I/O magazine

ICT RESEARCH PLATFORM NEDERLAND

VOLUME 20 OCTOBER 2023 NO 3

COLOFON

I/O Magazine is a publication of the ICT Research Platform Nederland (IPN) and is sent free of charge to ICT researchers and relations of IPN four times a year. IPN consists of the ICT research schools ASCI, IPA, and SIKS; the ICT-related themes of NWO domains Science (ENW) and Applied and Engineering Sciences (AES); the institutes of the technical universities, united in NIRICT; the institutes of the general universities; SURF; Netherlands eScience Center; CWI; Dutch Platform for Mathematics; Data Science Platform Netherlands; Dutch Tech Center for Life Sciences; VERSEN; TNO and COMMIT.

IPN (ICT Research Platform Nederland) unites all Dutch academic research groups with ICT science as their core and 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 the NWO Domain Science.

EDITORS Loes van Bree, Juul Brouwers, Sonja Knols, Femke Stephan **FINAL EDITING** Sonja Knols **TEXT CORRECTION** Dave Thomas, NST Science **CONTRIBUTORS** Marysa van den Berg, Leendert van der Ent, Sonja Knols, Bennie Mols **DESIGN** WAT ontwerpers, Utrecht - Leon Hulst **PHOTOGRAPHY** ANP, Bart van Overbeeke Fotografie (cover), iStock (p. 4, p. 8, p. 9, p. 10, p. 18), Ivar Pel (p. 6, p. 12, p. 16), Bart van Overbeeke (p. 7), WAT ontwerpers (p. 19), UvA - Dirk Gillissen (p. 22), Robert van der Molen (p. 24)

EDITORIAL ADDRESS Secretariat IPN, c/o NWO Science, PO Box 93460, 2509 AL The Hague, the Netherlands, +31 70 344 0772, ipn@nwo.nl, www.ict-research.nl

NWO

IPN ICT-ONDERZOEK PLATFORM NEDERLAND

PAUL KLINT

Creating a CV with an LLM

I regularly get questions on why I don't have a Wikipedia page, which is probably a serious ego defect. Can Large Language Models (LLM) come to the rescue?

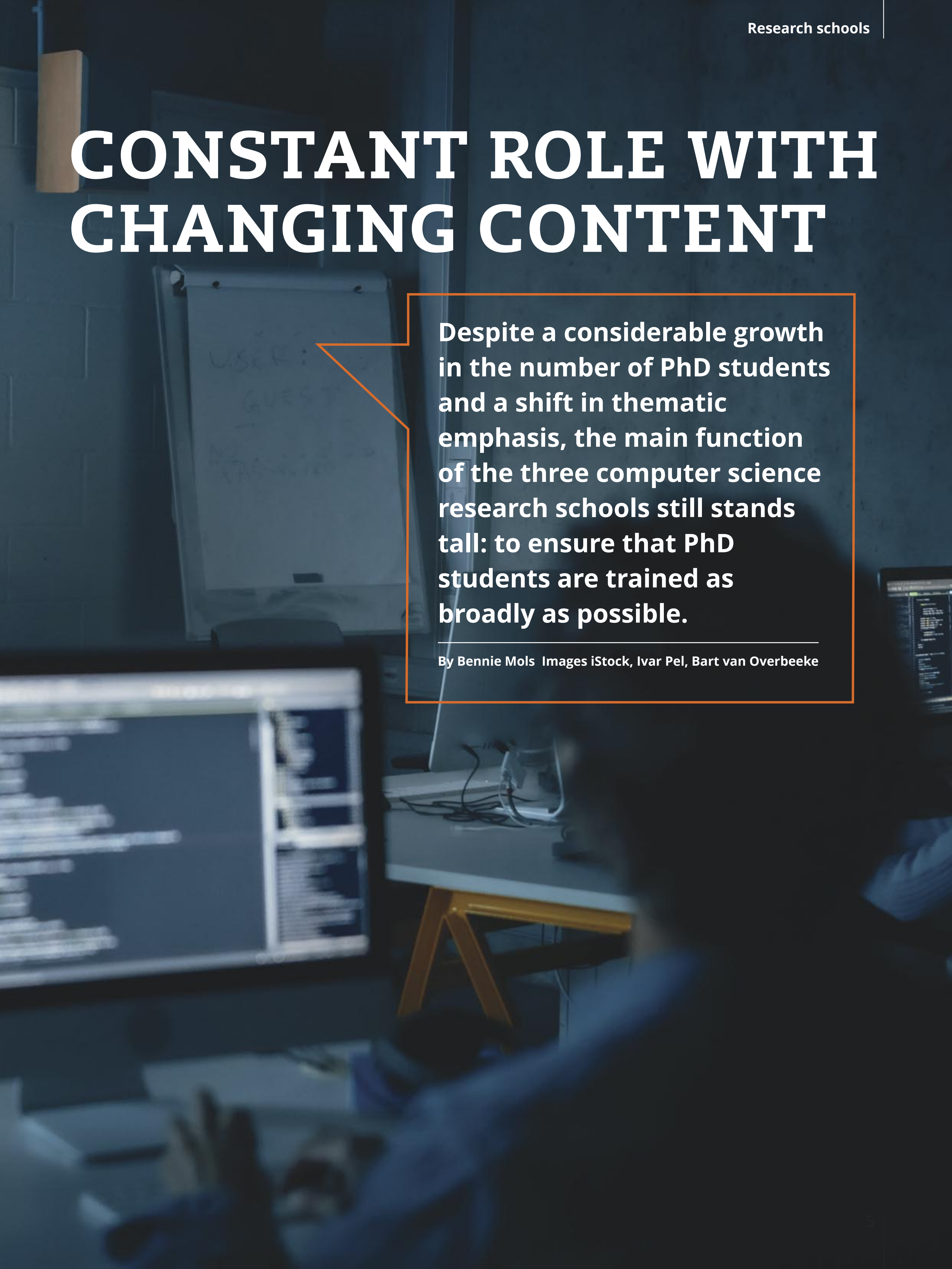
CVs come in various styles and lengths. People list their boring stuff to keep update-to-date and to adapt to new requirements. So do I. In answer to the next request for a Wikipedia entry, I decided to carry out an experiment with two of the much-advertised Large Language Models: ChatGPT and Bard. They are claimed to be able to write poems, generate software and give explanations about almost any topic. So why not assemble a CV? Would it be possible to outsource this writing task to such a system? Would they generate a usable CV in Wikipedia style? The nice aspect of this experiment is that I am, of course, in an excellent position to assess the correctness of the result.

