

# I/O

# magazine

ICT RESEARCH PLATFORM NEDERLAND

VOLUME 19 APRIL 2022 NO 1



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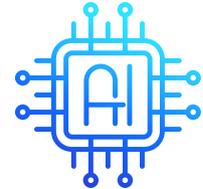
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**I/O Magazine** is a publication of the ICT Research Platform Nederland (IPN) and is sent free of charge to ICT researchers and relations of IPN four times a year. IPN consists of the ICT research schools ASCI, IPA, and SIKS; the ICT-related themes 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; e-Science 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 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 the NWO Domain Science.

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PAUL KLINT

# The Dark Ages and back again

## Is modern technology bringing us back to the Dark Ages? What to do about that?

In Medieval times, people believed in witches, mysticism, and miracles. There were crooks, swindlers and thieves. Communication was mostly oral and involved storytelling and gossiping. Access to knowledge was restricted to monks and a few independent scholars. What a relief the enlightenment has brought us: knowledge, rational thinking and decision-making as ideals. And here we are today: satellites and glass fibre cables are spanning the globe to bring our words to every person that wants to hear them.

Alas, technology changes fast, but human nature does not. We still like to believe in miracles, and we still like gossiping. The only difference is that now we use modern technology to satisfy these basic human needs. Enter social networks, disinformation, misinformation, online scams, swindlers and thieves. Anonymous trolls are spreading disinformation about vaccinations, elections, and conspiracies. States are spreading disinformation about alleged incidents that "legitimise" aggression and war. As Sun Tzu already observed: 'All warfare is based on deception'. However, I would strongly prefer that today's world leaders would follow another advice of him: 'The wise warrior avoids the battle'.

Mixing modern technology with basic human instincts is dangerous. Interestingly, knowledge about some aspects of human nature is already used in technology development: man-machine interaction, nudging, and gamification are examples. There is a reason that the children of Silicon Valley icons are not allowed to use tablets and mobile devices: they know that modern technology has become too addictive. Homework exercises: (1) count the number of people you encounter today that are looking at their phone; (2) count how many times you look at your own phone today (spoiler alert: research says 262 times).

When in a pessimistic mood, I think that technology is bringing us back to the Dark Ages. On more optimistic days, I think about a grand challenge to solve: how can we reconcile the dangerous aspects of human nature with modern technology? No more anonymous trolls, no more disinformation.

But is this even possible? What about freedom of speech? Who determines what is 'true'? What about the autonomy of citizens? What about democracy? What about state surveillance? But hold on, too many serious questions will spoil my day.



# AI IN THE WILD



Two of this year's keynote lectures at ICT.OPEN will be about AI. Professor Karl Tuyls will show that AI has made a leap from playing board games to supporting coaches in sports like football. Professor Hinda Haned focuses on mitigating algorithmic bias, and challenges the computer science community to think more from the perspective of an AI practitioner.

By Bennie Mols Images iStock, Seb Demilly, University of Amsterdam/Dirk Gilissen

Board games have been a challenge for AI ever since the start of the field in the 1950s. They provide a controlled environment, which still shares a lot of complexity with the real world. After decades of hard work checkers, chess and, most recently, Go were mastered by the machine, beating even the best human players. Building on these breakthroughs, AI is now also being applied to sports like football. Karl Tuyls will talk about this in his keynote presentation at ICT.OPEN. Tuyls is team lead at DeepMind in Paris and professor at the Universities of Liverpool and Leuven. In the past, he worked at Maastricht University, where he founded the Swarm Lab in 2010.



## Karl Tuyls

'Our ultimate goal is to develop an Automated Video Assistant Coach'

Tuyls' research is on the border of game theory, reinforcement learning and multi-agent systems. 'I'm interested in developing AI that does not live in a bubble with only one agent, but in environments where many agents interact', says Tuyls in an interview. In such an environment, game theory helps to study how decisions are made among all those agents.

Tuyls: 'I'm especially interested in environments that change over time and which we can study with evolutionary game theory. For a long time, this was only possible at the small scale of simplified abstract games. But thanks to deep learning, we are now able to scale this up to complex systems like team sports.'

## AI for sports

Together with two colleagues, Tuyls published the book 'AI for Sports' at the end of 2021, which reflects on how AI might be applied in sports. Just like poker, for example, football is an imperfect information game: a player doesn't always see what is happening at another part of the field, doesn't know the strategy of the opponent and doesn't even always know the intentions of his teammates.

At DeepMind, Tuyls' team cooperates with the English football club Liverpool to explore if and how AI could help to improve the club's performance. Tuyls: 'Our ultimate goal, in five years or so, is to develop an Automated Video Assistant Coach, called AVAC. AVAC is meant to do pre-match analysis, real-time analysis during the match and post-match analysis. We don't want to replace human coaches, but we are trying to improve football by using AI to optimise the coach's work.'

In the short term, AVAC might help to improve taking penalty shots. Which player should take a penalty? How should a player shoot the penalty? What to expect from a certain goalkeeper? In 2021, a DeepMind team published a research paper that also looked at 12,000 penalty kicks taken across Europe, both for players and for goalkeepers.

At present, the team is working on strategic decisions during the match. For this, they use an AI model of both teams. Tuyls: 'The idea is that the AI watches the first half of a match, for example, and then answers all kind of 'what-if'-questions: What would happen, for example, if the Dutch Liverpool defender Virgil van Dijk changes position? What would happen if we let a midfielder play in the attack? A coach might use AVAC at halftime to assist him in devising a new strategy for the second half.'

