I/O magazine

ICT RESEARCH PLATFORM NEDERLAND

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COLOFON

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IPN (ICT Research Platform Nederland) unites all Dutch academic research groups that have ICT science as their core and, as such, acts as a single point of contact for all matters relating to ICT innovation and its importance for our current and future society. IPN is supported by NWO Domain Science.

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PAUL KLINT

Cloaca Maxima

Which technological achievements stand the test of time?

Its construction started in 600 BC. Originally, it was intended as an open sewer to drain local marshes and waste water from Ancient Rome. In the first century, it evolved into a covered sewer and became part of a unique water management system comprising aqueducts, fresh drinking water, public baths, rainwater drainage, and sewers. I am referring to Cloaca Maxima, Rome's sewer system still in use today, which is both a public utility and a tourist attraction. The original builders would probably be highly surprised by this.

Romans were excellent engineers. Many of their buildings and artefacts have endured the test of time. Modern engineering has produced amazing results, such as (high-speed) trains, motorways, automated factories, computers, the Internet, and the International Space Station. But which of these will still be relevant millennia or at least centuries from now? What is the Cloaca Maxima we are working on today that will amaze future generations?

A first candidate that comes to mind is a future-proof Internet – the association with a sewer is purely incidental. Today's Internet is both robust and fragile. Robust thanks to its redundant design inspired by military considerations. It is fragile if we take physical attacks into account. Many a sea cable has been 'accidentally' damaged, and eaves-dropping on Internet connections is the standard. It is also fragile if we consider the lack of proper security and identity management. The huge impact of social media on individuals, society and democracy makes it societally fragile. A future-proof Internet will be an artefact based on physical, technical, legal, and societal innovations and will last for ages.

Two other candidates are related to global warming. Rising sea levels will require massive coastal defence works, and rising CO_2 levels may lead to the construction of worldwide carbon capture facilities. Both will have a global, long-lasting impact and leave physical traces on Planet Earth.

Can you come up with more examples? Tunnels that replace aeroplanes to travel between continents? Solar reflectors to reduce global warming? A permanent moon base? What is your Cloaca Maxima that will still exist centuries from now?

NWO

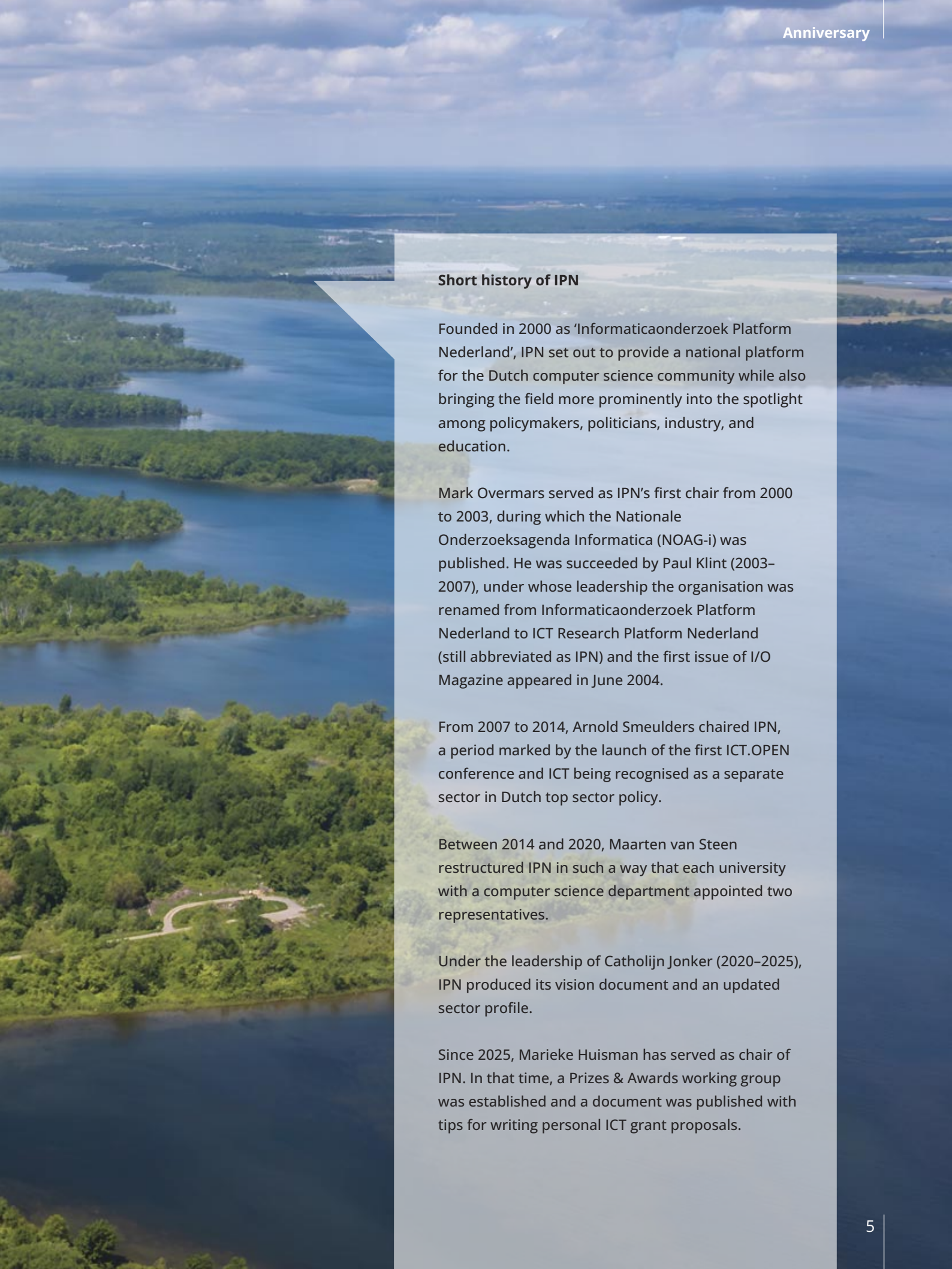
IPN ICT-ONDERZOEK PLATFORM NEDERLAND

FROM ISOLATED ISLANDS TO A CONNECTED ARCHIPELAGO

Last year marked the 25th anniversary of IPN's founding. What has the platform achieved so far, which challenges is it currently facing, and what are its plans for the future?

By Bennie Mols

Images iStock, Daan Muller, University of Twente



Short history of IPN

Founded in 2000 as 'Informaticaonderzoek Platform Nederland', IPN set out to provide a national platform for the Dutch computer science community while also bringing the field more prominently into the spotlight among policymakers, politicians, industry, and education.

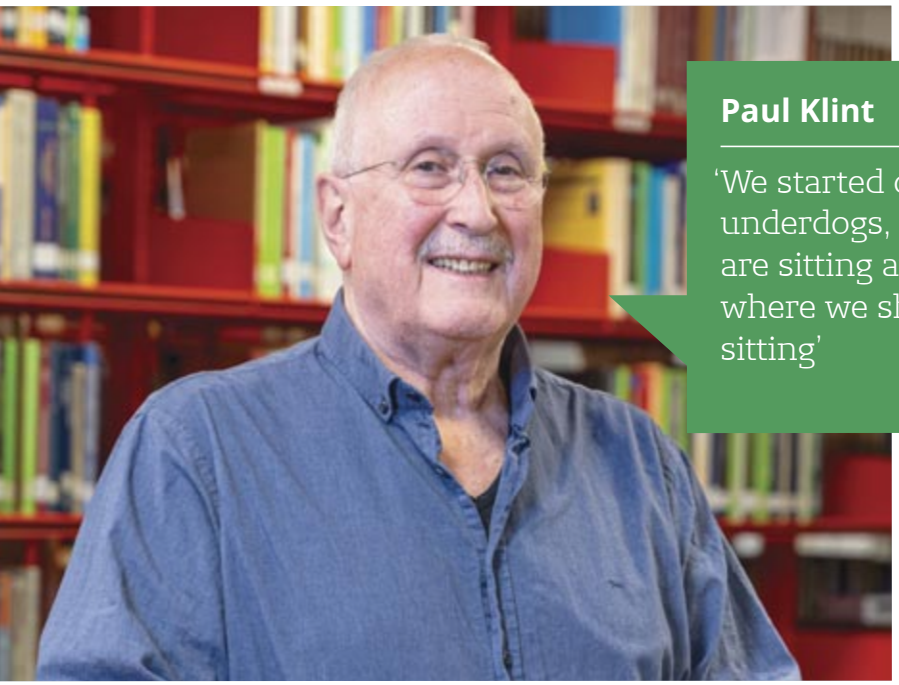
Mark Overmars served as IPN's first chair from 2000 to 2003, during which the Nationale Onderzoeksagenda Informatica (NOAG-i) was published. He was succeeded by Paul Klint (2003–2007), under whose leadership the organisation was renamed from Informaticaonderzoek Platform Nederland to ICT Research Platform Nederland (still abbreviated as IPN) and the first issue of I/O Magazine appeared in June 2004.