To cut a long story short, the result was a disaster in both cases. I have never worked for the affiliations that were mentioned in my supposed CV. The dissertation that was listed as mine was about a topic I have never researched and know nothing about, and the publication I was erroneously linked to did not even exist. In other words, this CV was completely fabulated. Having said that, I am not claiming that all fabulated CVs have been generated by ChatGPT.

Of course, I am an amateur in prompt engineering, and I can imagine that first feeding the beast with sufficient information would have generated a much better result. Nonetheless, all the above information is publicly available and could have been used by these tools.

So back to the labour-intensive, LLM-free, CV writing process. I am curious to hear from anyone who has either positive or negative experiences using LLMs for a similar task.

To conclude: I promise that my next column will not be generated by ChatGPT or any of its friends.



CONSTANT ROLE WITH CHANGING CONTENT

Despite a considerable growth in the number of PhD students and a shift in thematic emphasis, the main function of the three computer science research schools still stands tall: to ensure that PhD students are trained as broadly as possible.

By Bennie Mols Images iStock, Ivar Pel, Bart van Overbeeke

In 1991, the Minister of Education, Culture and Science, Jo Ritzen, established research schools with a dual purpose. The introduction of a new system for PhD students – the AIO system – necessitated well-organised researcher training, and there was also a wish to enhance the quality and coordination of the research done. To achieve these two goals, universities were invited to form highly qualified research centres for their major research fields, mostly via inter-university collaborations.

Arno Siebes:

'Research schools have become mostly education schools'

For computer science, this development led to the establishment of three research schools in 1996: the Advanced School for Computing and Imaging (ASCI), the Institute for Programming research and Algorithmics (IPA), and the School for Information and Knowledge Systems (SIKS). Today, almost three decades later, the three computer science research schools still exist, even though the end of the research school phenomenon has been predicted many times before, and despite all the changes within computer science itself: in particular, the huge increase in the number of students and PhD students, and the substantive thematic changes with the strong growth of fields such as data science and AI.

From research to education

How do current scientific directors Remco Veltkamp of ASCI, Arno Siebes of SIKS and Alexander Serebrenik of IPA view the role of their research schools?

Remco Veltkamp:

'It is quite conceivable that we will develop some joint courses for all three research schools'

'In the mid-1990s, there was a fear that if you didn't join a research school, you wouldn't get funded,' says Remco Veltkamp, 'but it hasn't worked out that way at all.' Arno Siebes adds: 'In the end, research schools have become mostly education schools, which is a good thing.'

The role of research schools has not really changed in recent decades, says Alexander Serebrenik. 'We still make sure that PhD students are trained fairly broadly, that they not only know about their own subject, but also have a broader view of the field of computer science. In training them, you have a spectrum of skills. At one end of that spectrum are basic skills such as writing, oral presentation and research methodology. That is what universities are responsible for. At the other end of the spectrum, you have subjects and skills needed for a specific doctoral project, which is primarily on the individual supervisors. Research schools are in between.'

Each research school offers a variety of thematic courses. PhD students generally attend one or two courses per year. Siebes emphasises that establishing social contacts with PhD students from other universities is also an important function of the research schools: 'Courses often last two or three days. Especially in the evenings, PhD students share experiences with each other. It is good that they can vent to each other now and then about what is and what is not going well.'

Just how important the social aspect of research schools is can be seen in the strong recruitment of new members after the corona crisis. Veltkamp: 'During the pandemic, physical meetings naturally fell silent. In the past year, ASCI suddenly gained 35 new PhD students, so they are very eager to come to our courses.'

Evolving topics

The main role of the research schools may not have changed in recent decades, but the topics they cover have. 'Of course, within IPA, we still cover software engineering, formal methods and algorithmics,' says Serebrenik, 'but nowadays, we also pay explicit attention to social aspects of software development, such as the topic of sustainability, for example. That's a substantial difference from twenty years ago when that was unthinkable.'

Siebes recognises this trend: 'I think the big change within SIKS is that we no longer deal only with pure computer science subjects. Topics such as data science and AI have moved into completely different subject areas. And that means that some non-traditional computer science groups have also joined SIKS, such as computational linguistics.'

Another trend is that in a subject such as AI, for example, there are more and more interfaces between the three research schools. Veltkamp: 'ASCI has two blood groups: computer systems and imaging. In imaging, which you can see in a broad sense as multimedia, a lot is happening on neural networks. But at SIKS and IPA there are also people working on that. It is, of course, quite conceivable that we will develop some joint courses in this area for all three research schools. We are thinking about that.'

At the latest ICT.OPEN conference, the three research schools already offered a joint leaflet of courses. In the past, there has been talk of a merger, but there is no urgent need for it. Veltkamp: 'If we collaborate well, that is fine enough.'

Over time, PhD students within the research schools have become increasingly international. All three scientific directors see this as a positive development. Serebrenik: 'That means that PhD students are easily exposed to different cultures and different opinions and that broadens the discussions, which is a good thing.'

A final trend to be mentioned is the sharp increase in costs of organising multi-day courses in hotels, as has always been the practice. Serebrenik: 'Especially for the social aspect, organising a course outside a university in a hotel works well, but we sometimes stay closer to home due to the high costs. We have also had to increase the participation fee.'

Changes in content

The three scientific directors agree that the role of the research schools is still primarily to broadly train PhD students. Siebes: 'In that sense, nothing will change in the future. But, of course, there will be an incredible number of changes in terms of content that we can't predict. If I were to compare our course program of twenty years ago with that of today, then I am pretty sure that there is hardly any similarity.'

In recent decades, topics that have long been studied in computer science, such as neural networks, language models and mobile computing, have been developed by the computer industry into everyday products and services, from mobile phones to cloud services. These products and services have led to major societal changes, giving rise to new scientific challenges that the research schools also need to tackle. Siebes: 'Topics like fairness, explainability and trust have come up and will never leave. We still have plenty to do in our education in these areas.'

And a social theme such as sustainability has led to a research topic such as 'green computing' within computer science and will lead to changes in handling large amounts of data. Veltkamp: 'So far, only data has been added. But if the impact on our planet becomes too big, at some point we may no longer be able to store all data, and we will have to throw data away. How will this affect algorithms, databases, AI and data science?'

'Society is changing,' Serebrenik concludes, 'and that means that society's expectations of computer science are changing. While topics such as data, algorithms and software are traditional computer science topics, societal changes force us to look at them differently.'

