 and will consist of three meetings during which young talent will not only develop skills such as consortium building and public communication but also learn to take part in a project evaluation committee and shape their role as academic leaders. The aim is to establish the initiative for the longer run, with new senior and junior courses being organised after 2026 as well.

## SPECIFIC FOCUS

'We wanted to organise a dedicated course focused on the specifics of the computer science field', Huisman explains. 'Even when it comes to a general competence like HR management, there are some aspects in which our field differs from others', says Barkema. 'For example, it is very hard to find qualified people in our field since there is an enormous pull from industry.'

Besides providing insights on topics like 'How Dutch ministries work and how to influence their policies' or 'How to be successful in broad review committees', Barkema stresses that another important aim of the course programme is to exchange practices between different

> 'We hope to increase the visibility and influence of the field as a whole'

universities. 'People often get told that things simply work this way. The participants can broaden their views by hearing from others about their organisations.'

The first twelve researchers have recently started their senior course programme. Next year, the first juniors will be trained. 'We are very happy that this idea is now becoming a reality since we are convinced that it will benefit the community as a whole', Huisman says. Barkema: 'Other organisations like PRIO, which represents the ICT research groups at higher vocational institutes, are also interested in this model. Perhaps, in the future, they will join in.'

## NEWS FROM THE ROUND TABLE FOR COMPUTER SCIENCE

The Computer Science Round Table received updates from NWO on the recent acceptance rates of the Open Competition and Talent Programme. These figures do not look good for the computer science discipline at all, particularly not when it comes to Open Competition ENW-XS and M calls. The Computer Science Round Table requested a meeting with the Science board of NWO to discuss these worrying figures and see what measures can be taken to turn the tide.

## IPN DISTINGUISHED SERVICE AWARD

At NWO ICT.OPEN 2025, the first IPN Distinguished Service Award will be presented to its winner. This award is dedicated to people who have achieved distinction in one or more of the following ways: demonstrably contributing to the position of the IPN community in the context of NWO, other academic research disciplines, and the Dutch ministries of Economic Affairs, and/or Education, Culture and Science; showing extraordinary tenacity, ingenuity and/or resourcefulness in achieving funding for the IPN community; going well beyond the normal performance requirements expected of an individual research employee or a member of IPN and thus providing a model for others; and/or developing a funding programme beneficial to the IPN community of such depth and scope as to warrant special recognition.

## TOWARD A EUROPEAN SECTOR PLAN

IPN has initiated a proposal to establish a European Sector Plan in IT & Computer Science to support European competitiveness. This proposal has received many positive reactions from governmental, advisory and academic stakeholders. Based on this, IPN has decided to continue their efforts on this subject. As a next step, supported by NWO and Top Sector ICT, IPN will clearly demonstrate how many additional IT professionals the Dutch sector plan has brought so far to the labour market. The results will be used to update the current sector portrait, which, on a more strategic level, will be linked to themes like AI, security, strategic autonomy, well-trained professionals, and productivity.

## MORE COMPUTING POWER FOR SCIENCE

Dutch researchers' need for computational capacity is growing faster than the available capacity in our country. Investments are necessary to stay ahead. This is the main message of the report 'Computational Needs for Accelerated Scientific Discovery', issued by NWO and SURF.
The greater dependence on computational and data capacity for research and the increasing demand mean that investments are needed to maintain the global top position of Dutch scientific research. Given the efforts made by other countries, the report concludes that the national digital infrastructure needs to be strengthened.

# OPTIMISING UNTIL THE LAST DROP

**The high volume-high mix printing solutions from Canon Production Printing are complex multi-process print factories. The company invests heavily in this knowledge-intensive specialisation, which is considered to be a core activity for the future. Eugen Schindler and Roelof Hamberg from the R&D division explain the core technologies and how the technology roadmap is organised.**

**By Leendert van der Ent**  Images Canon Production Printing

'Being active in a high-wage country such as the Netherlands automatically comes with a challenge. You have to steadily improve productivity to remain competitive', says Eugen Schindler, System Architect Digital Transformation at Canon Production Printing in Venlo. This productivity regards several aspects: 'Our systems not only have to become more productive, but they also have to either become more widely applicable or easier to customise to customer requirements.'

## MULTIDISCIPLINARY CHALLENGES

Building these increasingly versatile and productive machines also requires the R&D process to become more efficient. 'At the same time', says Manager External Partnerships Roelof Hamberg, 'printing quality standards must always be maintained. This requires digital engineering on virtually all levels to mass-produce a new print system after producing ideally only one integral physical prototype. And that prototype is not only for testing, but also for early-stage design optimisation. Some 95 to 97 percent of embedded software, paper handling, heat management and many other characteristics are tested upfront, in digital models.'