DeepMind's long term goal is to develop Artificial General Intelligence (AGI), a form of intelligence as general as the human mind. An important challenge if we are ever to realise AGI is solving the 'problem-problem', says Tuyls, and that is what he and his team are working hard on at the moment. The problem-problem asks the question, 'What are the problems and environments that we should present to our AI in order for it to ultimately reach AGI?'. Tuyls: 'It's a bit like developing a curriculum for learning mathematics at school. You don't start with differential equations but with more basic mathematical problems. Similarly, to solve the problem-problem we need to develop a curriculum for an AI system.'

Apart from solving the problem-problem, another great challenge Tuyl and his team are looking into is implementing multi-agent game-playing technology in real-world applications like automated traffic control, automatised auctions or automatically distributing and selling electricity.

## Practitioner's perspective

A second keynote speaker at ICT.OPEN, Hinda Haned, starts from the perspective of developers of real-world AI applications. Haned: 'I want to challenge the AI community to think more from the perspective of a data science practitioner working for a company or a public institution. All too often, AI algorithms are not useful in practice.'

Haned is Professor of Data Science at the University of Amsterdam and co-director of the Civic AI Lab. She also has her own company specialised in algorithmic auditing. 'In all my work, I focus on the responsible use of AI algorithms', she says in an interview. 'How do we detect the mistakes algorithms make, and how do we avoid them?'

Haned worked a lot with companies and leverages her experience to frame AI research questions from a practitioner's perspective. This perspective teaches us a few things, she tells us. First of all, the realisation that companies often have to work with constraints that researchers may not have in academia. Haned gives an example: 'Because of privacy regulations, a company does

not have access to all its customers' data, for example, ethnicity or gender. In academic papers, such constraints are often relaxed, assuming that researchers have access to these data. But if you don't take the constraints into account, theoretical results might not be so useful.'

From this follows the second lesson, says Haned. 'I like to show that a lot of constraints raise interesting new research questions that can be explored to devise new solutions, although some researchers might think such questions are not worthy of research.'

A third and final lesson is that researchers could benefit from improving how they communicate their results with business leaders. 'It is very easy to be smart', says Haned, 'but much harder to be empathetic and kind to business stakeholders. I often hear statements such as: "You should use my AI algorithm, because it is so powerful". But if other parties don't understand it, they are not going to adopt or buy it. I wish academics would be more aware of that. Try to be more of a data storyteller.'

## Mitigating bias

An important focus of Haned's work is on mitigating bias in algorithms. 'Harmful systems are more widespread than we think', she says. 'But it's not just about what a given system is doing; it's also about how humans are using the system. I am very much in favour of human intervention in algorithmic decisions. In general, algorithms should not make important decisions on their own. And in some domains, we shouldn't be using AI algorithms at all. We shouldn't automate everything just for the sake of it.'

This point of view leads to challenging research questions. When do we decide not to build an AI? What are the criteria? In which applications should human intervention always be possible, and what should the intervention be? How do we evaluate the potentially harmful impact of a system? 'Answering such questions involves other disciplines like the social sciences, law and policy', says Haned.

In the past, Haned worked as a forensic statistician. The AI community can learn a lot from the practice in this field, she thinks. 'Forensic science practice has strict criteria for using certain methods and software. We could establish similar safeguards when deploying AI-driven systems. That makes it possible to make progress with new technological tools, but at the same time guarantee that this takes place in an ethical manner.'

One of the biggest problems in the use of algorithms is the quality of the data, according to Haned. 'I think that AI scientists are rarely interested in how the data are collected. Nobody wants to work on it. It's hard. I also see it in my students. They want to build cool stuff, not to collect data. But data are the oil of the AI engine. There is no point in building very sophisticated AI if the data are bad.'



**Hinda Haned**

'We shouldn't automate everything just for the sake of it'

## ICT • OPEN

2022

ICT.OPEN is an annual conference that brings together some five hundred researchers from both fundamental and applied ICT research in the Netherlands. This year the conference is being organised for the tenth time and will take place on 6 and 7 April in RAI Amsterdam. The programme includes three keynote speakers: Hinda Haned and Karl Tuyls, whose talks are covered in this article, and Nele Mentens, whose work was already covered in the October 2021 edition of I/O Magazine. The conference is organised by the Dutch Research Council (NWO) and the ICT Research Platform for the Netherlands (IPN).





# MAKING SMART DEVICES SECURE WITH RANDOMNESS

By Bennie Mols Image iStock

**In December 2021, assistant professor Bart Mennink from the Digital Security group at Radboud University started a Vidi-project on future-proof cryptographic randomness. The project builds on his previous three year Veni-project.**

#### **What was the Veni-project about?**

'My Veni was about authentication and encryption. With authentication we want to ensure that nobody can change the message on the way from sender to receiver. With encryption we try to ensure that only the recipient can read the digital message. In the project I co-designed efficient algorithms that do both authentication and encryption.'

#### **What do you mean by efficient?**

'The algorithm should use as little memory and processing power as possible. That is especially important for the security of small devices, like smart watches or pacemakers. More and more small devices use computer chips and are vulnerable to attacks, especially so-called side-channel attacks in which bad guys try to eavesdrop on, for example, the energy consumption of the device.'