Alexander Serebrenik:

'We make sure that PhD students have a broader view of the field of computer science'

ABOUT THE THREE COMPUTER SCIENCE RESEARCH SCHOOLS

Advanced School for Computing and Imaging (ASCI)
Size: 106 PhDs, 83 staff members
Participating institutes:
Delft University of Technology ('administrative university'), VU Amsterdam, University of Amsterdam, Eindhoven University of Technology, Leiden University, Utrecht University, University of Twente, University of Groningen, Erasmus University Rotterdam
asci.tudelft.nl

Institute for Programming research and Algorithmics (IPA)
Size: 98 PhDs, 176 staff members
Participating institutes:
Eindhoven University of Technology ('administrative university'), Centrum Wiskunde & Informatica, Radboud University, University of Groningen, Delft University of Technology, Leiden University, Utrecht University, University of Twente, University of Amsterdam, VU Amsterdam, Open University
ipa.win.tue.nl

School for Information and Knowledge Systems (SIKS)
Size: 300 PhDs, 350 staff members
Participating institutes:
VU Amsterdam ('administrative university'), Utrecht University, University of Twente, University of Amsterdam, Delft University of Technology, Eindhoven University of Technology, Radboud University, Maastricht University, Tilburg University, Open University, Leiden University, University of Groningen, Centrum Wiskunde & Informatica
siks.nl

Fighting for more female students

By Sonja Knols
Image iStock

'We simply need to attract more Dutch female students to computer science since informatics, more than any other field, is determining where our society is going,' says CWI researcher Lynda Hardman. To share ideas on how to achieve this, she organised a workshop preceding the inaugural lecture of Felienne Hermans at VU Amsterdam on 15 June.

'When I was working at the artificial intelligence department back in the nineties in Edinburgh, I was one of the few women and thus acted as a role model. I used to think things would get better once I got older.' And although in the Netherlands, over the past years, the number of female professors in computer science has slowly but surely been rising, 'very few of them are Dutch.' Not that she has anything against foreigners, Hardman emphasises: 'After all, I'm a foreigner! But it is problematic that so few Dutch girls choose to study informatics.'
Hardman organised a workshop entitled "More female computer science students in the Netherlands" to discuss what should and could be done to turn the tide. 'Thanks to Felienne's network, we managed to bring together many different communities, each doing their own thing but mostly unaware of the others and how they could reinforce each other.'
Three organisations presented themselves and their work. The Co-Teach Informatica initiative shared how they link IT professionals to high schools for providing guest lectures as part of a wider informatics curriculum, VHTO presented the activities they develop to attract primary and secondary school girls to science, technology, engineering and mathematics, and Eljakim Schrijvers from Bebras presented his plans to organise the European Girls' Olympiad in Informatics in Veldhoven next year.

GETTING INTO ACTION

'During the plenary part of the workshop, the participants engaged in lively discussions where to start. We identified two action points,' Hardman says. 'One possible action relates most closely to Co-Teach Informatica, since they already have connections with numerous schools. We can increase the number of women who visit schools to teach and we can ensure that the materials used aren't biased towards topics that boys tend to find more interesting.'
A second action point is to address any existing gender bias as well as "anti-tech" bias that primary school teachers may have and help primary school teachers build more self-confidence with regard to their own technical abilities. VHTO will take the lead in this.
Even though in the Netherlands, girls tend to move away from STEM and informatics at a young age, universities can still help to increase the number of female students from the Netherlands at computer science departments, Hardman stresses. 'Girls need role models more than boys. I am aware of the existing excessive educational burden on scientific staff in computer science, but I would still urge universities to encourage and facilitate their Dutch-speaking, female staff to engage in initiatives that enable them to act as role models for young school girls. As the companies involved in initiatives like Co-Teach Informatica are aware of already: in the end, attracting a more diverse group of students is all about investing in your own future staff.'

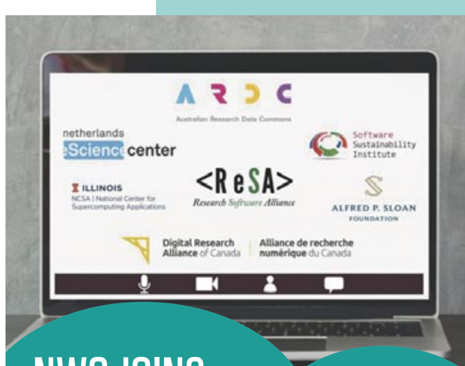
The inaugural lecture of Felienne Hermans can be found in video and comic book format (both in Dutch) on www.felienne.com/nl/oratie

GRANTS FOR COMPUTER SCIENCE TALENT

NWO has awarded Veni funding of up to 280,000 euros to 188 promising researchers from the full breadth of science. This funding will allow the laureates who have recently obtained their PhDs to further develop their own research ideas over the next three years. Of the 188 laureates, 14 researchers are active in the field of computer science. Their projects cover topics ranging from battery-free and neuromorphic computing to (quantum) cryptography, robotics, drone technology, brain-inspired devices, autonomous collaborative systems, image processing, software engineering and data science.
In addition, NWO has awarded 97 experienced researchers a Vidi grant worth 800,000 euros. The grant enables them to develop their own innovative line of research and set up their own research group. Five of the recipients are active in the computer science field.

NEW KIC CALL ON AI

Recently, a new call for proposals was opened for the KIC-programme 'AI for agriculture, horticulture, water and food'. The aim of this call is to research knowledge questions related to the development and application of AI systems within the domains of agri-, horticulture, water and food. This should enable the utilisation and further development of the technology within these sectors. On 12 October, an information and matchmaking event will take place. NWO invites researchers (humanities, natural sciences and social sciences), companies and societal organisations to attend.



NWO JOINS INTERNATIONAL SOFTWARE ALLIANCE

NWO has joined the Research Software Alliance (ReSA), an international non-profit organisation dedicated to cooperation in the area of research software. ReSA focuses on software developed to serve a research purpose and works towards recognising software as a key part of facilitating trusted, reproducible research outputs and open science. Among other things, members of this community work together to solve shared problems, learn and exchange best practices. Through ReSA, particularly through its Research Software Funders Forum, NWO can contribute to developing international open research software policies and guidelines.

CONNECTING WOMEN IN STEM

NWO Insight Out is a biennial career and networking event for women in STEM (science, technology, engineering and mathematics) disciplines. On three consecutive Thursdays in November, guided by various topical themes, a platform will be provided for women to connect with each other.

By offering a variety of live and online plenary presentations, panel discussions, workshops and networking activities, the event strives to provide a perspective for women aspiring a career in STEM.

Insight Out is organised by NWO, with input from LNVH, ECHO, de Jonge Akademie, PNN, PostdocNL and Young Academy Europe.