Higher productivity on the system level, for instance, means early detection – or preferably prediction – of out-of-spec performance. 'Higher productivity and predictive maintenance means minimised downtime', Schindler concludes. 'And that is where we expect AI applications such as those being researched in the NWO Perspectief programme FIND (see page 19) to fit into our development programmes. Processes such as paper handling or printhead nozzle clog up – with the potential to cause downtime – are influenced by a large number of mutually influential process parameters.'

# CANON PRODUCTION PRINTING

Canon Production Printing in Venlo develops and produces high-throughput digital printing solutions. The inkjet solutions used for applications such as full colour (photo) book printing-on-demand and personalised high-volume mailings of up to thousands of pages per minute are highly automated 'factories' of up to three meters in height and twenty meters in length. Textured and personalised printing of industrial products such as furniture, tiles and consumer packaging is a growing field of application.
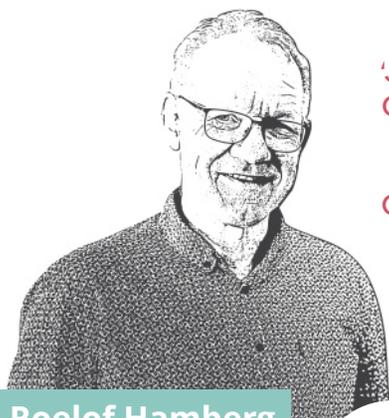
'SOME 95 TO 97 PERCENT OF EMBEDDED SOFTWARE, PAPER HANDLING, HEAT MANAGEMENT AND MANY OTHER CHARACTERISTICS ARE TESTED UPFRONT, IN DIGITAL MODELS'

**Roelof Hamberg**

**Eugen Schindler**

'OUR TECHNOLOGY ROADMAP COVERS TECHNOLOGIES SUCH AS ADVANCED DATA MANAGEMENT, DATA GOVERNANCE, INTERNET SECURITY, MODELLING AND AI'

Hamberg explains: 'As our machines have thousands of nozzles per colour jetting at high frequency, this is highly complicated. AI has the pattern recognition potential to optimise multidisciplinary maintenance scheduling, to further automate the loop – and thus to see to it that the entire production chain from paper handling in our machines to end product delivery to the customer becomes even more predictable than it already is.'

## ROADMAP

All in all, Canon Production Printing needs to master many different technologies to keep ahead of the pack. Core printing technologies such as embedded software, paper handling and nozzle dynamics are mainly covered by internal R&D and bilateral fundamental research relations. Schindler: 'Beyond that, our technology roadmap covers a number of equally vital but more generic technologies such as advanced data management, data governance, internet security, modelling and AI. We don't want to cover all of these entirely in-house.'

Canon therefore monitors developments in these technologies and participates in platform programmes in these fields with a good mix of non-competitive industry partners. Besides the FIND programme that starts in May, other examples are the NWO projects Mastering Complexity (MASCOT), Digital Twin, and ZORRO (Zero downtime in Cyber Physical Systems).

When it comes to the application of newly acquired knowledge, Schindler comments: 'Our technological capabilities are also managed outside product development projects. In practice, this comes down to not cramming every new development in our latest products but applying these only when opportunity and maturity fit.'

## ELABORATE NETWORK

To secure its cutting-edge technology positions, Canon Production Printing maintains quite an elaborate network of external research relations. Hamberg: 'We do projects together with all Dutch technical universities and their equivalents in München and Stuttgart. Apart from that, we also work for example with Radboud University, University of Amsterdam and in the Brainport context with TNO-ESI, for instance, on digital twins. Symposia such as the Models Conference are important for us since they allow us to give lectures and meet partners. When we explore new partnerships, we start with smaller assignments on the student level, after which we evaluate whether PhD research could be interesting for us. We're always open to new ideas.'

# The rising demand for adaptive IT

**By Bennie Mols**  Images Ivar Pel

**The Advanced Computing Engineering group at TNO develops adaptive IT systems, cloud-edge federations, and software innovations to enhance flexibility in complex digital environments.**



**Andreea Balau**



**Elena Lazovik**



**Niels Meima**

'Our mission is to bridge the gap between fundamental and industrial research', says Andreea Balau, research manager of the TNO research group Advanced Computing Engineering (ACE). 'We combine digital and societal innovations and bring movement where transitions become stuck.'

The ACE group consists of about thirty senior to junior researchers, some of whom, like Balau, work in The Hague and others in Groningen. The group has three core research lines: Adaptive IT systems, Cloud-Edge Federations, and Innovations in Software Engineering.

An ACE project where all three research lines intersect comes from the military domain. Modern military vehicles act as mobile miniature data centres. Military crew should be able to rely on the data that the vehicles collect and exchange. 'Such a collection of high-tech military vehicles is an example of a distributed IT system that must be able to constantly adapt to new circumstances', says Balau. 'Traditionally, adding a new sensor, like a camera, to a military vehicle was cumbersome work. Our group worked on a plug-and-play architecture for vehicle additions, making it easy to quickly change the configuration. In this way, the IT system can react swiftly to changing mission requirements that might arise. It allows the military crew to have access to the right information at the right time and at the right level.'