#### **How does your Vidi-project build on the Veni-project?**

'When encrypting a message, you want it to look random to an eavesdropper. So, you need a source of randomness for the encryption algorithm. The way a computer creates this is for example by using physical noise. I take that physical randomness as a given input to investigate various mathematical ways to create randomness in my cryptographic algorithm.'

#### **What appeals most to you in your area of research?**

'On the one hand it is the way mathematics leads to useful applications in the real world. On the other hand it is the theoretical beauty of proving that a certain algorithm is secure. For this, I mostly use probability theory and combinatorics. And then there is the aspect that the bad guys are continuously getting stronger. That motivates me to keep on inventing new solutions.'

#### **Do you need to be able to think as a bad guy yourself, when designing a secure algorithm?**

'Yes, when I design an algorithm I need to think about the methods a bad guy might use in an attack. But we need to realise that digital security is more than cryptog-

raphy. The human factor is very important as well.

I might have a super secure encryption of my computer's hard disk, but if someone puts a gun to my head, I will just give the password.'

#### **Do you try to embed your research in a larger context?**

'The nice thing of our Digital Security group in Nijmegen is that it combines different perspectives: cryptography, side-channel security, privacy, law... We all work together in order to see the bigger picture.'

#### **The project will take five years. When will you be satisfied at the end?**

'When we manage to provide solutions for new ways of attack that the bad guys are inventing. Not just new ways of side-channel attacks, but also attacks that will be made possible by a future quantum computer. In practice you see that it takes a long time to change existing security standards, which leads to unnecessary risks. Therefore we already have to prepare now for attacks that will only be possible in the future.'

More information:  
[www.cs.ru.nl/~bmennink](http://www.cs.ru.nl/~bmennink)

## KEES SCOUHAMER IMMINK PRIZE FOR TACO COHEN

During ICT.OPEN 2022, Taco Cohen will receive the Kees Schouhamer Immink Prize of ten thousand euros for his PhD thesis entitled *Equivariant Convolutional Networks*, which he defended on 9 June 2021 at the University of Amsterdam. In his thesis, he explored ways to leverage symmetries to improve the ability of convolutional neural networks to generalise from relatively small samples.

The Kees Schouhamer Immink Prize is awarded every two years to reward original research in the field of technical computer science and telecommunications in the broadest sense. The prize is intended as an incentive for a researcher who obtained a doctorate at a Dutch educational and/or research institution no more than four years ago.

More information (in Dutch):  
[khw.nl/kees-schouhamer-immink-prijs](http://khw.nl/kees-schouhamer-immink-prijs)



## NOMINATE FOR NWO DOMAIN SCIENCE PRIZES 2022

The NWO Domain Science (ENW) awards five special scientific prizes in the areas of societal impact, diversity & inclusion, team science and communication. The aim of the prizes is to reward scientists who make an outstanding contribution in these areas and inspire others to do the same. All disciplines within the physical and natural sciences are eligible.

Nominations can be made until 16 June 2022.



## KIC CALL NEXTGEN HIGH TECH EQUIPMENT

The KIC call Key Enabling Technologies: NextGeneration High Tech Equipment focuses on the multidisciplinary integration of the physical and digital components that are central to a cyber-physical system. This offers opportunities for improvements in the areas of predictability, scalability, autonomy, efficiency, sustainability and affordability of cyber-physical systems.

The budget available for this call is 5.5 million euros. A minimum of 1 million and a maximum of 2.75 million euros can be applied for per project. The deadline for applications is 21 June 2022.

More information via [www.nwo.nl/kic](http://www.nwo.nl/kic)

## HUMAN-CENTRED AI-RESEARCH IN ELSA LABS

NWO and the Netherlands AI Coalition have launched the NWA call *Human-centred AI for an inclusive society – towards an ecosystem of trust*. After an assessment by an independent NWO assessment committee, five projects have been awarded funding. In ELSA labs, researchers from knowledge institutions and public and private organisations will contribute to knowledge about the development and application of reliable, human-centred AI. In total, the projects have been awarded more than 10.9 million euros in funding. The projects have a duration of five to six years. The grants awarded are distributed across four categories: Defence, Justice and Security, Culture and Media, and other societal challenges. All projects fall under the overarching theme “Economy and Local Government”.





# FROM FACILITATING RESEARCHERS TO HELPING THE LOW-LITERATE

By Leendert van der Ent  
Image Koninklijke Bibliotheek

**Better accessibility, automated catalogue processing, warehouse automation... It is hard to find a sector where more diverse ICT aspects come into play than librarianship. A digital transformation is racing ahead in the sector with AI at the forefront to handle the large scale data of library collections.**

'The KB (Koninklijke Bibliotheek) is the national library of the Netherlands, based in The Hague', says good old Wikipedia. 'It collects everything that is published in and about the Netherlands, from medieval literature to today's publications. Some 7 million publications are stored in its repositories, comprising books, newspapers and periodicals. The KB also offers many digital services, such as the national online Library (with e-books and audiobooks) and Delpher (millions of digitised pages). Since 2015, the KB has had a coordinating role for the public library network.'

## DIGITAL TRANSITION

All of the activities mentioned here come with ICT needs. Rosemarie van der Veen-Oei, head of the KB's research department: 'We have become increasingly ICT-driven in recent years and are currently in a digital transition. For example, we're moving our data centre – an entire floor of servers in our building – to a government data centre. At the moment, we're also exploring a new off-site storage facility for our entire physical collection, which adds up to some 125 linear kilometres. It will feature an automated storage and retrieval system, digital content flows and data migration.'