From 2007 to 2014, Arnold Smeulders chaired IPN, a period marked by the launch of the first ICT.OPEN conference and ICT being recognised as a separate sector in Dutch top sector policy.

Between 2014 and 2020, Maarten van Steen restructured IPN in such a way that each university with a computer science department appointed two representatives.

Under the leadership of Catholijn Jonker (2020–2025), IPN produced its vision document and an updated sector profile.

Since 2025, Marieke Huisman has served as chair of IPN. In that time, a Prizes & Awards working group was established and a document was published with tips for writing personal ICT grant proposals.



Paul Klint

'We started out as underdogs, but now we are sitting at the tables where we should be sitting'

In 2000, the year IPN was founded, there were no smartphones, no social media, no cloud computing, no generative AI, and no platform economy. A quarter of a century later, digital technologies have become deeply embedded in society, fundamentally reshaping everyday life, work and economic activity. Against this societal transformation, IPN's 25th anniversary is a great moment to reflect on its achievements and the role it seeks to play in the years ahead.

Paul Klint served as IPN's second chair from 2003 to 2007 and has been a columnist for *I/O Magazine* since its first issue in June 2004. Asked about IPN's most significant achievement, he says: 'As computer scientists, we started out as underdogs, but now we are sitting at the tables where we should be sitting. From an administrative point of view, the past 25 years can be characterised as a period of maturation. Also, better cooperation has developed in sub-areas of computer science. What were once isolated islands of research have become an archipelago of connected ones.'

The current chair of IPN is Marieke Huisman. She emphasises that, over time, the platform has increasingly become an organisation for the community as a whole, in addition to being a lobby for computer science. 'We now have a working group on equity, diversion and inclusion, one on academic well-being, and one focused on ethics. Furthermore, in all computer science programmes, you see that there is greater awareness of the ethical aspects of our profession.'

Although IPN has a pretty good idea of who its external stakeholders are, there is still room to improve its effectiveness in reaching them, she says. 'That is why we have now also set up a working group External Relations. We should not be the only ones going to the ministry and saying that computer science research is important. CEOs from the business community should be doing the same.'

Improving image

Despite all IPN's efforts over the past quarter of a century, Klint believes there is still much to be gained in terms of the image the outside world – particularly policymakers, politicians, industry, and the general public – has of computer science. Klint: 'When it comes to the public perception of computer science, you see a lot about AI, a lot about quantum computing, but that's about it. However, it is precisely the less glorious aspects of IT that are essential to society. One of the spectacular challenges that is very unspectacular in terms of image is keeping the software that is everywhere up to date and modernising it.'

Countless organisations get completely stuck on this, Klint continues. 'This is also because, within organisations themselves, it is much sexier to say that you are going to build a new system than to say that you also need to maintain and update an existing system. A guideline is that you should spend approximately fifteen percent of software construction costs per year on maintenance. But that is never included in the budget. A fundamental insight that should penetrate the top levels of government and business is to include the costs of ICT maintenance and renovation in the budget, just as one does with the annual depreciation on the purchase of a new car.'

An important next step for IPN's near future is to formalise it, says Huisman. 'We hope to achieve this before the end of this year. This also means we can start managing our own budget instead of handling it through NWO. The plan is that the members – which are the computer science departments at Dutch universities and CWI – will all make a financial contribution. With this formal status, IPN will thus get more leverage, and we believe it will put computer science in the Netherlands even more firmly on the map.'

Reducing ratio

Over the past 25 years, the number of computer science students has increased sharply, leading to a disproportionately high student-to-staff ratio. 'Reducing the ratio remains a challenge,' Huisman says, 'even though we seem to be seeing some decline in the number of students studying computer science.'

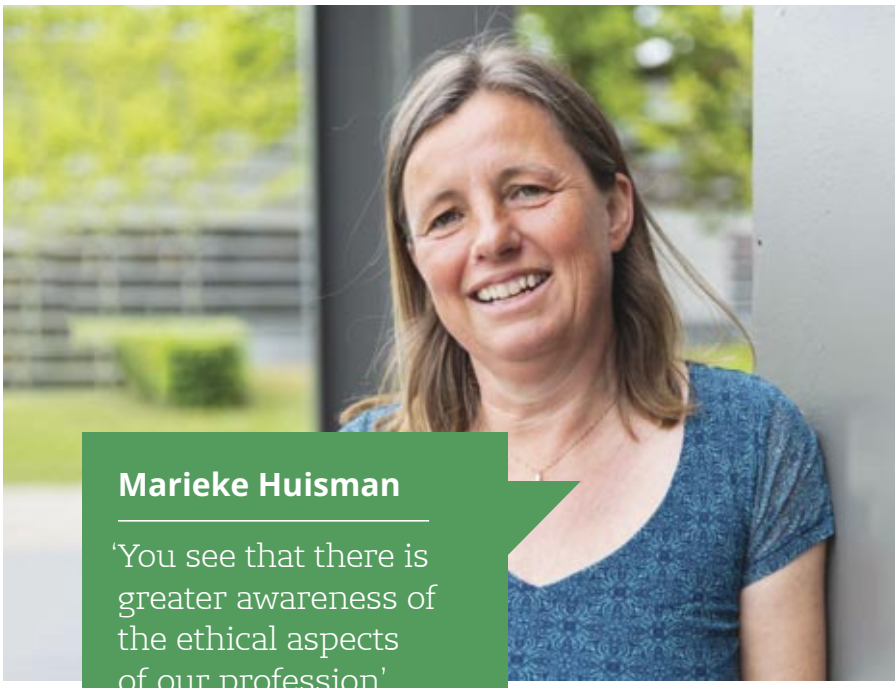
This, in turn, has causes that bring their own problems. Huisman: 'Government policy has made the Netherlands less attractive to foreign students, reducing the pool of available talent. In addition, the rise of artificial intelligence in society seems to have created a feeling of "why would you still study computer science when AI can also write computer code". I have heard from programme directors that parents of future students do ask those kinds of questions. But if you let AI do the programming, it doesn't always do what it's supposed to do. It is precisely because of these developments that highly educated computer scientists, who understand what AI can and cannot do, how it works and what impact it can have, will only become more important.'

Klint is also very concerned about the impact of AI on both education and research. 'I have heard from several lecturers in introductory programming how significant the impact of AI already is', he says. 'They told me that where they used to see a normal distribution in the students' results, they now see a radical division: between a group that has primarily used generative AI and not understood the material at all, and a group that, as in the past, has done their best and understood the material.'

When it comes to research, he is concerned about a world in which research proposals and research results are written by AI, then reviewed by AI, and finally carried out by AI. Klint: 'We are not there yet, but there are already serious issues in various parts of the publication pipeline. I believe that IPN can play a role in raising overall awareness of the dangers of AI for education and research and in drawing up rules for dealing with them.'