HOW SIDN KEEPS .NL

SIDS Labs aims to enhance the safety of the internet infrastructure, not the applications, but the underlying communication layer. 'This involves applied research, which means we naturally try to bridge the gap between academia and practice,' says Cristian Hesselman, director of SIDN Labs and Professor of Trusted Open Networking at the Design and Analysis of Communication Systems (DACS) group at the University of Twente.

By Leendert van der Ent Image iStock

'In 2011, SIDN – a foundation with the public assignment to keep the .nl domains safe – asked me to start up a research branch', says Hesselman. 'There was a blog called SIDN Labs which covered new internet developments, and we decided to use that name for our research team. Since then, we have been the research branch of SIDN, but we operate with a distinct profile.'

He explains that SIDN Labs' work touches upon three main protocols. The first domain is the Border Gateway Protocol (BGP). It enables the exchange of routing information between autonomous systems (AS). The internet consists of 75,000 autonomous systems that collaborate to expand regional coverage into a worldwide system. The second protocol is the Domain Name System (DNS), the network protocol used on the internet to translate computer names to numerical Internet Protocol (IP) addresses and back. The third protocol of interest is the Network Time Protocol (NTP), used to synchronise computer clock time sources in a network. 'Time and time stamps are absolutely vital to internet security', states Hesselman.

TRACK ANOMALIES

One part of SIDN Labs' work for internet infrastructure safety consists of large-scale internet measurements to track anomalies among the 75,000 network nodes. Hesselman: 'Apart from that, we develop and test new network technology – appliances, software and protocols. A current example of this is assessing the impact of post-quantum cryptography on the DNS.' Furthermore, SIDN Labs safeguards the roughly 6.3 million domain names in the .nl realm. Hesselman: 'A couple of years back, there were thousands of malicious web shops. We reduced this to a few hundred by developing a detection method for the misuse of corporate and government logos. These logos proved to be a much-used feature of fake websites. So we made a screenshot of the homepage to search for trusted logos and assessed if these were legitimate.' To its surprise, SIDN Labs also came across real government sites that had not been included in safety management yet.

LABS SAFE

CO-FINANCING

In some cases, SIDN Labs wishes to stimulate certain developments by co-financing research (with NWO). Examples of this are the projects Controllable, Accountable, Transparent: the Responsible Internet (CATRIN) and INTERSECT: An Internet of Secure Things.

CATRIN: www.nwo.nl/en/projects/nwa121518003

INTERSECT: intersct.nl

FUTURE CHALLENGES

'A good thing about the internet is that it was developed with few assumptions on the technology that runs it. That makes it quite forgiving and scalable', says Hesselman. 'But we now see new types of use on the horizon, based on other types of network technology, which could potentially introduce safety issues. Take, for instance, the management of our energy grid or factory management in industry 4.0 through the internet or autonomous driving.' Those are things that you do not want people to tamper with. Hesselman: 'To tackle the potential risks involved, we are assessing new safety concepts developed within the framework of the Scalability, Control and Isolation on Next-generation Networks (SCION) association.'

'WE FOCUS ON APPLIED RESEARCH, AND WITH THIS, WE TRY TO BRIDGE THE GAP BETWEEN ACADEMIA AND PRACTICE'

Cristian Hesselman

SIDN Labs has always made its results, data and software public. Hesselman: 'This made collaboration with academia easier, as they share this open approach.' From the outset, the research branch has collaborated with Tilburg University and Radboud University. A total of three PhD students have worked at SIDN Labs, and there are always undergraduate students involved. Currently, the organisation collaborates with the University of Twente, TU Delft and the University of Amsterdam on network technology. Furthermore, it works together with SURF, NL-ix and other organisations.

'We focus on applied research, and with this, we try to bridge the gap between academia and practice', says Hesselman. 'We do that quite literally as some of us work part-time at the University of Amsterdam, TU Delft and the University of Twente. We really benefit from that direct contact with academia and the chance to enthuse students. It furthers our general wish to contribute to a well-educated workforce.'

SIDN Labs' existence is based on societal impact. 'We therefore try to convey the importance of real practical interest', emphasises Hesselman. 'The example of logo detection is a good case in point. There, we combined the practical solution with a scientific article as a sort of quality test for the level of the technical solution we found.'

Developing high-quality evolving software

By Bennie Mols Images Ivar Pel

GROUP PASSPORT

RESEARCH FIELD

Model-driven software engineering, digital twins, software evolution and maintenance, human and social aspects of software engineering

INSTITUTION

Department of Mathematics and Computer Science of Eindhoven University of Technology

EMPLOYEES (as of September 2023)

3 full time and 2 part-time professors, 2 associate professors, 8 assistant professors, 3 postdocs, 15 PhD students

WEBSITE

www.tue.nl/en/research/research-groups/computer-science/software-engineering-and-technology-1

The Software Engineering and Technology group at Eindhoven University of Technology investigates how software can achieve high quality throughout its lifetime.

Michel Chaudron

Jacob Krüger

Lina Ochoa

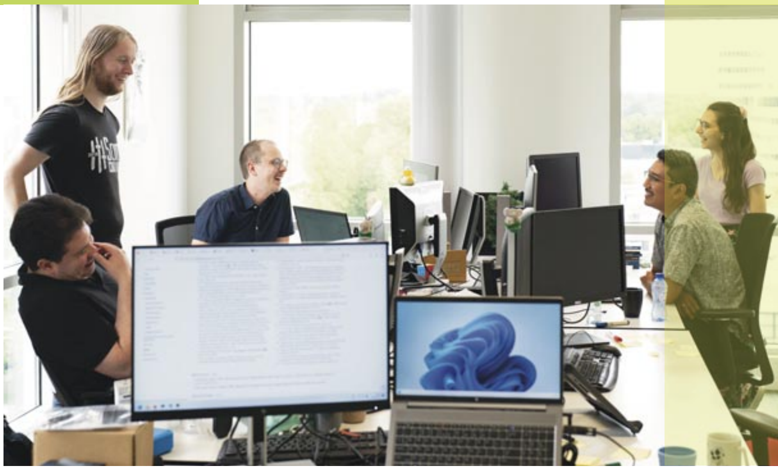
The software industry faces significant challenges in the form of rapid software growth, declining software quality and increasing societal expectations. The Software Engineering and Technology (SET) group at Eindhoven University of Technology develops methods and tools for the time- and cost-efficient evolution of high-quality software systems: from their inception, through development and maintenance, to phase-out.

'Our group does not quite conform to the classic organisation of a research group', Michel Chaudron says. 'We have three full-time professors who form a kind of partnership in which the three of us make the important decisions.' The trio consists of Chaudron, Professor of Software Engineering with a focus on software architecture, design and modelling, Mark van den Brand, Professor of Software Engineering who focuses on model-driven methods, and Alexander Serebrenik, Professor of Social Software engineering, who focuses on social factors in developing and using software.