Moreover, digital infrastructure integrity and cyber security are important aspects for the KB. 'We also value the social debate around digital space; in that area, we are partners in the Public Spaces initiative. The KB also supports public libraries in their task around digital inclusion, as expressed, for example, in Informatiepunt Digitale Overheid. Furthermore, we offer digital services, for instance through the development of the online library.'

## ICT WITH INDUSTRY

The KB has a lot of experience in collaborating with researchers, Van der Veen-Oei says: 'For example with TU Delft we studied the feasibility of 360° imaging to support virtual access to our special collections. Connecting datasets across heterogeneous collections is another important and difficult task.'

Besides that the KB is involved in many research consortia, for instance, CLARIAH. The KB also offers the KB Research Lab, which houses datasets made available to researchers and experimental tools from research projects conducted at the KB. 'Every year, we offer an early career researcher the opportunity to work as a researcher-in-residence at our premises for six months', Van der Veen-Oei notes.

The KB is a recurring and enthusiastic participant in ICT with Industry. The organisation mainly brings experimental and exploratory questions for long term innovation to the table there. Why? 'We're looking for inspiring ideas and possible directions towards solutions. Afterwards, we can adapt those ideas within the organisation to fit our practical needs and wishes.'

## CASES

The fact that this really works has been demonstrated by the 2019 case study led by Iris Hendrickx (Radboud University). The question involved automatically generated metadata – author names, keywords – to the KB's collection. Van der Veen Oei: 'We are now in the testing stage of a so-called demosaurus – a tool to help our librarian cataloguers in their work.'



For the 2020 edition, the KB and the KNAW Humanities Cluster submitted the question, "How can Optical Character Recognition (OCR) techniques be improved to automatically transfer scans of Gothic printed matter to digital text?" The team led by Lambert Schomaker (University of Groningen) used machine learning techniques for this purpose. The results have been published and presented in a promising outlook for the future integration of Gothic font documents in current search engines such as Delpher. From this edition of ICT with Industry, the KB and the University of Groningen started a consortium to develop a grant application.

## COMMON THREAD

AI and machine learning are on the agenda in 2022. 'Our question this year focused on the possibilities for text simplification using AI', says Van der Veen-Oei. 'Is it possible to simplify texts automatically? If possible, that would be great, as digital accessibility for low-literacy and people with disabilities is one of our spearheads in the coming years, and it is an important societal issue.'

So AI is really a common thread.... 'Well, AI won't provide all solutions, but it certainly opens up many opportunities for unlocking our collections in a different perspective. Conversely, our collections can play an important role in the further development of AI.'

More information  
on the KB Research  
Lab: [lab.kb.nl](http://lab.kb.nl)



Rosemarie van der Veen-Oei

*'We're not looking for consultancy, but for inspiring ideas'*



# The power of logic in computation

By Bennie Mols Images Ivar Pel



## GROUP PASSPORT

### RESEARCH FIELD

Foundations of computing, formal software analysis

### INSTITUTION

The Fundamental Computing Group is part of the Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence at the University of Groningen (RUG)

### EMPLOYEES

2 associate professors, 1 assistant professor, 2 lecturers, 2 postdocs, 2 emeritus professors, 4 PhD students (plus 3 external PhD students).

### WEBSITES

[www.rug.nl/research/bernoulli/groups/fundamental-computing/](http://www.rug.nl/research/bernoulli/groups/fundamental-computing/)

[www.jperez.nl](http://www.jperez.nl)

Teaching package on the correctness of software: [www.rug.nl/society-business/scholierenacademie/leraren/op-school/program-correctness](http://www.rug.nl/society-business/scholierenacademie/leraren/op-school/program-correctness)

Animation on software correctness: [www.youtube.com/watch?v=85fiogkCyLY](https://www.youtube.com/watch?v=85fiogkCyLY)

**A few years ago, Jorge Pérez, associate professor in Software Foundations at the University of Groningen, tried to get a digital boarding pass for a flight. The software showed him an error, and he couldn't get his boarding pass. 'This most likely happened because something failed in the communication between the various processes involved in producing my boarding pass', explains Pérez. 'I use a screenshot of the error to explain to my students how software errors still occur and appear in systems we usually take for granted.'**



Jorge Pérez

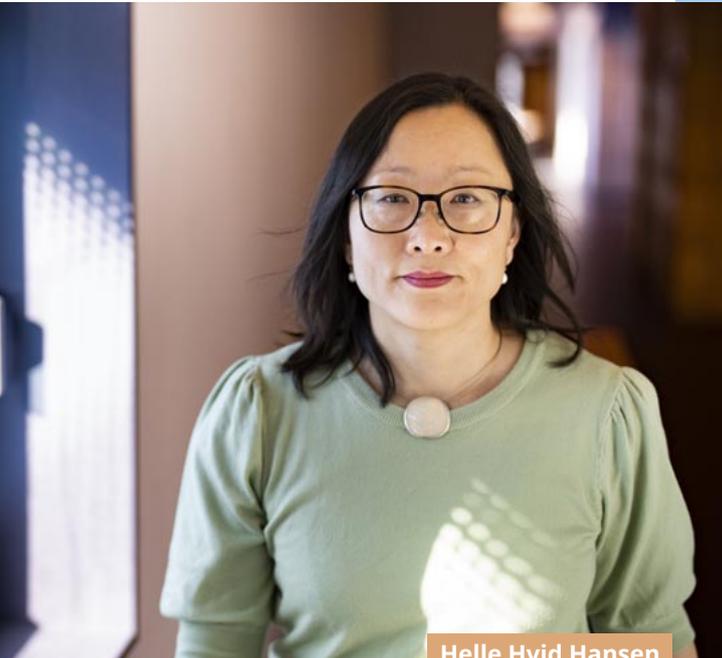
Pérez specialises in rigorous formalisms for so-called communicating programs, programs that coordinate by sending messages to each other. Communicating programs are embedded in many widely used services, like Amazon or Bol. 'We users see only a single interface', says Pérez, 'but under the hood, there are many different layers of communicating programs. If I buy something via Bol, my request goes to Bol, Bol communicates with the actual vendor, and the payment proceeds via communication with my bank.'