Sovereignty

Another current issue that IPN should address, according to both Huisman and Klint, is digital sovereignty. Klint gives an example from the scientific community itself: 'Researchers store a significant amount of computer code and data on GitHub. But GitHub is owned by Microsoft. Do we really want to store our data there?' Huisman indicates that IPN has already taken the first steps: 'We are working on a position paper to set out our ideas on how we can contribute to digital sovereignty from the perspective of computer science research.'



Marieke Huisman

'You see that there is greater awareness of the ethical aspects of our profession'

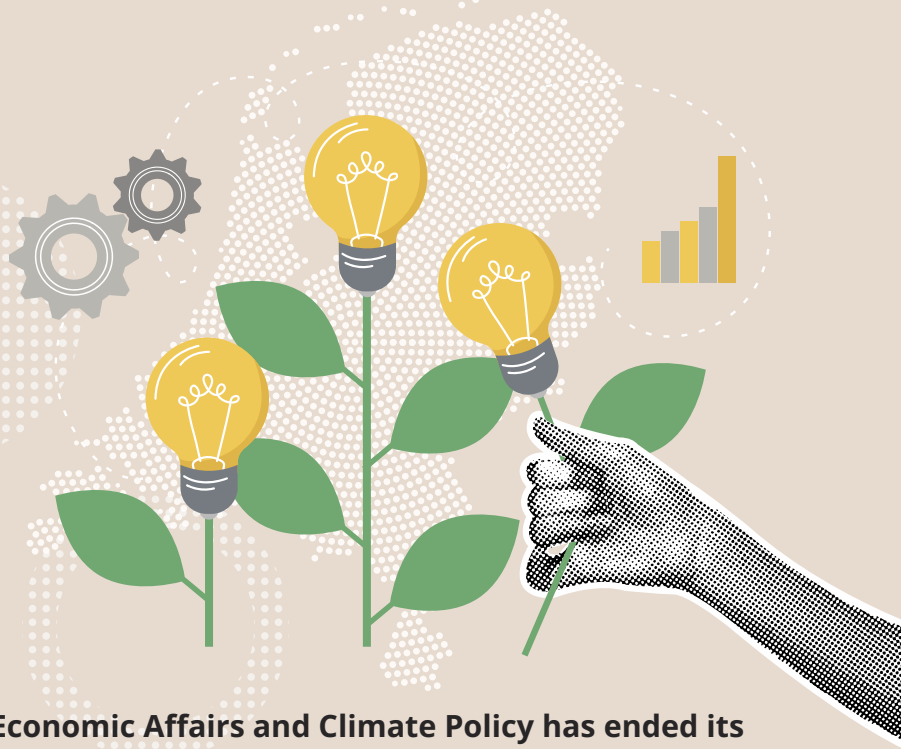
In the year IPN turned 25, approximately seven percent of the Dutch labour market was working in the IT sector, and that percentage is expected to grow to ten percent by 2035. This means that the role of IPN will only become more important. Huisman: 'By having a more formal status soon, I believe we can take another step forward in terms of raising awareness and visibility of IPN among computer scientists. I hope that in the future, more computer scientists will say about IPN: Yes, that's useful to me.'

MORE INFORMATION

IPN: ict-research.nl

Four former chairs in 2020 on 20 years of IPN: ict-research.nl/wp-content/uploads/2020/03/IO-magazine-NR1-2020-web.pdf

Renewed national innovation policy



As of 1 January, 2026, the Ministry of Economic Affairs and Climate Policy has ended its top sector policy in favour of a targeted innovation and industry policy focusing on six growth markets. In response, Top Sector ICT has been rebranded as Digital Holland. Director Frits Grotenhuis explains what this means for researchers.

By Sonja Knols Image iStock

The new Dutch innovation- and industry policy focuses on the six strategic growth markets semiconductors, biotechnology, defence-related technologies (including 6G), digital services (particularly AI), mechanical engineering, and innovative chemistry.

Continuity

Innovation policy is now more closely linked to industrial policy, with a stronger emphasis on valorisation and economic impact. For the ICT sector, Grotenhuis expects continuity rather than disruption. 'Under Top Sector ICT, strong networks and successful initiatives were established, and these will continue under the new name Digital Holland.' The Top Consortium for Knowledge and Innovation (TKI) ICT will continue to exist, and the Knowledge and Innovation Agenda for Digitalisation (KIA Digitalisation) will remain the guiding principle, Grotenhuis says.

Dutch innovation policy can appear complex with different organisations, policy frameworks, and strategic agendas. with terms such as TKI, growth market, KIA, KIC, and National Technology Strategy. Grotenhuis explains: 'The National Technology Strategy is an overarching policy document that identified ten priority key technologies. For each of these technologies, so called action agendas have been developed.'

Two action agendas

The two digital action agendas, AI/Data Action Agenda and Cybersecurity Technologies Action Agenda, are coordinated by Digital Holland under the KIA Digitalisation flag. 'We identify, prioritise and organise ICT research and innovation in these fields by bringing together public and private parties with a focus on key ICT technologies and societal challenges. We organise events, initiate and coordinate public-private partnerships, and send out newsletters with information on matters such as upcoming grants and subsidies.'

As examples of what these activities can lead to, Grotenhuis mentions the recently launched National Coalition for Neuromorphic Computing, in which Digital Holland plays an initiating, coordinating and supporting role. 'That is a role we are familiar with, since we did the same for the AI Coalition for NL and the Growth Fund programme AINed, which now play prominent roles in the National Technology Strategy action plan for AI and data.

Momentum

ICT has been labelled a Calimero for too long, but in recent years, we have moved beyond that, Grotenhuis states. 'There is now so much momentum that we are in a unique position to make a lasting impact, as long as we join forces and show what we as a sector are capable of. An interesting opportunity to do this is during the Digitalisation Week, which will be held from 18-25 September, 2026. We are organising this together with NL Digital to highlight the importance of ICT innovation.' IPN will also organise a Nieuwspoort meeting during this week.

Grotenhuis urges computer scientists to stay informed and involved. 'Subscribe to our newsletter and stay up to date via the KIA website. And please, provide us with your ideas and input via IPN, both through the IPN board and the IPN special interest groups. Because any successful, lasting innovation is built on a foundation of solid scientific research.'

How to write personal grant proposals

To support computer scientists, Marieke Huisman and Inald Lagendijk, with the input from a large number of people in the field, created a slide set with tips for writing personal grant proposals in ICT.

This slide set brings together the experience of tens of successful computer scientists. It contains tips and tricks that have worked for others and should help you focus on what really matters to get your proposal accepted. This slide set covers all the facets involved in writing a successful proposal, ranging from preparing to write to showing why you are the right person for the proposal, to organising helpful feedback.

The slide deck can be found on the IPN website: ict-research.nl/publications

Alice & Eve wins NWO prize

The Diversity & Inclusion Initiative Award 2025 of the Dutch Research Council (NWO) Domain Science is granted to the Steering Committee of Alice & Eve.

Alice & Eve is an initiative to celebrate women in computing in the Netherlands. Its Steering Committee consists of Marieke Huisman, Cynthia Liem, Sophie Lathouwers, Alma Schaafstal, Alexander Serebrenik and Marielle Stoelinga.