An example of the group's Cloud-Edge Federation research is the project ECOFED, in which TNO works closely with the Dutch and EU cloud industry to enable an open cloud ecosystem. Its open architecture eliminates vendor lock-ins to increase market dynamics between providers and consumers. 'This way, we contribute to the EU's Digital Sovereignty goals and lower dependency on a few big tech companies', Balau explains. 'It allows you to use different providers, switch easily and compose multiple cloud environments from a diverse technological landscape.' In 2024, ECOFED won a Computable Award.

Balau explains that the group's third research line, Innovations in Software Engineering, supports the other two research lines. 'Here we look at hybrid computing architectures, in which, for example CPUs, GPUs, edge devices and even neuromorphic computing are combined. We are also looking at how we can integrate new developments such as Generative AI systems into this.'

## Smarter systems

Elena Lazovik has been working in TNO's ACE group for thirteen years. She has a background in both law and computer science, having started as a lawyer, but switching to computer science. 'I knew TNO from invited lectures at university', she states. 'As a senior scientist, I now give these kinds of invited lectures myself.' Lazovik has been doing research towards autonomous computing and digital twins for offshore windmills and smart electricity grids, for example. 'We try to make such systems smarter so that they can take their own decisions.'

She is also responsible for the scientific strategy of ACE. 'What attracted me to my work', she says, 'is bringing experts from different domains together. As TNO, we tackle complex, multidisciplinary problems. Companies want their IT systems to become more adaptive but are often afraid to modify them due to their complexity. I enjoy developing easy-to-use solutions for them. We also have the Adaptive IT Laboratory in which we create demos for our partners.'

Although ACE is a group of thirty people spread geographically, there is a lot of exchange of ideas, Lazovik says. 'We have a very open, collegial atmosphere. Of course, we collaborate a lot online, but three times a year, the whole group meets in person: once in Groningen, once in The Hague and once in a central location in the middle of the country.'

## Work in practice

Niels Meima works within the research branch Adaptive IT. 'I like to combine the latest knowledge from different fields and then demonstrate that a system can work in practice', he says. In one of his projects, he investigates the most energy-efficient or cheapest route for an electric car, considering the start and end point, charging points along the possible ways and the influence of weather conditions.

Meima has been working in TNO's ACE group for over four years now. 'I came here through my master's internship', he says. 'I stayed because, on the one hand, I have a lot of research freedom – it does feel a bit like a playground – and on the other hand, I can build things that can be applied. I'm usually involved in about five projects at a time.'

Meima thinks that in the coming years, TNO will focus more on supporting smaller companies, start-ups, and scale-ups. 'This requires a somewhat different way of working than we are used to', he explains. 'We need to be more flexible and responsive, as these organisations often shift goals rapidly. But I do think that we are well placed to validate their ideas and help them grow. In this way, we can contribute to a stronger, more innovative Dutch economy.'

## GROUP PASSPORT

**RESEARCH FIELD**

Distributed systems, adaptive IT, cloud-edge federation, innovative software engineering, digital twinning

**INSTITUTION**

TNO

**RESEARCH FACILITY**

Adaptive IT Laboratory

**EMPLOYEES** as of February 2025

Around 30 highly skilled professionals with a scientific, consultancy or project management role.

**WEBSITES**

Group website:

**www.tno.nl/en/about-tno/organisation/units/information-communication-technology/advanced-computing-engineering/**

ECOFED:
**ecofed.eu**

Plug-and-play architectures for military vehicles (Project 'NATO Generic Vehicle Architecture (NGVA) Compliant Vehicle Infrastructure Demonstrator'):
**www.youtube.com/watch?v=VH7EKxSTl5I**

**Hannes Mühleisen** is a co-creator of the DuckDB database management system and co-founder and CEO of DuckDB Labs. He has been a researcher at the Centrum Wiskunde & Informatica (CWI) in Amsterdam since 2012, and Professor of Data Engineering at Radboud University since 2023. Before that, he obtained his PhD in computer science from the Freie Universität Berlin.

# DEMOCRATISING
# DATA TECHNOLOGY

**During NWO ICT.OPEN 2025, Hannes Mühleisen will receive the Dutch Prize for ICT Research. He is known for his groundbreaking research on data architecture and the creation of his own data management system DuckDB. 'Tables and data management tools are eternal.'**

**By Marysa van den Berg**
Image Ivar Pel

### How and when did you become interested in data and data management?

'When I was a teenager, around 2000, I was working on the school website. It used the then-popular data management tool MySQL. That program was a mystery to me; like it was in a sort of arcane language. But I quickly became enamoured with it. That fascination about managing data never left me. So, I went on to study computer science and did my PhD in data management-related topics.'