Pérez is leader of the Fundamental Computing Group, which uses logic to provide foundations for computing in general and for proving that software is correct. Pérez: 'We all rely on software being correct and always doing what it is supposed to do. We are frustrated when it does not work correctly. But it goes beyond frustration: incorrect software can have wide-ranging catastrophic consequences for society.'

Both the Fundamental Computing Group and the research in logic have a long and rich history in Groningen. After the recent retirement of a few members, the group entered into a transition phase in which new members had to redefine the group's research. 'I see it as an opportunity for us to strengthen our national visibility', says Pérez, who himself started eight years ago in Groningen. 'The new members are full of energy, bring their own networks, and are eager to develop new research directions.'

Pérez finds it important to reach beyond the scientific community. He is a member of the Young Academy Groningen and in cooperation with the Scholierenacademie he developed a teaching package. In addition, the group produced a short animation on software correctness, which was aimed at the general public. Pérez: 'The teaching package explains to high school students how communicating programs work, how they sometimes do not work and what the consequences may be. Unfortunately, because of the pandemic, we couldn't go to schools and discuss the subject with students and their teachers, but we hope this will be possible soon.'





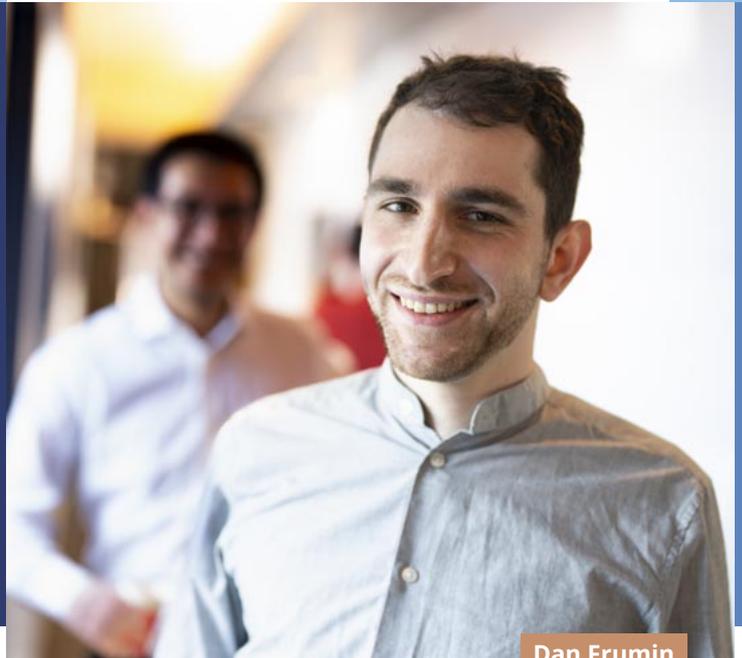
Helle Hvid Hansen

## Mathematical toolkit

One of the new group members is Helle Hvid Hansen, who joined in June 2020 as associate professor in Logic and Semantics of Computing. Hansen: 'I'm fascinated by the fundamental relationships between logic and the structure and behaviour of computer programs. My research targets foundational questions that are central to the rigorous analysis of software, such as: How can we represent and reason about program behaviour? For example, when do two apparently different programs have the same behaviour? Which logics can express relevant properties of programs?'

Hansen specialises in an area called coalgebra. 'This is a relatively recent discipline that allows different types of program behaviours, for example, nondeterministic, probabilistic, and infinitely-running programs, to be treated in a unified setting. You can think of coalgebra as a rich mathematical toolkit, applicable in multiple situations; you don't need to rework the theory for each specific class of programs.'

Hansen was attracted to the group, and the University of Groningen more generally, because her research would be well-embedded. 'My research is connected, but at the same time complementary, to other research expertise in Groningen in formal methods, multi-agent systems and formal philosophy', she says. 'I also like the idea of joining a growing group and being part of setting new directions. I am excited to start working with the new PhDs and postdocs that are joining us in the coming months.'



Dan Frumin

## Sharing memory

Dan Frumin is a postdoc in the Fundamental Computing Group, where he started in October 2020. While he was doing his PhD in Nijmegen, he met Jorge Pérez at a conference. 'Later, I heard that he was looking for a postdoc for one of his projects', says Frumin. 'It was an interesting opportunity for me to join a dynamic, growing group.'

Frumin specialises in logic and verification of concurrent programs that share memory. Frumin: 'Computers usually run different processes simultaneously that share the same memory. You don't want to store information that is immediately going to be carelessly overwritten by another process. You need protocols to ensure that the memory will be shared correctly. I work on the verification of such protocols.'