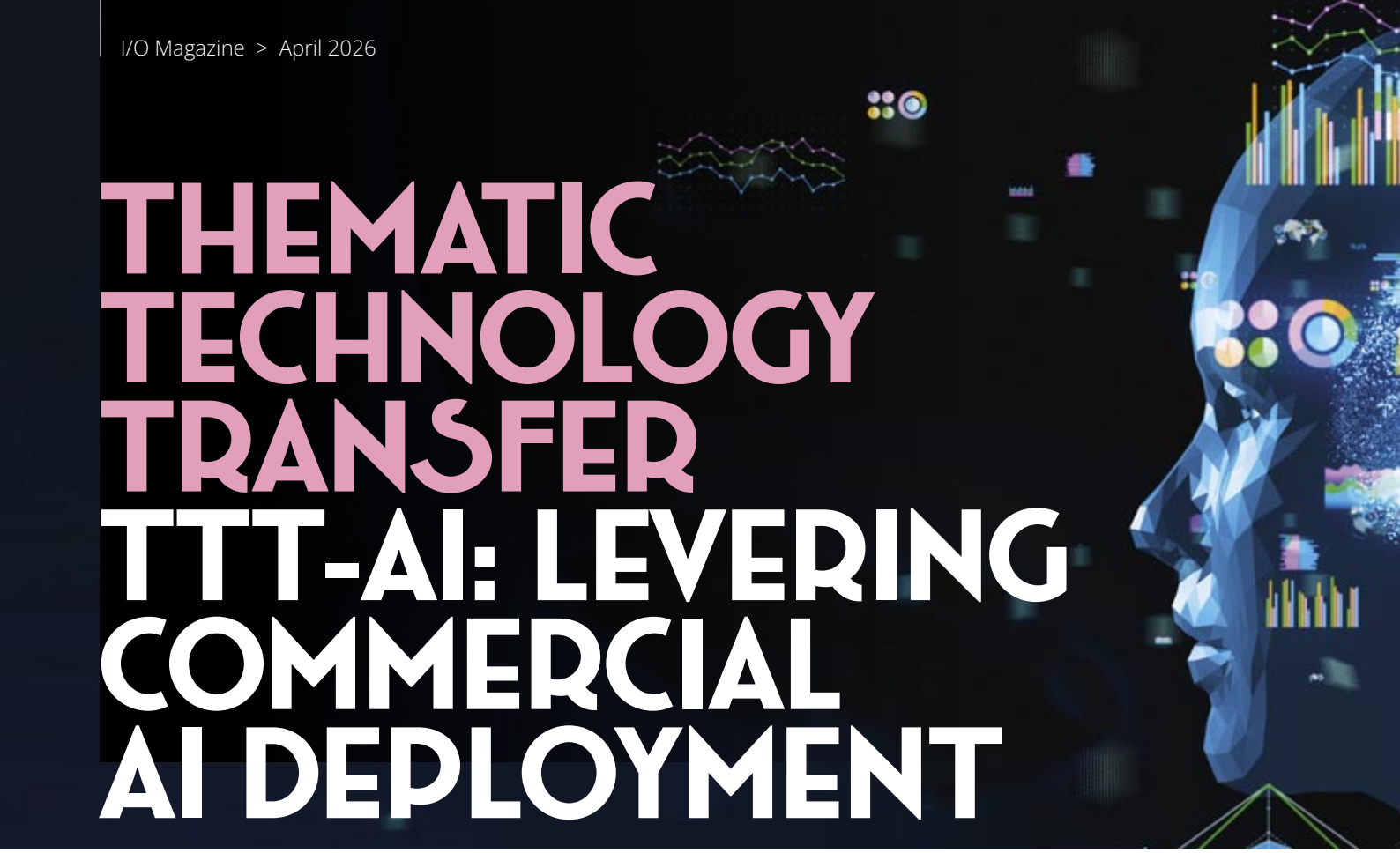
With the Diversity & Inclusion Initiative Award, the NWO Domain Science wants to reward effective initiatives that increase diversity and/or inclusion in the physical and natural sciences and draw attention to (small-scale) initiatives that have led to greater diversity and inclusion on the work floor. The award consists of a sum of 50,000 euro, to be used in keeping with the goal for which the prize was awarded.

New IPN board

From 1 January 2026, IPN has a new board. After having served the maximum of two terms, Gerard Barkema, Andy Pimentel and Han La Poutré stepped down from the board by the end of 2025. They are succeeded by Balder ten Cate (TU Delft), Judith Masthoff (Utrecht University), and Nava Tintarev (Maastricht University). To ensure a smooth transition between the former and new boards, Marieke Huisman stays on for a second term as chair of the group. In addition, two other new board members, Dimka Karastoyanova (University of Groningen) and Geert-Jan Houben (TU Delft), joined the board somewhat earlier, in April 2025.

Computing time on National Computer Facilities

Researchers can once again apply for computing time on national computer facilities, along with associated data services and expertise, for their research. Through the new computing time call, computing time with data storage can be requested on the following computer systems: Snellius supercomputer, Data Processing (Grid/Spider), Cloud Research Consultancy and HPC Cloud (via SURF Research Cloud). In addition, the Dutch allocation of the pre-exascale supercomputer LUMI also falls under this call.



THEMATIC TECHNOLOGY TRANSFER

TTT-AI: LEVERING COMMERCIAL AI DEPLOYMENT

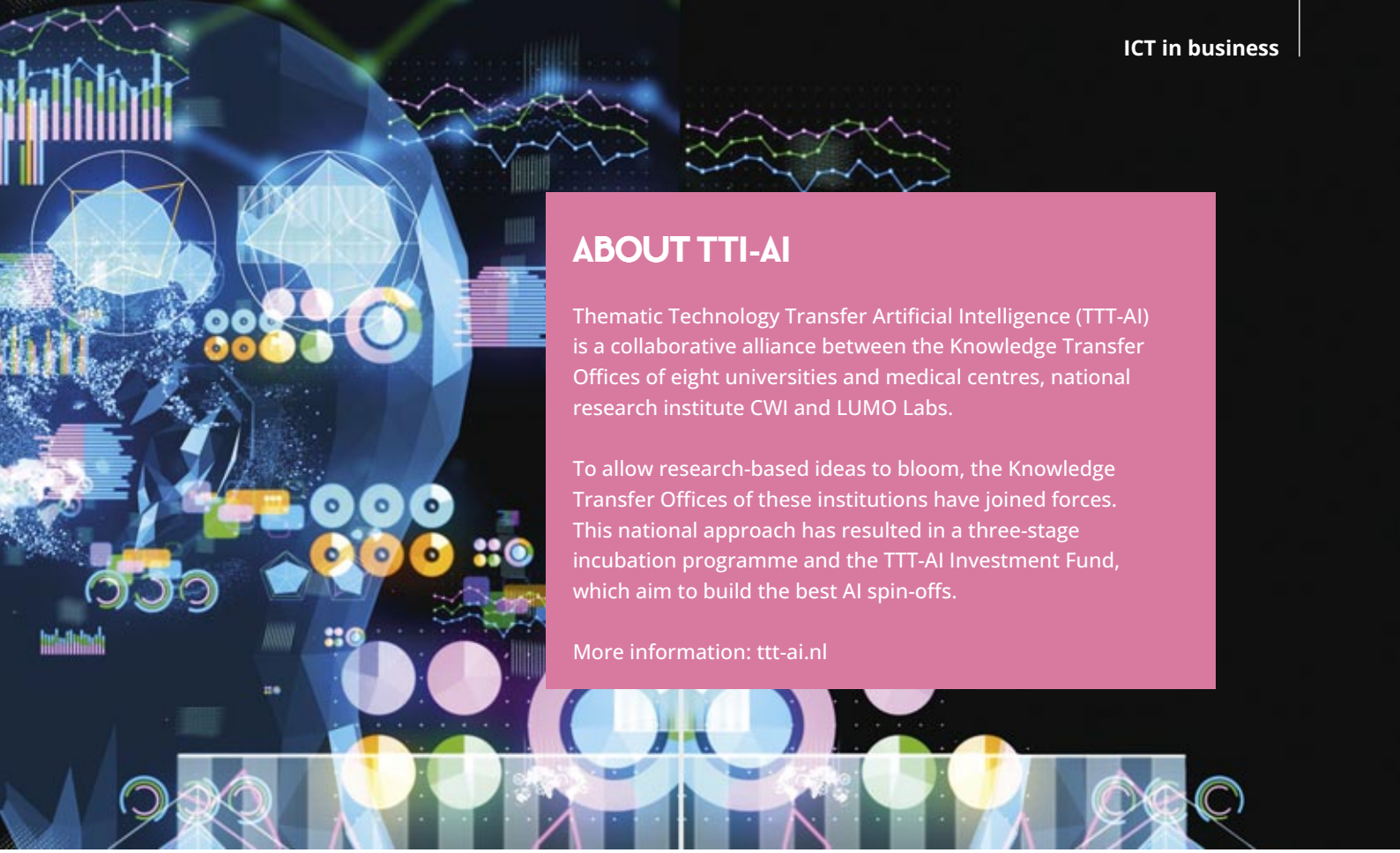
The first phase of TTT-AI has come to an end. Dozens of start-ups have already emerged, and many more are to follow, as AI applications gain ever more traction. TTT-AI therefore enters its next phase with confidence – backed by a 13 million euro budget and an 8 million euro pre-seed investment fund to further boost commercial AI applications.