### In 2021, you published the now-famous DuckDB and founded DuckDB Labs. How did this unfold?

'DuckDB is a software system that can analyse and create reports and visualisations from data. It is based on the latest developments in research and is more efficient and faster than many of the data management tools that are currently available. Back then, my fellow CWI researcher Mark Raasveldt and I were working on its protype. We started to attract a lot of attention from companies and institutions that wanted to use it. Also, back then, I could not afford daycare for my children on my researcher's salary alone. So, we kind of had no choice but to commercialise our invention. Actually, the week that my daughter was born, we founded DuckDB Labs.'

### Besides working for the company, you are still doing research at CWI and Radboud University. Why is this work so important?

'My research projects tend to be related to DuckDB. For example, one of my current PhD students is trying to make the system operate continuously, even when it runs out of memory. He is truly pushing the boundaries of what you can do with a computer in terms of data set sizes. As a nice side effect, his efforts also reduce the demands on the hardware that you need to solve certain data problems. You often hear about data centres that use massive amounts of energy and have a giant $CO_2$ footprint. Our work can help address these problems.'

### What are the challenges of data management that you find so fascinating?

'Tables and data management tools have been around for thousands of years. We will always need them; they are eternal. Still, the field is changing a lot nowadays. We are democratising data technology, meaning everybody has started using it, from students and journalists to scientists and government people. But not everyone has the required expertise. That is a great challenge for us database system builders; to make the software more forgiving for mistakes and do things for the user without them explicitly asking for it.'

# GO TO OR NOT GO TO, THAT'S THE QUESTION

**By Bennie Mols**  Image iStock

Theoretical computer scientist Tobias Kappé investigates in his NWO Veni project when the so often disliked 'Go To' statements in computer programming are really necessary, and when they are not.

In 1968, the Netherlands' most famous computer scientist Edsger Dijkstra wrote the article 'Go To Statement Considered Harmful'. In it, he argued that the use of 'Go To' leads to chaotic, poorly structured code and that programmers should use better-structured programming techniques.

'The objection to "Go To" statements is that you quickly end up with spaghetti code', says theoretical computer scientist Tobias Kappé of Leiden University. 'One part of the program jumps to another part, which also jumps to something else. And then the program becomes cluttered very quickly.'

### Finding alternatives

Dijkstra's article generated a lot of discussion, but scientists still don't understand exactly when it is absolutely necessary to use 'Go To' and when not. Kappé: 'I am investigating those limits in my Veni project. It would be really nice to have a tool that analyses code and says, "hey, but you can do this without 'Go To', and this is how".'

Part of this theoretical work consists of a better understanding of so-called decompilers. Whereas a compiler translates a piece of code written in a higher level programming language into machine language that the computer understands, a decompiler does the opposite: translating machine code into a piece of code that is more easily readable by humans.

'One practical relevance of decompilers lies in analysing malware, such as computer viruses', Kappé explains. 'The receiver of malware can only see the machine code. Decompilers are used to analyse how the malware works and how we can defend against it. A second practical application of decompilers is reconstructing old computer programs for which only machine code is available.'

For his analysis of decompilers Kappé uses automata theory, which transforms machine code into a kind of flowchart that graphically describes step by step what the computer program does. 'Such a flowchart often contains loops', Kappé says, 'pieces of code that keep repeating themselves. These should also end up in the higher level code and there are good techniques for this. But there are also situations where the decompiler doesn't know what to do. Unfortunately, we don't know exactly which situations those are. It could be because of a "Go To" statement. One question I want to answer is when you can replace such a "Go To" with a loop, for example, and when you cannot.'

'The objection to "Go To" statements is that you quickly end up with spaghetti code'

### Compile, decompile

Kappé started his Veni project in November 2024. Building on previous research he did together with researchers from University College London, Virginia Tech and Open University, he had already developed a way to help find bugs in decompilers. Kappé: 'We took a pretty complicated piece of code. We compiled that into machine code and then decompiled it back to a piece of code. Then you have the original program and a version that was first compiled and then decompiled. We have developed a model that can compare the two programs in a fairly efficient way. If the compiled/decompiled version does not match the original version, there is something wrong in the decompiler.'

Although Kappé's work is highly theoretical in nature, it also appeals to many computer scientists outside his own specialism. 'The discussion about "Go To" is in the collective consciousness of computer scientists', he says. 'Almost everyone has an opinion on it. That makes it fun to discuss this topic with people.'