'Software engineering has largely become an empirical study,' says Chaudron, 'which is why we think the link to practice is very important. Our group is good at collaborating with companies and we have a great connection to the industry in the Brainport Eindhoven technology region.'

One line of research Chaudron works on is recovering the architecture from its implementation and creating visualisations to help understand the architecture. Chaudron: 'Software is actually an edifice of layered abstractions that continuously evolves. Practical software consists of millions of lines of code, nowadays even in several programming languages. If you want to know how that software works, you first want to understand its structure: what relationships exist between different components? That's a big puzzle, and software visualisation helps solve it by making the relations between pieces of the puzzle better visible.'

The most important change facing software engineering in the coming years, and thus also the research in the group, is the introduction of AI, says Chaudron. In industry, software developers are already using ChatGPT for many of their tasks. Chaudron: 'AI will turn everything within software engineering on its head: from requirements analysis, creating designs, generating source code and debugging, to writing documentation. We know that AI in software engineering can lead to a major productivity improvement, but the big challenge is to ensure that this does not lead to a lower quality because we start to rely too much on AI.'



One of the ideas Chaudron developed with fellow professor Jurgen Vinju to prevent this is creating a national or even international research infrastructure to connect different software analysis tools.

Complementing curiosities

Jacob Krüger joined the Software Engineering and Technology group as an assistant professor in September 2022. Krüger received his undergraduate and graduate training in Germany, and he notices the difference between the culture in the SET group and the academic culture in Germany: 'It's so much less hierarchical than I was used to. In SET, it's much more about collaboration. Michel, Alexander, and Mark, the three group leaders, are trying to create a group in which people can work on their own favourite topics but in such a way that all the topics complement each other. And everybody is involved in deciding the development of the whole group.'

Krüger studies human factors in software development, in particular economic and psychological factors. 'A typical team of software developers consists of, let's say, four to fifteen developers', he states, 'and often you have multiple teams working in parallel. Potentially hundreds of people are involved, which creates a complex social environment.'

Improving software quality costs time and therefore money, but it might also save money by delivering more reliable software. By studying the economics of software development, Krüger noticed how important it is to also look at how developers approach their work cognitively: 'How do they understand code? What do they memorise and what not? One of the results that we have found is that developers are good at memorising high-level abstractions, architectures and features, but not at memorising lower-level code. Based on these findings, we try to build tools to support them in recovering what has happened over time with the software.'

Examine evolution

Lina Ochoa joined the SET group in April 2023 as an assistant professor. She studies the evolution of software ecosystems. Ochoa: 'Let's say a team of software developers has released a software project, but after a while starts changing some features. A new version of the software is released and the changes will impact other teams of developers that rely on that project. One of the main challenges is to understand the people working on the software and the values they have.'

On a more technical level, Ochoa develops tools that make software more robust against changes. Ochoa: 'For example, when software libraries evolve, they incorporate new features like bug fixes and security patches. These changes might break the contract previously established with clients. As a result, clients may hesitate to upgrade their software. An analysis tool might help library developers to understand and anticipate the impact of their changes.'

Like Krüger, Ochoa appreciates the non-competitive and collaborative environment in the SET group: 'People are very good at what they do, but at the same time, they are humble and willing to teach you things that you don't know yet. I feel they provide the support you need to grow.'

Anja Volk is a Professor of Music information computing at Utrecht University. She has a dual background in mathematics and musicology. By working in diverse interdisciplinary research groups in Germany (1999-2003), the USA (2003-2005) and the Netherlands (since 2006), she has gained an international reputation in her field. In 2010, she was awarded an NWO Vidi grant, which allowed her to start her own research group at the intersection of music information retrieval, musicology and cognition.

UNDERSTANDING THE POWER OF MUSIC

Last May, Anja Volk became a professor at the intersection of computer science and music. As one of its pioneers, she basically helped establish her research field of music information computing. Here, she shares her fascination for the field and her ideas about the importance of it.

By Marysa van den Berg
Image Ivar Pel

How did you become interested in music information computing?

'As a student, I first wanted to understand why music is so important in our daily lives. So, I studied musicology. In addition, I also always had a great love for the sciences. That's why I started my second study at the same time, which was mathematics. During my PhD period, music became increasingly digitised. This allowed for the extraction and processing of music information from digitised collections using the computer. My interdisciplinary background was perfect for this research.'

What is so fascinating about this field?

'Music is so powerful. It can be used as an emotion regulator, has great potential to support child development and can help people with neurodevelopmental disorders. Also, almost everybody can tap along to a piece of music, even without any musical training. What is it in that music that makes people move? I build computational models to obtain that information.'

How does this music information retrieval work?

'Music has incredibly complex structures, and I need the full range of computational approaches to model them. For instance, I use geometric models to analyse the temporal patterns in a certain piece of music. Is it fairly regular? Then it might be easy to dance or move along to the music. We investigate patterns to classify music with methods such as machine learning, functional programming or sequence alignment. It turns out that patterns that reoccur in different songs help people recognise similar songs.'

What are the applications of your research?

'Using the information from music patterns, we can build better music search engines and improve music recommendation and playlist creation. Lately, I have become interested in the area of health and well-being, for instance, supporting children and people with autism and attention deficit. In the development of serious games, we use music to help time certain actions and train rhythmic and attention skills.'

What are your thoughts about using AI in music information computing?

'I think music is a fantastic playground to explore the broader applications of AI and discuss benefits, ethics and implications. We shouldn't worry about AI replacing human creativity, but instead, consider it as an inspiring partner in the creative process.'

Thanks to museum Speelklok for providing the photo location.

WHAT KEEPS SOFTWARE DEVELOPERS FROM TESTING MORE?

By Bennie Mols Image iStock

In the Vici project TestShift, Andy Zaidman explores ways to help software developers test their software more and better.

Testing software is crucial to enhance the software's overall quality, reliability, and user experience. In his previously completed NWO Vidi project, Andy Zaidman from TU Delft developed a telemetry-based solution to track the daily testing activities of 2400 software engineers and he observed that software engineers spend significantly less time on testing than they think.

'On average, the software developers thought they were testing 50 percent of the time', says Zaidman, 'while our analysis showed that it was only 27 percent in reality. People like to build things, but when it comes to getting the bugs out, they think: "This takes so much time that it's no longer fun."'

In his current NWO Vici project TestShift, Zaidman is figuring out what holds software developers back from testing. The Vici project started in March 2020 and involves the work of three PhD students and two postdocs.