By Leendert van der Ent Image iStock

TTT-AI operates within the Thematic Technology Transfer scheme of the Netherlands Enterprise Agency (RVO), which supports consortia in turning academic research into start-ups. With the initial five-year period of the AI-themed consortium coming to its official end, it is the perfect moment to look back on what has been achieved so far. Over 200 potential start-up cases have been evaluated, resulting in about 25 actual start-ups so far. Twelve of these start-ups have been financed by the TTT-AI pre-seed investment fund managed by LUMO Labs in Eindhoven, a key partner in TTT-AI.

'This is only the tip of the iceberg of TTT-AI's activities', says Peter Westerhuijs. He is a business developer at the University of Amsterdam and programme manager of the TTT-AI consortium. 'The tight thematic collaboration that has arisen between close to a dozen universities, university medical centres and other knowledge institutions is also an important deliverable. The same goes for connecting these knowledge institutions to countless other relevant parties such as ICAI Labs, AIC4NL and players in relevant sectors such as defence, industry and health. Sharing knowledge and building networks through workshops has been very successful. An example is the annual NWO start-up orientation workshop we host. Researchers interested in starting a company learn from experienced entrepreneurs about the practical ins and outs of the first steps towards commercial application. All of this networking is vital to accomplish one of our most important tasks, namely to pair entrepreneurs with researchers to create the perfect team for a specific start-up.'

A key role of the TTI-AI programme is to identify similar or complementary projects at different institutes. Westerhuijs: 'Half of our cases are in the medical field, partly overlapping with enabling technology for fundamental research. Many others revolve around drone and robot technology. Before you start a company, it is vital to assess whether a certain activity already exists and to join forces with other parties to overcome fragmentation in a small home market.



ABOUT TTI-AI

Thematic Technology Transfer Artificial Intelligence (TTT-AI) is a collaborative alliance between the Knowledge Transfer Offices of eight universities and medical centres, national research institute CWI and LUMO Labs.

To allow research-based ideas to bloom, the Knowledge Transfer Offices of these institutions have joined forces. This national approach has resulted in a three-stage incubation programme and the TTT-AI Investment Fund, which aim to build the best AI spin-offs.

More information: ttt-ai.nl

We must leave the "not invented here" syndrome behind and bring people together to increase impact, and mobilise more data, knowledge, hardware access, competences and intellectual property within our Dutch network. By connecting teams with founders, investors, industry experts, launching customers, and specialised facilities, TTT-AI enables faster creation of stronger business cases with more potential for the international market. This collaborative strength makes Dutch initiatives particularly attractive to other European AI hubs.'

Peter Westerhuijs

'WE HAVE TALENT, STRONG AI RESEARCH, AND PROMISING START-UPS. THAT MAKES THE OVERALL PERSPECTIVE FOR EUROPEAN AI VALORISATION FAVOURABLE'

EUROPEAN PERSPECTIVE

Speaking of Europe, Westerhuijs adds: 'We have talent, strong AI research, and promising start-ups. That makes the overall perspective for European AI valorisation favourable. At the same time, we are dealing with too many regulations and insufficient risk capital. As a result, successful scale-ups often move abroad, especially to the United States. Apart from that, what would also help is a more active public sector that adopts innovations and acts as a launching customer for start-ups, not in the least in the context of European autonomy and strategic defence.'

During the second phase of its existence, TTT-AI aims to further boost the success of promising AI cases in the Netherlands. With expanded budget and pre-seed funding, and LUMO Labs reappointed to manage the new 8 million euro successor fund, the programme is positioned to deliver even greater impact. Westerhuijs: 'That is important, as this kind of funding is often the stepping stone toward a multiplier in private equity.'

Software for the quantum age

By Bennie Mols
Images Ivar Pel

GROUP PASSPORT

RESEARCH FIELD

Quantum simulation and few-qubit applications; quantum information science; cryptography in a quantum world; quantum algorithms and complexity; quantum for society and business

INSTITUTION

Centrum Wiskunde & Informatica (CWI) and University of Amsterdam (UvA)

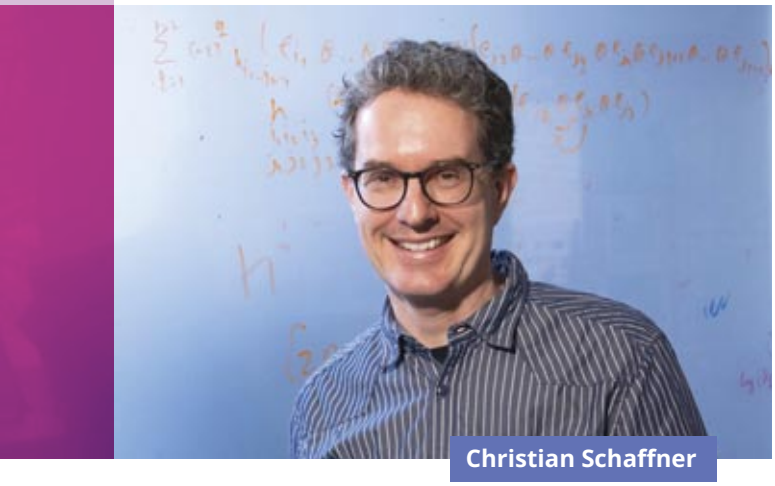
EMPLOYEES AS OF FEBRUARY 2026

Total 120:
38 permanent academic staff members,
8 postdocs, 30 PhD students,
35 MSc students, 9 support staff

WEBSITE

qusoft.org

At QuSoft, the Research Centre for Quantum Software, about one hundred researchers are developing quantum software that will turn the future quantum computer into a practical problem solver. This year, the organisation is celebrating its tenth anniversary.



Christian Schaffner

Lynn Engelberts

John van de Wetering

Following the inception of the quantum computer in the 1980s, its first few decades of development focused primarily on the hardware. However, quantum hardware can only solve practical problems if it is equipped with suitable quantum software. QuSoft at the Amsterdam Science Park is the world's first quantum software research centre, founded in December 2015 by Centrum Wiskunde & Informatica (CWI) and the University of Amsterdam (UvA).