As Frumin, Hansen and other recent hires started their positions in the middle of the pandemic, it was hard to bind the group together in the usual way with in-person activities. 'We have used Discord, a kind of chat room, for informal interactions and sharing interesting links and content. This has worked quite nicely. But what binds us together the most as a group is that we all share a common passion for mathematical beauty in applying logic to computation, from different but related perspectives.'



**Jasmin Christian Blanchette** was a software engineer and documentation manager for (what is now called) The Qt Company in Oslo. He did his PhD at the Chair for Logic and Verification at the Technical University of Munich, co-developing Isabelle. He currently is an associate professor in Theoretical Computer Science at VU Amsterdam and guest researcher at Loria (Nancy), the Max Planck Institute for Informatics in Saarbrücken and the Bundeswehr University Munich.

# DRIVEN TO DEVELOP CORRECT SOFTWARE

Jasmin Blanchette is the Dutch Prize for ICT Research laureate 2022. His field is theorem proving – the scene of a slow-motion revolution. A select group of researchers worldwide focus on this topic to contribute to, among other things, more reliable chips and more stable operating systems.

By Leendert van der Ent

Image Ivar Pel

## What does a theorem prover do?

‘We allow mathematical formulas to be expressed in a formal language and provide tools for proving those formulas in a logical calculus. With this approach, we verify core components of software for their mathematical coherence and correctness. We don’t go through all code, as this approach doesn’t scale very well on millions of lines of code. We check whether vital pieces of code are fundamentally correct.’

## What challenges you in this field?

‘In mathematics, the terms “obviously” and “clearly” are regularly used to skip parts of a line of reasoning that are common knowledge. For the computer, however, jumping these gaps is not obvious. Why is a step from A to B allowed? The challenge is to fill in these gaps on mathematically sound grounds. This “proof automation” is not feasible often enough yet. Our job is to make it work more often.’

## How?

‘There are many different methods we can use. One of these is to start with what you know (a lemma) and start to derive consequences from that, for instance, by combining info we have previously obtained.’

## Where are these results applied?

‘Over the last 13 years, I’ve seen the field grow steadily. Theorem provers still predominantly work in academia to support computer scientists and hardware designers. There are not many users in industry yet. We are typically asked by chip manufacturers and developers of operating systems – among them Intel, AMD and Apple – to verify hardware and software. The Pentium bug and blue screens of death are examples of errors that our tools could have prevented.’

## How will you deploy your prize money?

‘I’m not entirely sure on what I’m allowed to spend the prize yet, but my wish would be to use it on staffing: to keep on a co-worker as a postdoc for eight months after they obtained their PhD. In that way, we could wrap up the project properly and realise a solid knowledge transfer to their successor.’

# OPPORTUNITIES FOR DUTCH ICT RESEARCH

**The Coalition Agreement underlying the recently installed Dutch Cabinet oozes ambition when it comes to innovation and scientific research. Since digitalisation is mentioned as one of the three main transitions society is facing, the coming years will provide ample opportunities for ICT researchers to play their part.**

By Sonja Knols Images WAT ontwerpers

Since 10 January 2022, the fourth Rutte Cabinet has been in power. The Coalition Agreement underlying the collaboration between the People's Party for Freedom and Democracy (VVD), Christian Democratic Alliance (CDA), Democrats '66 (D66) and Christian Union (CU) oozes plenty of ambition when it comes to scientific research and digitalisation. For example, for the first time ever, a dedicated State Secretary has been appointed for Digitalisation.

The Coalition Agreement states that 'We will move towards a knowledge-based economy where we invest in research and development, in line with the Lisbon objectives. We will strengthen the foundations of our knowledge institutions and innovative ecosystems, [...] and encourage them to collaborate within the region and internationally. We will support innovative start-ups and scaleups and focus mission-driven innovation policy on the three major transitions: climate and energy, digitalisation and key technologies, and the circular economy.'

As far as digitalisation goes, 'The current digital revolution offers tremendous opportunities for our society and economy. We will capitalise on these opportunities with excellent digital skills, a strong European digital market, high-performance digital infrastructure and ambitious cooperation in technological innovation.' Furthermore, the text explicitly refers to the importance of stimulating innovation and investing in topics like cybersecurity, digital ethics, chip technology, artificial intelligence and quantum computing.

## Perfect timing

Realising the government's ambitions requires a strong knowledge foundation and ICT workforce. That aligns perfectly with the recently published IPN vision, which calls for an increase in the structural funds for fundamental ICT research and academic education in the field of computer sciences. Therefore, over the coming months, NWO and IPN will actively promote this vision to government, industry and societal partners, starting with a dedicated meeting prior to ICT.OPEN.

Also, individual ICT researchers in decision-making positions can start preparing to seize the opportunities that will come along, by delving into the vision of the Cabinet, and asking themselves how the research of their group, institute or department attributes to achieving the government's goals. By sharing plans and ideas through IPN and NWO's Round Table Computer Science, the Dutch ICT research community can gain enough leverage to ensure a solid scientific foundation under our digitalising society.

The coalition agreement (in Dutch) can be found at [www.kabinetsformatie2021.nl](http://www.kabinetsformatie2021.nl)



# POWER TO THE PEOPLE

When consumers become producers of electricity, serious challenges are posed to the Dutch electricity grid. And these are not just technological hurdles – there are also major ethical and legal issues to overcome. A multidisciplinary team is working on a local, self-managing electricity system that is equally beneficial to everyone.