# FOUNDATION MODELS FOR USE ACROSS INDUSTRIES

**By Leendert van der Ent**
Images WAT ontwerpers, iStock
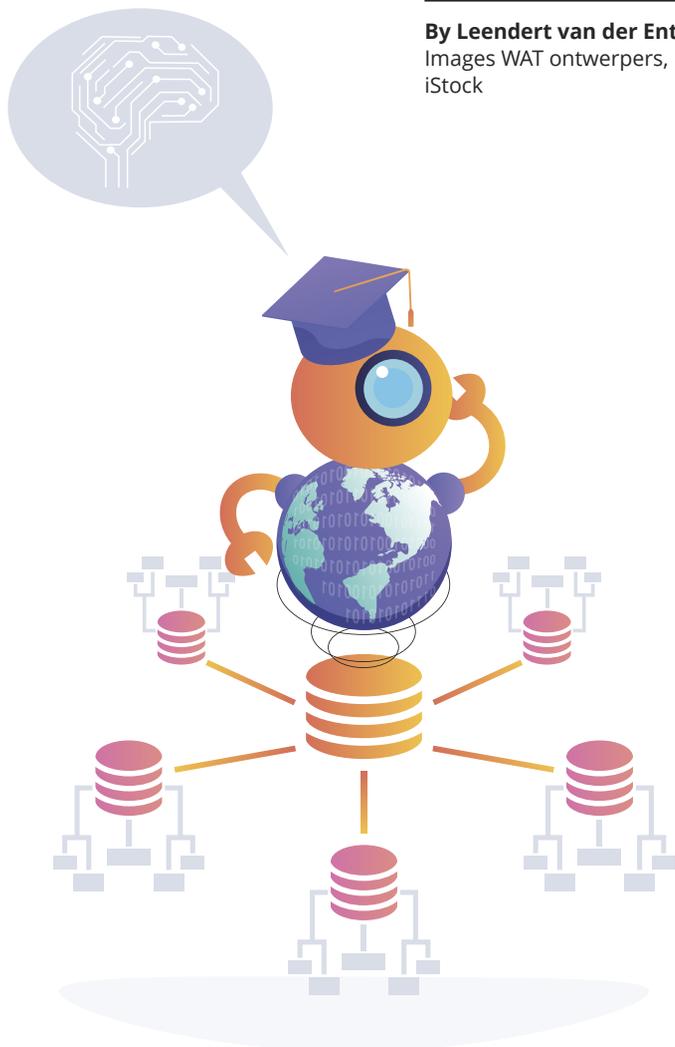
**In May, the multi-million euro computer science programme Foundation for Industry (FIND) will see its kick-off. Its aim is to enhance foundation models for AI applications in mobility, smart industry, and health.**

Associate Professor Gijs Dubbelman, principal investigator of the Mobile Perception Systems lab at Eindhoven University of Technology, heads the NWO Perspectief programme FIND. 'As a sequel to the Efficient Deep Learning (EDL) programme, FIND will focus on large AI: so-called foundation models. In EDL, datasets needed extensive labelling to be effective in specific use cases. Foundation models can be pre-trained on vast amounts of unlabelled data, allowing them to achieve superior accuracy and generalisation – and they can do this across a wide range of use cases.'

Co-applicant Dave Marples, Chief Scientist at Technolution: 'The constantly repeated narrative that Europe lags behind in AI is not true when it comes to research quality – the basis for new insights and opportunities. I am passionate about the FIND programme. It is not a matter of throwing huge amounts of money at large systems. We want to find smarter, better algorithms; innovation born out of constraint. Time and again, it has been shown that such constraints deliver insightful solutions, from the computational efficiency of the old Eastern Bloc programs to the much more recent example of DeepSeek.'

## 'FOUNDATION MODELS CAN BE PRE-TRAINED ON VAST AMOUNTS OF UNLABELLED DATA, ALLOWING THEM TO ACHIEVE SUPERIOR ACCURACY AND GENERALISATION'