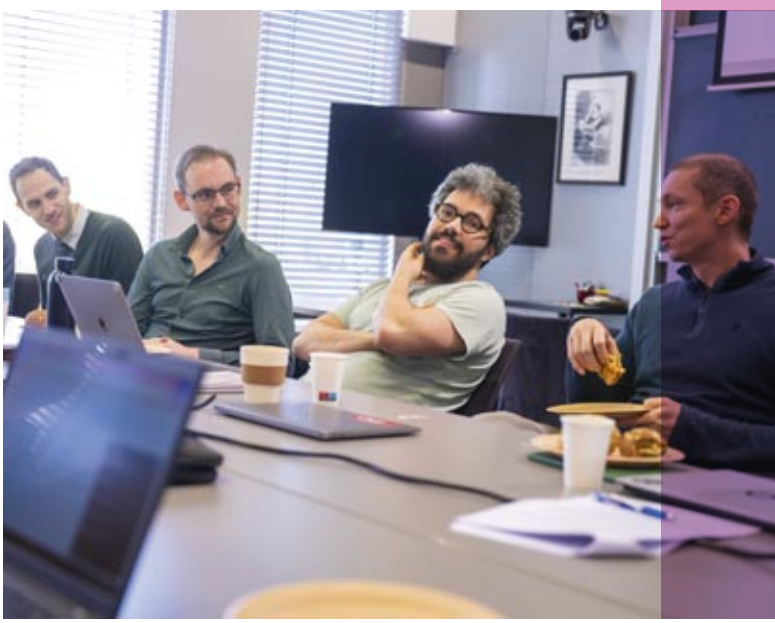
'In ten years, we have become a national and international centre for quantum software,' says Christian Schaffner, director of QuSoft and Professor of Theoretical Computer Science at UvA. 'In terms of size, with some hundred researchers, and with our strong focus on mathematics and computer science, we are unique in the world.'

Over the past decade, QuSoft has produced approximately 30 PhD students and 14 postdocs, who are all prepared for the age of the quantum computer. Among the many research highlights, QuSoft researcher Ronald de Wolf (CWI, UvA) and his co-authors received the Gödel Prize 2023 for their outstanding publication in theoretical computer science. This makes De Wolf the only Dutch person ever to have won this prestigious computer science prize.

Another highlight is the establishment of a new and worldwide unique master's programme in Quantum Computer Science at the UvA. Schaffner: 'If quantum computers really take off, there will be a shortage of experts. We want to respond to that now. Currently, we are in the second year of our master's programme Quantum Computer Science. In the first year, we had nine first-year students; this year we already have 27; and we hope to grow to 50 new first-year students in the coming years.'

One of the important developments in the coming years is the construction of LabQ, a new building at Amsterdam Science Park, planned to be ready by the end of 2028. This lab will bring together Amsterdam-based education, research, and valorisation in the fields of quantum physics, quantum computing, and quantum technology.

'Bringing all of this quantum knowledge together in one building will provide an extra boost for our ecosystem', Schaffner says. 'The recently published National Technology Strategy and the Wennink report on the future earning capacity of the Netherlands have also identified quantum technology as one of the strategic opportunities in which the Netherlands excels.



If that leads to new research investments, we are prepared for it, partly because in the coming years we will be conducting more research into practical applications, such as quantum drug discovery.'

Quantum compiling

Research at QuSoft combines computer science with mathematics and physics. Approximately half of QuSoft's researchers have a background in computer science. John van de Wetering, a senior researcher and assistant professor at UvA, has a background in all three disciplines, but his QuSoft research primarily falls within computer science. Van de Wetering: 'I conduct research into quantum compiling. How do you translate a quantum calculation described in a high-level language into low-level instructions that the quantum computer can execute? I want to know how to do that in such a way that you can be sure that the compilation is done correctly.'

Both the problems they study at QuSoft, and their terminology and academic culture belong to computer science, says Van de Wetering. 'We find ourselves in between mathematics, with its rigorous formality, and the more intuitive approach of physics.'

One of the reasons he applied for his current position was that Van de Wetering would become responsible for setting up the new master's programme in Quantum Computer Science. 'In addition to doing research, I was looking for a new challenge, and I found it in setting up a programme that did not exist anywhere else. I am now responsible for the scientific content of the programme and I teach two of our fifteen courses: Quantum Programming Project, in which students write open-source software for external partners, and Full-stack Quantum Computing, which is about quantum compiling and quantum error correction.'

Post-quantum cryptosystems

At CWI, fourth-year PhD student Lynn Engelberts works at the intersection of quantum algorithms and classical cryptography. 'My research can be seen in the context of Shor's famous quantum algorithm from 1994 for factoring large numbers', Engelberts tells. 'That algorithm shows that many current cryptosystems that are widely used in banking, for example, are not secure against attackers with large-scale quantum computers.'

A proposed solution is post-quantum cryptography, classical schemes that are – based on their mathematical properties – believed to be secure even if attackers use a quantum computer. To keep current applications secure, post-quantum cryptography is already gradually being introduced. Engelberts: 'I am trying to understand whether such post-quantum cryptosystems really are secure against both classical and quantum attacks.'

After obtaining a joint bachelor's degree from UvA and VU Amsterdam, and a master's degree from the University of Oxford, Engelberts returned to Amsterdam to pursue her PhD. 'I concluded that QuSoft and CWI are the best places for me. QuSoft has an excellent international reputation. I have just returned from an international conference where I noticed once again how easy it is to network: there is always someone who knows someone from QuSoft. We have a large group, with many young people and a lot of energy. And in addition to the quality of the research, there is also a strong focus on the human aspect.'

Robbert Krebbers is an Associate Professor and Vice Department Head of the Department of Software Science at the Institute for Computing and Information Sciences at Radboud University Nijmegen. He is one of the lead developers of Iris, a framework for concurrent separation logic in Rocq (formerly Coq). Previously, he served as an assistant professor in the Programming Languages Group at TU Delft (2016-2020). He earned his PhD from Radboud University Nijmegen in 2015.

BUILDING BLOCKS FOR SOFTWARE VERIFICATION

During NWO ICT.OPEN 2026, Robbert Krebbers will receive the Dutch Prize for ICT Research. Krebbers is renowned for his research on software verification: how can we ensure a program runs correctly, and how do we prove that?

By Marysa van den Berg
Image Ivar Pel

How and when did you become interested in software verification?
'During my bachelor's and master's, I discovered my fascination with using mathematical proofs to ensure bugs cannot occur. I found it even more compelling that you could have computers verify these proofs using a proof assistant. While that sounds theoretical, I soon realised challenging software, such as optimising compilers and microkernel operating systems, could be verified this way.'

What are the primary challenges currently facing this field?
'We all know that computer programs crash, behave unexpectedly, or leak private information. We need more robust methods to verify that software is doing exactly what it's supposed to. This becomes significantly more complex for software that runs concurrently – executing multiple interleaving tasks in parallel. I am fascinated by tackling these challenges through mathematically elegant solutions with practical applications applied to real programming languages and libraries.'

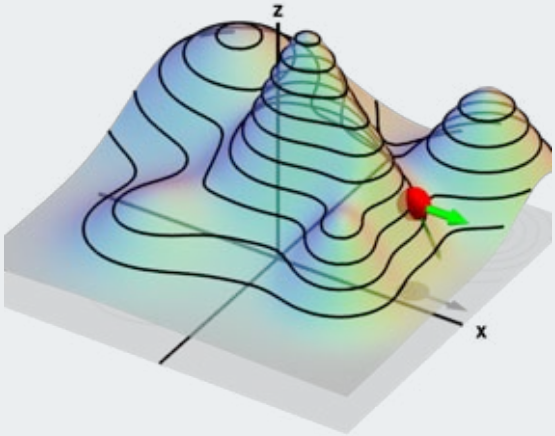
Together with Ralf Jung, you are leading Iris. How does this framework function?
'Iris is a framework for software verification with a specific focus on concurrency. One reason Iris has become so popular is that it isn't tied to a single programming language or paradigm. Instead, it provides the "Lego bricks" that allow researchers to build their own verification techniques tailored to their specific needs. This prevents them from having to reinvent the wheel every time.

We've seen Iris applied to languages like Rust, C, Go, Scala, and WebAssembly to solve a wide range of issues, including verification of type systems and libraries for concurrency, distributed systems, weak memory concurrency, crash safety, and information flow security. My colleagues and I have used Iris, for example, to prove that Rust and its concurrency libraries truly ensure memory safety and data-race freedom.'