Two tracks

In TestShift, Zaidman focuses on two research tracks. The first is completely human-centred and tries to understand the socio-technical aspects that hold software developers back from testing. Using automatic sentiment analysis on millions of posts on the widely used Stack Overflow Q&A site, he concluded that people get negative feelings from testing complex software, because it also makes testing difficult. Zaidman: 'People find it very difficult to understand what has been developed in the past and to test what others have developed. Follow-up research through on-site interviews revealed another interesting sociological finding. Getting high test quality often requires one person to lead a team in tow.'

Part of the human-centred track is developing a testing analytics dashboard. Zaidman: 'My idea is that such a dashboard raises awareness about how much development time is spent on quality assurance. Equally, it helps engineers to see that if they increase their effort on software testing, the number of reported bugs will probably decrease. You need to make this point as clear as possible to a software engineering team.'

The second research track of the TestShift project aims to help software developers write tests. Although AI is making strong progress in generating tests, the results can be disappointing in practice, according to Zaidman: 'The time you gain from writing software tests with the help of AI can easily be lost when the tests generated start to fail. Then you need to understand why these tests that are hard to read really failed.'

Therefore, within the TestShift project, Zaidman and his colleagues start from manually created tests and let AI-inspired techniques make systematic changes to these existing test cases. The surrounding toolkit then points to what changes have been made, and how test metrics are impacted. Zaidman: 'This enables software engineers to obtain tests that are relatively easy to understand because they resemble their own creations, and the tool explains how the newly generated test is of added value. As we live in a software-enabled world where more and more people rely on software for everyday tasks, the quality of that software will only increase in importance. That means there is still a lot of work to do in the area of software quality assurance.'

More information
testshiftproject.github.io

HOW QUANTUM COMPUTING STARTS TO RESEMBLE CLASSICAL COMPUTING

By Leendert van der Ent
Images WAT ontwerpers

Maastricht University has been part of the IBM Quantum Network since 2020, working on physics cases. The university benefits from access to quantum computing technologies and resources, including collaboration with IBM quantum scientists. This collaboration shows how quantum computing is becoming more accessible and how its benefits over classical computing are becoming clear in practice.

The IBM Quantum Network is a global ecosystem of over 250 companies and knowledge institutions. It aims to advance Quantum Computing (QC) through collaboration and providing access to knowledge and IBM's quantum computing hardware and open-source software. Assistant Professor Menica Dibenedetto from the Maastricht University Department of Advanced Computing Sciences: 'The departments of Advanced Computing Sciences and Gravitational Waves and Fundamental Physics are involved in work on requirements for the future Einstein Telescope and a tracking challenge for the detector of the High-Luminosity Large Hadron Collider at CERN in Geneva. With these cases, we focus on Quantum Approximate Optimisation Algorithms (QAOA). They enable us to run algorithms we already developed for quantum computing on actual quantum computing hardware.'

THEORY IN PLACE

IBM Quantum Ambassador Armand Stekelenburg: 'The theory and underlying mathematics for quantum computing go back to the 1970s – long before any quantum computer even existed. Now that we have such computers, there are few surprises. We know how the equations and simulations should be carried out. It comes down to exploiting the specialities of qubits in quantum computing over bits in classical computing.'

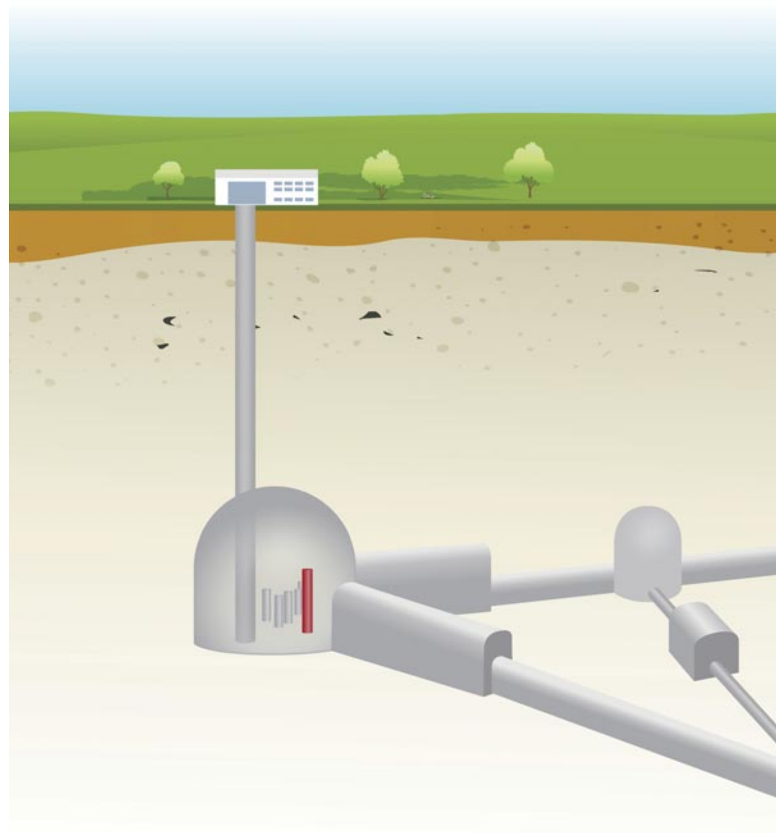
These specialities are superposition, entanglement and interference. 'This allows, for instance, for faster information searching in datasets, as quantum computing doesn't calculate data one by one as in classical computing. It allows for working with a hierarchy in data importance. Typically, the most suited problems for quantum computing have a low number of inputs, a myriad of (im)possibilities and only one outcome.'

POWER OF QUANTUM COMPUTING

'We have already experienced the power of quantum computing with this category of problems in gravitational waves research,' says Jérémie Gobeil. He is both a physicist and a computer scientist and works as a postdoc at the university's Gravitational Waves and Fundamental Physics department. 'We used Grover's algorithm, which is an algorithm for unstructured search that finds the unique input to a black box function with high probability.'

Computer science emerged from mathematics and eventually became an independent field. Gobeil: 'Now computer science is interacting with physics, resulting in another new emerging field. This field requires a different approach and involves a steep learning curve thanks to quantum computing. As IBM covers the hardware and a lot of programming, we can concentrate on our research application and on what is feasible and doable for that.