## USE CASES

The relatively generic nature of foundation models offers versatility and enables companies from a wide range of fields to participate in FIND. Dubbelman: 'In general, we aim at making the human workforce more effective and efficient. In the
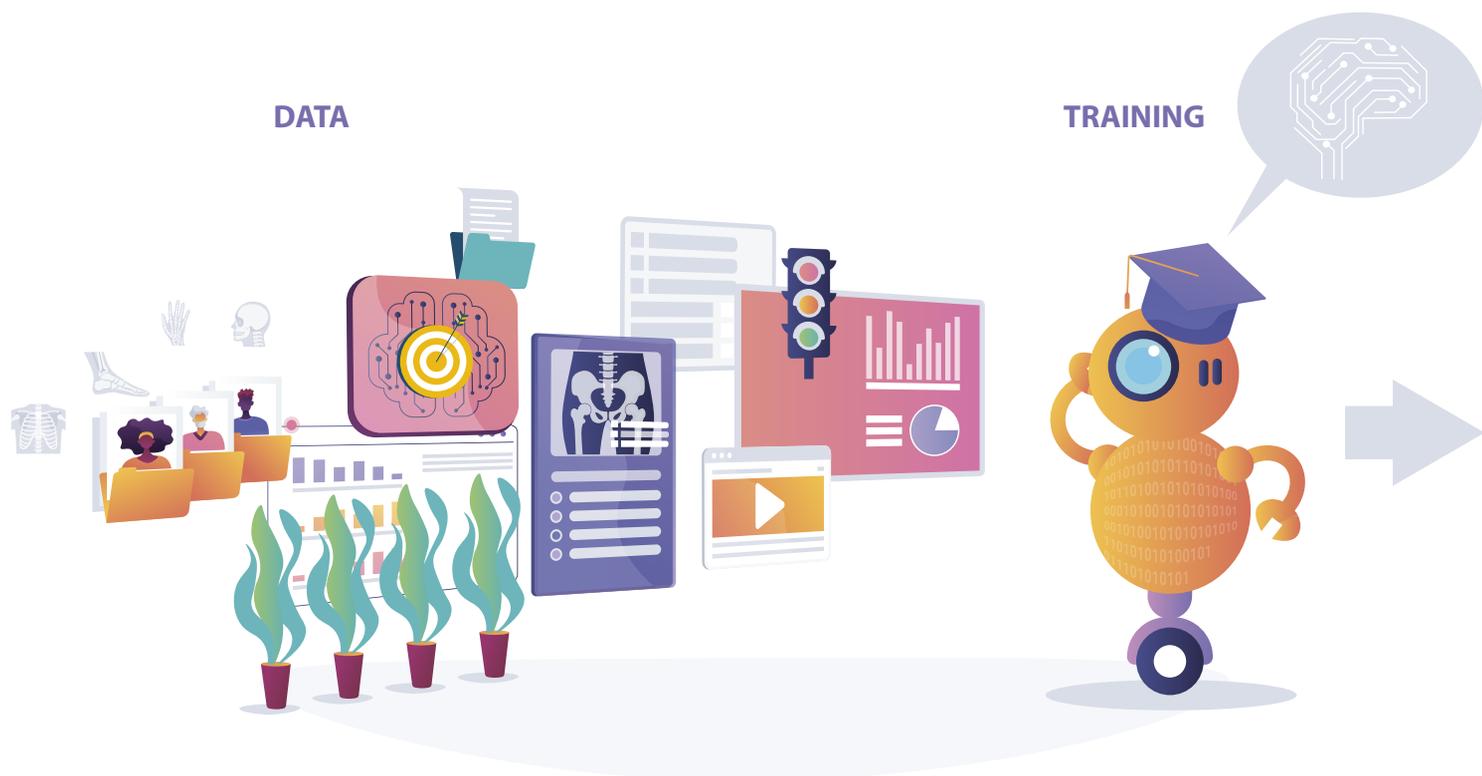
domain of "Mobility & mobile robotics", we will, for instance, look into the optimisation of traffic light operation at city level.' That is the field in which Technolution is active. Marples: 'The FIND programme brings together an interesting set of complex problems from industry, for which AI holds the promise to bring solutions. In our case, this concerns the highly complex Dutch transport infrastructure with its many cyclists and boats passing under drawbridges. There are, of course, off-the-shelf solutions. On the one hand, participants don't like the idea of providing their confidential data to private third parties and on the other, they're attracted by the potential of solutions that are more subtle and tailored to their specific use case.'

Dubbelman: 'In the "Smart industry" domain, we have wildly differing cases ranging from optimising wafer quality control or assessing radar data for automotive solutions in the context of self-driving vehicles to optimising phenotyping for plant breeding and energy-saving lighting management at the building level. The third domain is "Health", where we work on automated and optimised analysis of medical imaging and assessing the effectiveness of treatments on the basis of huge amounts of data.'

## MATRIX

FIND is organised according to a matrix model. Across the three domains mentioned, three enabling technologies will be further developed. 'The first is pre-training and adaptation of the foundation models. How can we do that in the most efficient and effective way?', Dubbelman explains. 'The second theme is to embed AI locally in the machines it drives. Certain industries are not very big in cloud applications nor fond of them because of privacy concerns. This means model efficiency will have to be enhanced by improving the architecture.

Chip design will also have to be enhanced, aimed at decreasing energy use and speeding up decision making to as close to real-time as possible, which is especially important for industrial applications.'

The third enabling technology touches on robustness and process traceability. Dubbelman comments: 'The outcome of the AI decision usually is black or white: "yes" or "no". But it is always based on some estimation. Could the system also elaborate on its decision by quantifying the chance of the decision being wrong? Or could it log the steps leading to the outcome, with the level of uncertainty playing a role in each step? And could it explain this in human language? This is a very important issue, as we as humans are somewhat uncomfortable with black-box outcomes. It basically comes down to making AI behave more like a human by connecting text language, audio language and (video)imaging to provide explanations.'