You are also working on the ERC Consolidator project COCONUT. What is the goal there?
'Our aim is to ensure that a programming language can catch errors early. Ideally, if a programmer makes a mistake, the compiler should flag it before the program is even executed. COCONUT aims to advance the automatic detection of these bugs in the context of concurrency. I will actually be using the prize money from the Dutch Prize for ICT Research to extend a postdoc position within this project.'

SUPERCHARGING THE HIDDEN ENGINE OF AI

By Bennie Mols



Modern machine learning runs on a hidden engine: automatic differentiation. In his project FoRECAST, funded by an ERC Starting Grant, Matthijs Vákár is pushing this crucial technique to its next generation.

Under the hood of modern AI applications, there is software that automatically calculates derivatives of functions. TensorFlow, PyTorch, and JAX are three major software frameworks that perform this mathematical task efficiently.

'The ability to automatically calculate derivatives has been very important for the success of AI applications over the past ten years', says Matthijs Vákár, an associate professor in the Department of Information and Computing Sciences at Utrecht University. Many machine learning applications solve optimisation problems that require derivatives to be computed repeatedly – a process that resembles navigating a hilly landscape to find the highest peak by following the steepest path. 'What I am trying to do in my ERC project', says Vákár, 'is to come up with new ideas for the next generation of automatic differentiation software.'

Increasing complexity

In 2025, Vákár started his ERC project FoRECAST: *Formalised Reasoning about Expectations: Composable, Automated, Speedy, Trustworthy*. He now works with two PhD students and hopes to recruit a third later this year. The motivation for the project lies in the fact that machine learning is being applied in increasingly complex settings. 'This means calculating derivatives of increasingly complex functions', says Vákár. 'I focus on differentiating functions that involve randomness and can only be estimated. This is the case, for example, in programs in which probabilistic choices are made.' FoRECAST also aims to make probabilistic inference methods composable, so that researchers can reliably mix and match algorithms rather than treating each one as a one-off solution.

Use cases

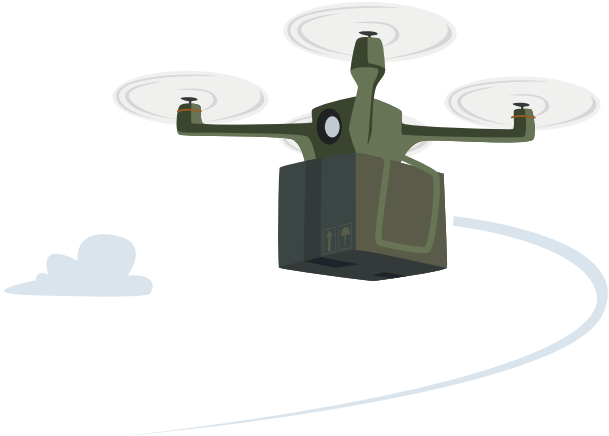
Vákár has already developed the underlying theory and is convinced it works in principle. 'The next question is whether it also works efficiently enough. My ultimate goal is to build a research prototype that we can release open source and that has real potential for commercialisation.'
He also wants to develop two concrete use cases: one in reinforcement learning and another in designing scientific experiments. Vákár: 'In reinforcement learning, an agent interacts with a complex environment that is not completely known. The agent tries out actions, receives rewards or punishments, and adjusts its strategy to maximise the total reward. But it is not always known what the reward will be.'

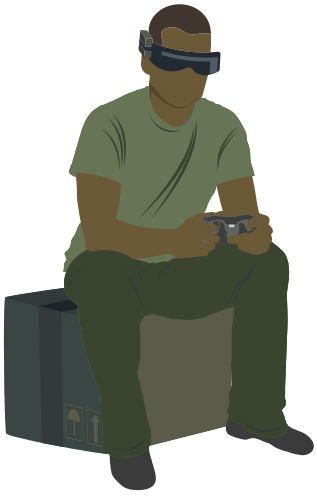
When designing a scientific experiment, researchers often face the question of what the next measurement setting should be. Vákár: 'If the experiment is expensive, you cannot try everything, so how can you determine which measurement setting offers the best chance of learning something new? That is an example of an optimisation problem that can be solved with the techniques I am developing.'

At a conceptual level, Vákár's research ties in with a broader shift in the field of programming languages. Vákár: 'Because derivatives are essential in many modern applications, computer scientists are pushing for a new programming paradigm in which everything is differentiable. Unlike traditional programs, which process information only from input to output, differentiation requires information to flow in both directions. The ideas I am developing in the ERC project are in line with this requirement.'

The European security situation requires radical changes in all domains of security-related ICT systems. Conversely, all ICT systems are security-related. In the realm of defence ICT systems, a lot of work has to be done. What are the main challenges, what do these mean for ICT researchers in knowledge institutes, and what is already happening there?

CHALLENGES IN ICT DEFENCE





By Leendert van der Ent Images WAT ontwerpers, iStock

The EU is tangled up in a hybrid war with Russia. The Greenland crisis has shown that the reliance on American software systems poses a giant security liability. Apart from that, Europe must be on the alert for Chinese industrial and military espionage. All things considered, the ICT challenges are enormous, time is limited, and even increased budgets are insufficient. Frank Bekkers, director of the security programme at The Hague Center for Strategic Studies: 'It requires a Herculean effort to adapt all systems. These range from "grey" ministerial, civil-military management systems to "green" command and control systems and embedded software in all kinds of military hardware. Boundaries between domains have faded; ICT systems permeate everything.'

STRATEGIC AUTONOMY

Bekkers indicates that our addiction to American military systems was, in fact, already baked into the post-WWII Marshall support. 'And within NATO, certain domains, such as strategic intelligence and command and control systems, were entirely left to the Americans. Add the fact that software platforms

OPENBOTS

The military application of (autonomous) robots is one of the fastest developing fields in defence. TU Delft, the University of Amsterdam, TNO, and the Royal Netherlands Marechaussee have joined forces in OpenBots to develop generative AI for surveillance robots that support the marechaussee security staff in public spaces. The difficulty for robots is assessing situations and coming up with a reaction suited to routine tasks, such as surveillance rounds along fences. Another challenge is to create the ideal collaboration between robots and humans. OpenBots is funded by NWO-AES, TNO and the Royal Netherlands Marechaussee.

More information:
autonomousrobots.nl

have a buy-in aspect that makes it hard to switch after initial procurement.' To achieve European strategic autonomy, we have to build European systems, Bekkers states. 'We have the knowledge and the industrial capabilities to do so, but to create the necessary mass and operational strength will require time, resolution and enormous budgets.'

However, according to Bekkers, business as usual will not do. 'Article 346 of the Treaty on the Functioning of the European Union (TFEU) allows EU Member States to derogate from standard EU public procurement rules to protect essential security interests. Freedom of partner selection is already sufficiently covered by that. The EU's policies to diversify sectors in which we have to become less dependent on the Americans are on the right track, but the actual, timely execution is hardly feasible. The procurement practice and the collaboration between clients and contractors, including academic researchers, will have to change. There is no time for the lengthy establishment of fixed specifications, followed by prolonged public procurement procedures of the traditional model. Flexibility and speed are essential. That requires a closer collaboration between public and private parties.'

END-USER FOCUSED MINDSET

The new situation requires researchers to become more actively involved in their clients' use cases, says Bekkers, in an interaction sustained throughout the product's lifecycle. 'The innovation cycle of drone technology is the perfect example. Deliverables are not expected within a couple of years, but within weeks. In peacetime, demand for military capabilities can seem abstract. Now it is much more concrete; a close back-and-forth between users and researchers is needed, and a

ELSA LAB DEFENCE

There are several labs for embedding Ethical, Legal and Societal Aspects (ELSA) of technology development. One of these labs is the ELSA Lab Defence. Jurriaan van Diggelen of TNO is its programme manager. 'Every new technology holds the prospect of societal progress. But it also offers the possibility of abuse. Developers of such a technology are responsible for the consequences. ELSA labs provide design choices favouring progress and blocking abuse.'