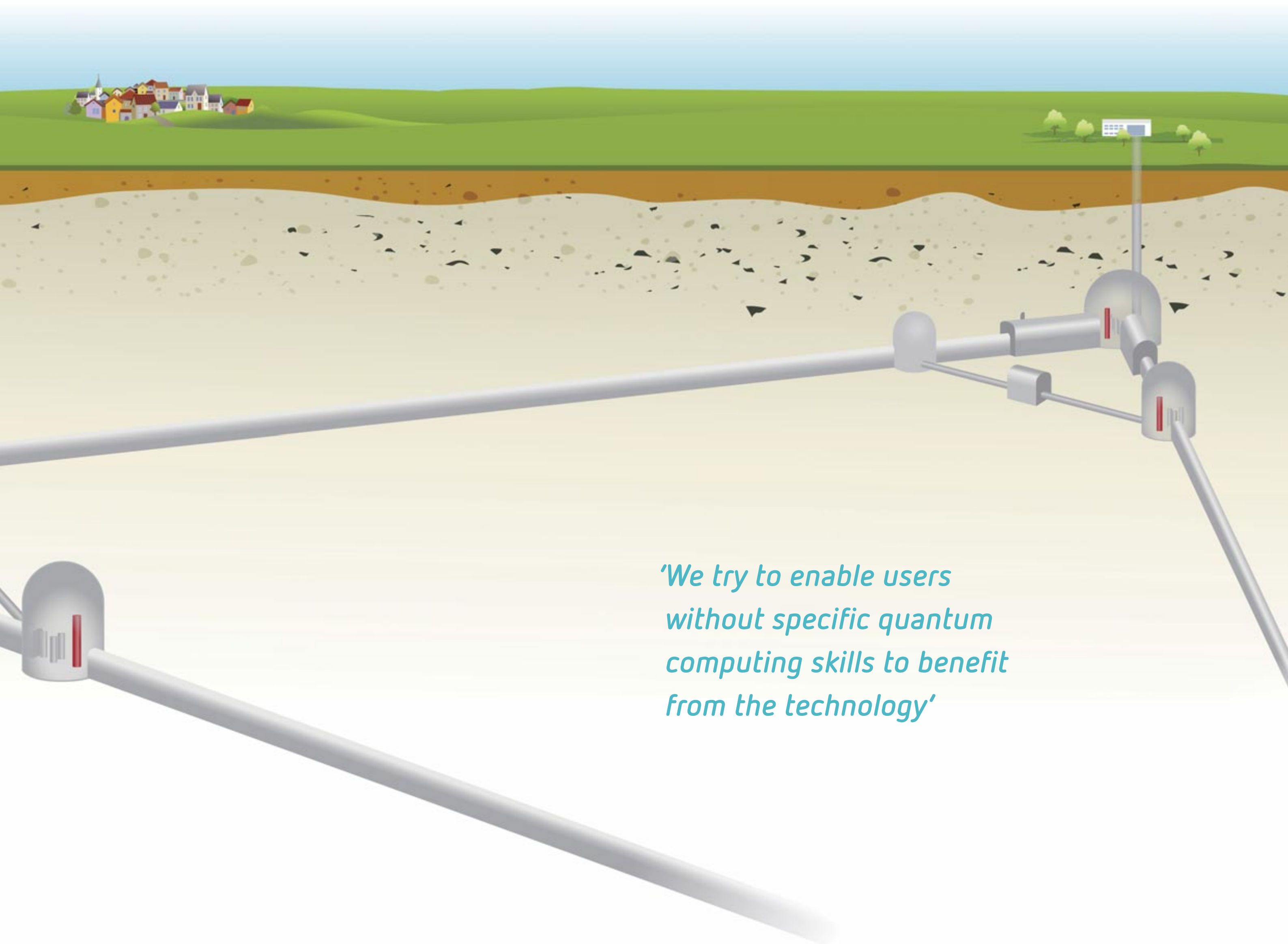
That is exactly what IBM aims for comments Stekelenburg: 'Going forward, we try to enable users without specific quantum computing skills to benefit from the technology. We keep on developing the hardware, and at the same time, we expand the accessibility and accommodate client use cases.' Gobeil notices this: 'Working with quantum computing slowly evolves towards working with classical computers. By now, you can, for instance, use commands such as "sort". And, if needed, we can contact IBM people for advice, clues and directions.' Stekelenburg adds: 'For us, it is also useful to get to know the use cases and to see how users get started with our quantum hardware.'



CHALLENGING CASES

Besides Jérémie Gobeil, postdoc Miriam Lucio Martinez is also involved in the research at Dibenedetto's department. Both work on physics showcases. 'As a university', Dibenedetto states, 'we have lots of freedom to come up with new ideas and to try out various roadmaps. This works both ways. For us, it's great when our staff and students get familiar with a quantum computer and become part of the network around it.' The two physics cases are superbly suited to test algorithms for quantum computing, says Dibenedetto: 'There is a kind of quantum flavour in the data. The next-generation fundamental physics and space measurement instruments will have higher sensitivity and pick up signals from a wider frequency range.'

The new gravitational wave detector uses a matching template to compare collected incoming data signals to the parameters you are looking for. This template looks at fifty dimensionalities. Apart from that, it also detects signals from unknown sources. Dibenedetto: 'This is too much and too complex for present supercomputers to handle. You just need quantum computing to process the data quantities associated with these new instruments. Still, it is far from easy to solve the Einstein field equation. Many parameters still need optimisation. For instance, anomaly detection in the data requires the addition of quantum AI, a field that grows by the day.'



'We try to enable users without specific quantum computing skills to benefit from the technology'

WIDE FIELD OF APPLICATIONS

Apart from the Large Hadron Collider and the Einstein Telescope cases, Maastricht University will also have other, more theoretical study areas, such as quantum anomaly detection on different types of data time series and quantum variational distribution. All methods developed for these physics showcases can be applied to similar problems in other domains. That is the beauty of it, says Stekelenburg: 'The IBM Quantum Network also aims to develop real-life quantum computing applications for the finance, drug discovery, automotive and logistics sectors. All of these share the same challenges beyond classic data analysis.'

Dibenedetto: 'Maastricht University joining the IBM Quantum Network is exemplary for our broader commitment to quantum computing. The Advanced Computer Science department is part of a strong and interesting network with IBM, CERN and Nikhef and our physics colleagues belong to Quantum Delta NL. In the fruitful collaboration we have enjoyed in the IBM Quantum Network so far, both parties have benefitted from the knowledge exchange during the exploration of the challenges and limitations in the practical use of quantum computers.'

Stekelenburg: 'The Maastricht University cases offer a great example of what quantum computing can do in practice to solve major scientific challenges. However, the basic problem of finding anomalies comes down to extracting rare anomalies from huge amounts of data with a poor signal-to-noise ratio. Apart from that, the cases strive to extract more information from the same dataset. And with that, you have a similar challenge as, for instance, the tax department faces regarding fraud detection and many other practical use cases.'