By **Amanda Verdonk**  
Images WAT ontwerpers



The Dutch power grid is busy. In large parts of the country, the grid has even reached its maximum capacity. The construction of new solar parks, residential areas and industrial zones is increasingly delayed because grid capacity cannot be made available in time. This is all due to increased power consumption and renewable electricity production. More and more homes are now “all electric” and are heated by electric heat pumps instead of gas. Furthermore, electric vehicles are taking off, and electricity is coming from more decentralised sources, such as rooftop solar panels and solar and wind parks. Consumers are also becoming producers, or rather prosumers, of electricity. As a result of these trends, the robustness of the power grid is under pressure.

## Free energy

Plans are being made to strengthen the grid by installing more power cables and transformers, but this is expensive and procedures take a long time. At the transmission level of the electricity system, the wholesale markets for electricity play an important role in the coordination between demand, supply and the available network capacity. At the local distribution part of the electricity system, such coordination is non-existent.

*‘We want to lay the foundation for a local electricity system that manages itself’*

The technical systems that would be needed are lacking, as well as the legal framework to allow for it. And that is a missed opportunity, because it could help to absorb congestion peaks. Koen Kok, Professor of Intelligent Energy Systems at Eindhoven University of Technology, gives an example. 'Suppose a lot of power suddenly becomes available, for example from the solar panels on your roof or because the wind on the North Sea picks up unexpectedly. Then, "free" green energy is available. At those precise moments, your devices should start using electricity; your freezer, heat pump or electric car charger.' To enable this coordination, software with smart algorithms is needed to let the electrical devices in homes and buildings interact with each other and the local electricity system. The goal: more sustainable electricity for everyone and a fair energy bill. Kok is programme leader of the Perspectief programme MEGAMIND, funded by NWO. Five knowledge institutions and nine sector partners are working on this process which they call "decentralised coordination". Kok: 'We want to lay the foundation for a local electricity system that manages itself.'

However, some of the hurdles aren't of a technical nature: decentralised coordination to solve congestion is not allowed yet, and many ethical objections need to be overcome. Realising this kind of coordination requires data needs to be collected and sometimes shared between actors in the system. Some of these data are privacy-sensitive – you could, for example, deduce from the data when people are at home and how they use their devices. Is that allowed? And with whom is this data shared? In addition, the question arises: can everyone benefit equally from the energy transition? To gain more insights into these issues, lawyers and ethicists are involved in the programme.

## Haves and have nots

Merel Noorman is assistant professor of Law and Technology at Tilburg University. 'We have to look for a new way to safeguard values such as fairness, so that the benefits and burdens of the energy transition are distributed evenly. And that people without electric cars and solar panels, who do not benefit from subsidies and have no ability to return surplus energy to the grid, are not disadvantaged.' The question is how this could be put into practice. Noorman: 'Now that more and more electrical appliances are being used and the grid is heavily congested, choices have to be made as to who can charge and discharge their car, and when. How can this be done in a fair way? Should the highest bidder be able to load first or do we prioritise vulnerable people? This should be considered carefully.'

'People can also become part of the solution', emphasises Saskia Lavrijssen, Professor of Economic Regulation and Market Governance at Tilburg University. 'If there are shortages on the grid, you could also choose to temporarily use less energy. When people don't benefit equally, the danger of a clash between the "haves" and "have nots" is real.'



### MEGAMIND facts

Duration: 5 years

Budget: € 3,700,000

Researchers: 8 PhDs, 2 postdocs

Project partners: Eindhoven University of Technology, Tilburg University, University of Twente, TU Delft and TNO (knowledge institutions), Enexis, Liander, Stedin and TenneT (energy network operators), Equans (energy service provider), PwC, IBM and Smart State Technology (consultancy and technology companies), Transdev (public transport operator).

*'Incorporating ethics and law is crucial to ensure that new technology is embedded and accepted in society'*



## Embedded in society

Before such a development can actually take place, the legislation needs to be amended. In the European Union, the Clean Energy Package has already been passed for this, but it has not yet been implemented in the Netherlands. Lavrijssen: 'In the new Dutch draft law, which I hope will pass soon, the rights and obligations of consumers and prosumers, as well as the role of the network administrator, are clarified. It also regulates more clearly the usage of data sharing.'

The interdisciplinary character of this research programme, in which technology, ethics and law are developed simultaneously, is of great added value, according to the researchers. Lavrijssen: 'Incorporating ethics and law is extremely important to ensure that new technology is actually embedded and

accepted in society. If researchers don't work together, they may end up with a technology that is contrary to justice or based on wrong assumptions, and will therefore have no support. There is currently a deluge of new rules about data sharing, AI and energy law, of which many engineers and energy specialists are not aware. We will bring together all these rules.'

When Kok was involved in drawing up this research programme a few years ago, capacity problems were not as topical as they are today. He notices that interest from the field has increased. 'This problem is developing extremely quickly. Perhaps we should also come up with quick solutions, such as an accelerated track with a spin-off innovation that we can quickly apply. The most important goal, however, is to take a step back and carefully consider how to implement these innovations in society.'