## INDUSTRY INVOLVEMENT

Apart from the research quality, the close collaboration between university and industry is a real boon for FIND, Marples finds: 'The interface between academic research and industrial application can be quite complex. This setup can smoothen things. The researchers work with real-life data and can tune their efforts based on practice-based comments – which sometimes will allow for simplification. The fact that we start with fundamental research and move all the way up to TRL 5 is an exciting feature. This also means that the industrial partners don't just sit and wait for results. We will also heavily invest in enhancing the chance of ending up with commercially viable applications. Better insights gained by the researchers in the complexities of the problems leads to better applications.'

**FOUNDATION MODEL**
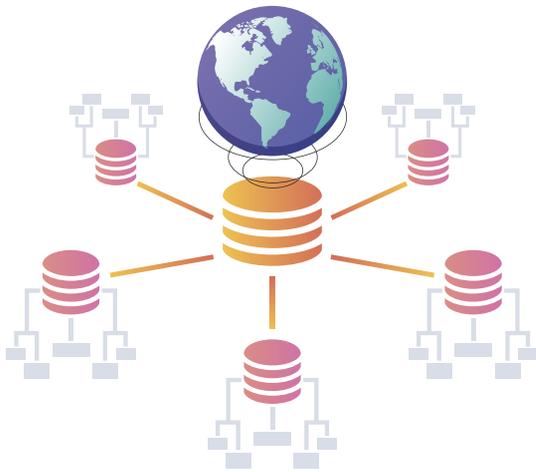
**TASKS**

## 'THE FACT THAT WE START WITH FUNDAMENTAL RESEARCH AND MOVE ALL THE WAY UP TO TRL 5 IS AN EXCITING FEATURE'

### HOLY GRAIL

Naturally, there are many other challenges to overcome, and acquiring sufficient training data and computational power is a very practical one. Dubbelman: 'We have plenty of good ideas in Europe, but we lack the scale of infrastructure that the US and China have. That scale is needed to develop competitive large AI models. In terms of science, the biggest challenge will be using the crosslinks between audio, video and text modalities to enhance learning.'

From childhood onwards, humans acquire a lot of knowledge about their environment. 'We can leverage this knowledge implicitly or even subconsciously when learning a new task, for instance, when we are learning to drive a car', says Dubbelman. 'The ability to efficiently gain new knowledge on top of existing knowledge is a feature that foundation models lack; their ability to generalise and extrapolate acquired knowledge between tasks is relatively limited when compared to that of humans. The holy grail is to get to vision-language models that are able to learn a new task after having seen just a few examples.'

## FOUNDATION FOR INDUSTRY (FIND) - LARGE AI MODELS FOR A RESILIENT HIGH-TECH INDUSTRY

In May 2025, FIND will start as the third consecutive ICT-related NWO Perspectief programme after I-Cave (Integrated Connected Vehicles), aimed at boosting efforts towards automated and cooperative driving, and Effective Deep Learning (EDL), aiming at forwarding self-learning AI. The FIND programme will be instrumental to secure more self-sufficiency for the European industry to be less dependent on Chinese or American AI ventures.

### BUDGET
6.5 million euros

### DURATION
6 years (enabling scale-up, PhD research and properly finishing the programme)

### COMPANIES
ASML, Brainport Development, Canon, KAIKO, KeyGene, NKI, NXP, PercivAI, Shell, Signify, Stryker, Technolution, TNO

### RESEARCH THEMES
optimisation of model pre-training, AI as an embedded application, robustness and process traceability

# ROOM FOR **BLUE SKY RESEARCH**

**By Sonja Knols**

### Arjen de Vries

Professor of Information Retrieval and Research Director of the Institute for Computing and Information Sciences at Radboud University

'Serendipitous findings are crucial to developing really new things. However, this type of blue sky research is hardly funded anymore. If you focus your research on just today's applications, you miss out on tomorrow's challenges and opportunities. The sector plan funds allow us to explore these types of new routes.

As we are not a very large institute, we wanted the entire organisation to benefit from the new hires. We therefore aligned the new positions with the strengths we already had in our three research themes Software Science, Digital Security, and Data Science. Furthermore, we wanted to enhance our expertise in human-computer interaction in Nijmegen. Therefore, in the first sector plan round, we hired two junior researchers on that topic, and in the second round, we managed to get Roel to join us as a full professor. All in all, the sector plan funds allowed us to grow quite a bit, from approximately 35 FTE to about 45 FTE.

We decided not to draw up compelling vacancies but to focus on the people instead. We were mainly interested in what ideas they brought to the table and what their added value would be to our existing expertise. Thanks to the new hires, cross-overs in topics have arisen, such as software verification and AI. Now, we are also working on a new master's programme that combines AI and security.

I think our special welcome meetings, where all new hires got to know each other, really helped. Another plus point is the Interdisciplinary Hub for Digitalization and Society in Nijmegen. That brings together computer scientists with legal, ethical, psychological and philosophical experts, broadening our researchers' horizons.