In the case of military AI this is far from trivial. What to do when systemic adversaries make different ethical choices that place us at a disadvantage? Van Diggelen: 'Sure, it is difficult. That is why seven parties, including NWO in a funding role, are involved to address the issue optimally. The guidelines in the Geneva Convention form the starting point, for instance, stating that a clear distinction between combatants and non-combatants must be upheld and that violence must be proportional. That can pose severe design challenges for AI image classification algorithms, for instance. How can AI distinguish between civilians holding weapons and soldiers posing as civilians?'

Involving civil society is always hard, as, by definition, it involves people who are farther removed from the technology. 'Nevertheless, involving them is extremely important, as civilians will suffer the consequences when the wrong choices are made. These choices will, in practice, not be as black-and-white as "Should we ban lethal autonomous AI systems or not?" The relevant questions are more about what level of human control and oversight will need to be built in. Systemic adversaries will also address these questions, but from a different set of values than ours. An important takeaway, I think, is that outcomes from the ELSA labs are not meant to impede technology developers. Rather, they help developers by offering concrete design guidelines that comply with legal and ethical frameworks.'

More information:
elsalabdefence.nl

speedy up-and-down cycle through all technology readiness levels is required. Solutions can be quick and dirty; practical combat deployment will prove the solution's value and the tweaks that might be necessary. This approach asks for a different, end-user-focused mindset. Although this example regards extremely practical applications, it also touches fundamental science. Apart from purely curiosity-driven research, there should also be more room for targeted fundamental research towards breakthroughs in various fields to attain certain much-needed deliverables.'

BOLD CHOICES

By Sonja Knols

Alan Hanjalic

Head Department of Intelligent Systems and co-leader of Computer Science at TU Delft

'In Delft, our computer science activities are divided over two departments. The first sector plan offered us the opportunity to open ten scientific staff positions across both departments combined. This opportunity inspired us to define five overarching themes, building on diverse expertise and synergistic potential, and aiming at clear joint positioning not only within the Dutch computer science landscape, but also internationally. This has led to more cross-departmental collaboration and strengthened us internally as an organisation. We were happy to see this reflected in the feedback we received in the last mid-term research assessment, which we underwent jointly as a computer science entity rather than as individual departments, like in the past.

Whereas the first sector plan was aimed at strengthening science, the second was more broadly intended to provide the computer science sector with greater peace and space. The main value for us in this was the possibility not only to appoint scientific staff but also to hire a number of software engineers. With additional investments from our Faculty of Electrical Engineering, Mathematics and Computer Science, this resulted in our current pool of 12 engineers who support software development for our research projects, and manage, maintain, and expand our computer science research infrastructure. These engineers form a structural part of our organisation, the Research Engineering and Infrastructure team, serving both departments.

Establishing this team paid off in many ways. Not only do we have in-house capacity to address increasingly complex software and infrastructure needs across different research projects, but the services the team offers also enhance our international attractiveness as an academic employer. High-quality support is nowadays just as valuable for applicants for faculty positions as the individual benefits, like salary. All in all, we strongly recommend that, should there ever be new sector-plan-type investments, room be made to fund profiles beyond just scientific staff.

It goes without saying that any new investments in our field should also align with the Wennink report, which identifies many strategic domains in which computer science expertise, especially regarding digitalisation and AI, plays a critical role. For Dutch computer science to flourish and contribute in the best possible way to the national development strategy, we need the entire ecosystem surrounding it to be on par. This means, for example, that as a field, we should have access to top-of-the-bill computing infrastructure.'

The two successive sector plans have led to a significant number of new hires across various Dutch universities. Alan Hanjalic, co-leader of Computer Science at TU Delft, explains how the second sector plan round helped establish a pool of software engineers who have significantly contributed to the research and valorisation impact. Rihan Hai, Assistant Professor of Web Information Systems, explains how the sector plan funds enabled her to take a bold leap into the unknown.

Rihan Hai

Assistant Professor of Web Information Systems at TU Delft since January 2022

'During my PhD research at RWTH Aachen I was building software and mathematical foundations for data lakes: collections of heterogeneous data from different sources. In 2021, I came to Delft as a postdoc to expand on this work. When a position for an assistant professor opened, I seized the opportunity to build my own team, which now comprises four PhD students and one postdoc.

Over the past five years, I have been developing an entirely new research direction. I want to understand how we can apply data science knowledge to improve AI and quantum computing, and vice versa.

My first line of research in this direction is to leverage the power of databases to improve the accuracy and speed of artificial intelligence. For example, when you are using large language models on edge devices like smart watches, you cannot use computing methods that are based on large matrices, since they simply do not feed into the available memory. We are advancing "out-of-core" methods that let very large AI models run on limited memory by processing them piece by piece instead of loading everything at once.

In my second line of research, I am combining quantum computing with databases. For example, by representing quantum computation as data, we can use database theory and technologies to make quantum computation analysable and scalable on classical hardware. With existing simulation methods, you might need petabytes of memory to simulate fifty qubits. By using out-of-core methods, we hope to significantly reduce memory usage and lower hardware restrictions in simulations. This second line of research is still in a conceptual phase; we are currently thinking about what a future quantum database would look like.

As a database researcher looking to collaborate with the AI and quantum computing communities, Delft is the perfect location for me, with the TU Delft AI Initiative and QuTech around the corner. Ultimately, I want to do good research with people who share similar interests. The sector plan funding has made me more creative and productive, and has helped me open new windows into interesting cross-overs that might benefit multiple disciplines. I have made some bold choices in pursuing these high risk, high gain research directions. But the sector plan funds made me feel safe enough to do this.'

EMPOWERING WOMEN IN TECH

By Marysa van den Berg Image Bram Saeys

Katja Tuma's mission is clear: to create a fostering environment where women can fully explore their technological potential. To achieve this, she supported student organisers as scientific lead, and co-founded Hack4Her, a women-focused hackathon that is going national this year.

'In our hackathons, students collaborate to build innovative solutions to societal and technological challenges within a very tight timeframe. Although participation in most hackathons is technically open to everyone, research shows they often turn into "masculinist" environments. This is reflected in the use of aggressive language and the glorification of individual technological mastery.

Such an atmosphere may deter women from joining. That is a significant loss because women bring technical talent, fresh perspectives and diverse ideas that are essential for creating truly impactful, inclusive solutions.

Beyond hackathons, there is a broader issue of women being underrepresented in computer science. While there are great initiatives to attract more women to the field, I believe we are missing a huge opportunity by not doing enough to retain the women who are already here.'

Making it happen

'That is where Hack4Her comes in. It is designed to be a supportive environment for women to showcase their technical skills and stay inspired by this fantastic field.

The story of Hack4Her began in 2021 during my time as a diversity officer at VU Amsterdam. I connected with two students, Isabella and Mylène, who had founded the first Diversity Committee within the study association STORM after encountering racism and sexism.

Coming from Slovenia, I was surprised to hear these same old stories in the Netherlands: stories of women being pushed into "softer" roles in programming projects, like documentation and project management, rather than development. This motivated me to support this initiative and make Hack4Her a reality.

The event is growing every year. In June 2026, we will host Hack4Her in both Amsterdam and Eindhoven. I believe Hack4Her is more than just an event; it's a movement. We are building a community that inspires women across the country, and perhaps eventually beyond, to use their technical knowledge and skills to solve real-world challenges.'

Katja Tuma is an assistant professor at Eindhoven University of Technology within the Software Engineering and Technology cluster. She obtained her PhD in Computer Science and Engineering from the University of Gothenburg. Her research sits at the intersection of software engineering, security and AI, and risk analysis.