More information **www.ibm.com/quantum/network**

BUILDING **BRIDGES**

By Sonja Knols

Marcel Worring

Former director of the Informatics Institute and current leader of the MultiX group at the University of Amsterdam

'The sector plan funds have helped us to bundle existing, yet rather fragmented, initiatives and strengthen them. By doing this, we've managed to establish firm foundations on which we've built new relationships with the world outside of academia, such as companies, hospitals and municipalities.

As an institute, we decided to define new positions at the interfaces of areas we already excelled in. Therefore most of the first seven sector plan positions are, in one way or another, related to artificial intelligence. That also applies to the research of Thomas, which is centred around data exchange systems and how to make sure we exchange data in the right way. That is a core topic within the field of AI. Furthermore, we invested in combining AI and health, which has already paid off. That interdisciplinary field has grown tremendously, and our relations with Amsterdam UMC and the Netherlands Cancer Institute have intensified. This is reflected in dual appointments of staff and the establishment of joint labs. Similarly, the investments we made in quantum computing have acted as a multiplier. The University of Amsterdam was already highly active in quantum computing, but the Informatics Institute was not. We used the sector plan funds to appoint someone dedicated to the subject. Since then, other groups have also redirected their research towards quantum computing. As a result, we now have a strong and visible position in that field.

For me, the most important advantage of the sector plan funds was and remains that they help relieve the burden of education. Currently, our student-to-staff ratio is 35:1, which means that every staff member has to supervise 35 master students. In addition, sector plan funds urge every institute to rethink its priorities: In which field do you really want to be at the top of the game? It is good to be forced to think about what you really stand for and in which subjects you want to go the extra mile and offer true excellence. That is especially important in the master phase since that is where you distinguish yourself from other academic institutes. I am very pleased that in the discussions with IPN, we managed to draw a national landscape with different peaks at different locations.'

The two successive sector plans have resulted in a significant number of new hires at various Dutch universities. Marcel Worring, former director of the Informatics Institute at the University of Amsterdam, explains how the funds have acted as a multiplier on existing initiatives, and assistant professor Thomas van Binsbergen tells how his current position enables him to explore two research directions, which have more in common than one would think at first glance.

L. Thomas van Binsbergen

Assistant Professor Data Exchange Systems at the University of Amsterdam since November 2020

'My appointment here in Amsterdam quite naturally followed from the project I worked on as a postdoc at CWI. This joint project between CWI and the University of Amsterdam aimed to develop a data exchange system that automatically takes into account norms like laws, regulations and codes of conduct formalised as code in the eFLINT language. One of the two research lines I am pursuing builds further on this work.

Central to that research are a number of use cases provided by societal organisations such as hospitals and municipalities, for example through the Amsterdam data exchange project. We want to design a reconfigurable system that enables the different participants in a data-sharing consortium to take control over which parts of their data they share and under which conditions, and that is compliant with and adjustable to the relevant laws and regulations. The system should bring together existing technology for data sharing and, depending on the case-specific requirements, will be reconfigured to select an appropriate technical solution. To realise this, we need to translate all of the legal requirements into software specifications. Though that may sound rather straightforward, it involves many challenges in practice. For example, legal documents are subject to interpretation, which is something that software finds hard to deal with, and legal obligations are difficult to enforce.

My second line of research, the PLanCompS project, is more theoretical in nature. Together with a PhD student, I am studying commonalities in the semantics of programming languages. There are hundreds of different programming languages. Most of these share high-level characteristics, such as ways to structure data or the notion that variables are subjected to rules about when they are available. We decouple the syntax of the languages from their semantics, seek fundamental constructs of languages, and provide mathematically sound descriptions of those. The project has produced a library of fundamental constructs. This work can be used to construct new languages, improve programming environments, or prevent code from turning into legacy code.

Legal documents and programming languages have a lot in common. For example, they are both extremely structured, and rely on correct cross references. I love the interaction between fundamental theory and practical applications in my work. It would be great if the concepts I develop end up in applications that help professionals in public organisations, or in methods to develop new programming languages and programming environments that people without a background in computer science can also use.'

THE IMPORTANCE OF PRIVACY BY DESIGN

By Marysa van den Berg Image Robert van der Molen

Engineers should do more to protect the privacy of future users of their systems. And those users need to be more aware of the dangers of sharing their personal data with others. That is the strong belief of Jaap-Henk Hoepman, associate professor of privacy-enhancing tools and privacy by design at Radboud University, who has written two books about the topic.

‘If you buy a concert ticket online, you must enter a lot of personal data about yourself, like your name, address, phone number et cetera. This is crazy, because had you purchased that ticket in a shop with cash, nobody would have ever known you planned to go to that concert – unless you tell people, of course. Is it necessary to have all that information about a person? I don’t think so.

These kinds of privacy issues have recently become more significant due to technological advances. But much like slavery was abolished 150 year ago, personal data extraction cannot and should not be a viable business model any longer. There are many myths involving privacy. I address these in my book *Privacy is hard and seven other myths*. One of the most persistent ones is ‘I have nothing to hide’. But this notion totally ignores the fact that many things we do and say are only intended for certain people.

I think one of the main messages of my book is that privacy also has a big societal value. Remember the Cambridge Analytica scandal, named after a company that harvested personal data of millions of Facebook users to provide analytical assistance to the 2016 US presidential campaigns? Privacy is not only important to safeguard our democratic processes, but it also provided the starting point to gaining labour, women, and gay rights, for example. Talking about these issues in private was key to gaining those rights.’

Jaap-Henk Hoepman is associate professor of privacy-enhancing tools and privacy by design in the Digital Security group at the Institute for Computing and Information Science of Radboud University and associate professor at the IT Law section of the Transboundary Legal Studies department of the University of Groningen. He is also a guest professor at the PRISEC (Privacy and Security group) of Karlstad University, Sweden, and writes books and blogs about privacy issues and the societal impact of new technologies.

DO NOT RELY ON BIG CLOUD SERVICES

‘So, what can we do to safeguard privacy in our systems? We have laws of course, but we also need a technical approach. I wrote the *Little blue book* about a concept called privacy design strategies. There are simple strategies that engineers can use to implement privacy from the start. Strategies like minimisation of data (for example, providing an address is not always needed), separating data (like keeping financial data and personal data apart), and running processes locally (like classifying pictures taken by your phone).

Such advice is not yet taken to heart by all engineers. I am now talking to these people to help them see the importance of privacy by design. For academics and universities, I also have a message. We should move away from relying on big cloud services like Microsoft and Google and use our own local infrastructure more. I think that is the future.’