# BUILDING A CHAIN OF TRUST

By Amanda Verdonk

**Cryptocurrencies are hot – almost everyone knows bitcoins. But what about the blockchain, the underlying technology? What exactly is it, how does it work and is it more than a hype? For answers, we turn to Dick Epema, Professor of Distributed Systems at TU Delft and director of the Delft Blockchain Lab.**

‘The real beginning of blockchain can be dated back to 2009, when bitcoin came into existence. It was not completely new, rather a clever combination of already existing techniques. Decentralisation is the strongest feature of bitcoin. There is no central party like a traditional bank that approves payments. Everyone can get a copy of the blockchain and use it to verify transactions. Bitcoin solves the so-called double spending problem: how do you prevent people from making two payments with the same money?’

‘To understand how this works, we need to dive into the blockchain. That is, unsurprisingly, a chain of blocks. Everyone who participates has a copy of the blockchain on his computer. New blocks are generated every few minutes and contain all transactions that took place in that time, for everybody to see and check. Compare these blocks to the paper statements that you used to receive from your bank – they were properly numbered,

so you knew exactly which statements followed each other. In the blockchain, another mechanism ensures that you cannot mess with the contents and the ordering of the blocks. A unique ‘hash’ is generated for each block; this is a long sequence of zeros and ones, like a fingerprint. Every block contains the hash of the previous block. If you change something in a block, its hash changes too, exposing the change and breaking the order. This way, it becomes clear for all involved what the most recent status is. Another feature of the blockchain is that all historical transactions are stored in it, and that you have to use cryptographic keys to demonstrate your positive balances from the past and use these for new transactions.’

## Blocking free riders

‘Blockchain is definitely not a hype. It really is a very smart decentralised system. Twenty years ago, our distributed systems group had already started working with predecessors, such as peer-to-peer systems. These were used to download large music files, for example via Napster and BitTorrent. Everyone had parts of those files and shared these parts. However, there were always people who wanted to download files but did not contribute. We have built reputation and trust systems to block these “free riders”. Blockchains are the next step in this development, as they are all about trust and safeguarding value.’

‘There is not just one type of blockchain. For example, we have created our own alternative blockchain, which we incorporate into blockchain-based marketplaces and demonstrate in practice. Our system is faster and more



scalable than what is currently used by most bitcoin systems. A disadvantage of the traditional blockchain is that, due to its built-in control mechanisms, it allows only a few transactions per second. The system is verifying too much. If you do business with just a few people, you don't need to know what all other people are doing. So you don't necessarily have to be all linked together. Our system is more optimistic, you could say, and verifies only when there are doubts, which makes it faster. In addition, there are also permissioned blockchains, to which you must be admitted. These could work in limited settings for internal processes in governments and companies. Many people are shocked to hear that in bitcoin-like blockchains, transactions are in fact public for the whole world, even though they are cryptographically protected.'

## Growing numbers

'We should not use blockchain for everything. It only makes sense in situations where multiple parties work together, where you exchange value and where registration should be irrevocable. Matters that are privacy-sensitive and complex, such as medical data or pension data, are certainly not the best areas for setting up a blockchain. However, it is clear that the possibilities of blockchain extend far beyond just cryptocurrencies. At the moment, there are thousands of crypto coins alone, many of which use similar techniques. So there will probably be tens of thousands, if not hundreds of thousands of blockchains all together. I have no doubt that that number will only keep growing.'

'We should not use blockchain for everything'



**Monique Tabak is a biomedical engineer and an associate professor Personalised eHealth Technology at the University of Twente. She also works at Roessingh Research and Development, affiliated with Roessingh Rehabilitation Centre, one of the largest rehabilitation centres in the Netherlands.**

## MORE CONTROL OVER YOUR HEALTH

By Amanda Verdonk Image Gijs van Ouwkerk

**People with multiple chronic conditions are a major burden on healthcare. According to Monique Tabak from the University of Twente, the key lies in self-monitoring and self-management aided by ICT.**

'On average, people are getting older and therefore more often suffer from one or more chronic conditions. They visit a specialist only a few times a year. ICT can provide information on a more frequent basis, for example by measuring lifestyle and keeping a symptom diary on the patient's phone. By using smart algorithms, you can keep a closer eye on a patient and possibly also predict when things are about to go wrong.'

'I mainly conduct research on eHealth for patients with COPD. Many of them also have other, related disorders. However, healthcare is now organised in separate domains. For example, a patient goes to a pulmonologist for their COPD, a cardiologist for their heart condition and a psychologist for their anxiety disorder, while the symptoms can be similar. Suppose they experience shortness of breath, which of their disorders is causing this? I coordinate a European research project called RE-SAMPLE, in which we will monitor patients at home using sensors and a smartphone app. By combining this real-world data with hospital data and existing knowledge, we hope to be able to predict what the primary cause of the symptoms is and start treatment as early as possible.'

### VIRTUAL BUDDY

'The application should become a kind of virtual buddy that monitors your data, advises you on your exercises or reminds you to take your medication. It can also advise you to start with medication when the models predict a flare-up is coming. The app regularly asks how you are feeling. We have seen in previous research that the therapy loyalty is very high. Patients like to have more control over their own health.'

'I hope that our solution will be part of the clinical practice in five years' time. A lot is already happening in the field of eHealth, but many innovations from science have not yet reached the clinics. This requires an organisational and cultural change. In practice, eHealth has not really evolved beyond video calling. Monitoring and treatment with smart algorithms have only been applied to a limited extent. I hope that will change, because it is really necessary. Due to the high costs, the lack of staff and the increase in patients, our current health system is unsustainable. We need to provide much more proactive care in which the patient is more in the lead. If people can monitor themselves better at home, that will result in fewer unnecessary hospital visits, faster treatments and a better quality of life.'