Unfortunately, much of what we were able to build up is starting to fall apart again. Personnel appointed during the first sector plan are now part of the permanent budgets, and those are being cut. When someone leaves, I can no longer fill that vacancy. It troubles me to see how all the goods things we so carefully built up are now being made undone.'

**The two successive sector plans have resulted in a significant number of new hires at various Dutch universities. Arjen de Vries, Research Director of the Institute for Computing and Information Sciences at Radboud University, explains how his institute has benefitted. Roel Vertegaal, Professor of Human-Computer Interaction at the same institution, explains what convinced him to return to the Netherlands after having worked overseas for 25 years.**

## Roel Vertegaal

Professor of Human-Computer Interaction at Radboud University since May 2024

'I left the Netherlands 25 years ago because of the then prevailing climate for my field, interactive technologies. Research into these types of systems – like a computer mouse or a touchscreen – was much more advanced and better funded in the US and Canada. About two years ago, the situation seemed reversed: with Robbert Dijkgraaf as the then Minister of Education, Culture and Science and investments in science such as the sector plan funds, the climate here seemed more favourable than that in Canada. As I had been wanting to return for a while, the time seemed ripe to move back.

Although I do not regret my decision, the situation here has now completely changed. Substantial cuts have been made in budgets for science and arts, which form an important source of inspiration for academics. That makes it harder for me to acquire the funds I need to expand my team.

My research is about novel interaction techniques. For example, I invented the foldable smartphone. This technology is now in the hands of billions of users. Such inventions all start with simple, long-term ideas. Take bending as an interaction technique. We wanted to add a third dimension to the two-dimensional movement of a mouse or a touch screen so that users could navigate information more efficiently.

Generally, computer systems use only a limited part of our human interaction capabilities. In the Human Media Lab, which moved with me from Canada to Nijmegen, we are looking for richer ways to communicate with each other, with the ultimate aim of better communicating through and with digital systems. Right now, we are working on models that allow us to implement new findings from neuroscience about how people perform tasks. We are modelling the information transfer required in human tasks, ranging from moving your hand to conducting more complex tasks.

In essence, all of our human actions come down to information-processing tasks. In my group, we develop new user interfaces to acquire and process that information, for example, in wearable computers that automatically assist you in everyday tasks. That type of research fits well with the data science expertise of the computer science institute as well as the neuroscientific work at the Donders Institute for Brain, Cognition, and Behaviour here on campus. Our work aims to develop cheap, private, wearable, real-time artificial intelligence that everyone can use in their everyday tasks. As a society, we need to support such work on future breakthrough technologies.'

# SERIOUS AI TO SOLVE
## BIOLOGICAL ISSUES

**By Marysa van den Berg**  Image Ivar Pel

**Professor Sanne Abeln is trying to bridge the gap between informatics and the life sciences. She thinks that combing the two worlds is essential to solve the problems that have real impact, like in medicine.**

'When I was about sixteen years old, I visited Daan Frenkel's lab at AMOLF in Amsterdam. I saw these wonderful simulations of molecules and I wanted to create them myself. But then with biomolecules, because I wanted to better understand how life works. So, I studied mathematics and computer science to learn about the methods first, and then did my PhD in bioinformatics. That eventually led to my own AI technology for Life research group at Utrecht University. Developments in biology and informatics are rapidly advancing. In biology, more and more high-throughput experimental techniques are becoming available to provide extremely detailed data on complex living systems. In informatics, there has been huge progress in artificial intelligence methodology that can help analyse this data. That makes combining the two fields very exciting.

However, there are many issues to overcome to successfully apply current AI technology to the life sciences. For example, humans cannot (yet) fully understand the language of DNA sequences. What are the underlying causes of patterns we find in the DNA?

## BIG CHANGES

Our group tries to make AI more explainable so we can get more out of the data and make truly meaningful predictions about diseases. We do this by developing new AI methodology. Using this, we recently discovered, together with molecular biology researchers from the Netherlands Cancer Institute (NKI), that big changes in the DNA can be just as crucial in developing colon cancer as small mutations.

This study perfectly shows what combining the two fields can do for medicine. I think we should embrace this type of research more. I have been a member of many NWO committees to discuss proposals from the ICT world, and I noticed many are not accepted because they are deemed "not computer science enough".

That is not a helpful way to look at things because the life sciences bring in difficult computational problems that you do not find elsewhere. Also, this type of research can have a high societal impact: such as finding biomarkers for diseases and determining the best microbes to put in soil to help food production, which is essential for the growing world population. These issues need serious AI work to solve, so we should stimulate this interdisciplinary research.'

**Sanne Abeln has been a Professor in AI Technology for Life at Utrecht University since 1 April 2023. She obtained her PhD at the University of Oxford, was a postdoctoral researcher at AMOLF, and an assistant and later associate professor in Bioinformatics at VU Amsterdam.**