Strengthening the foundations for a strong digital society

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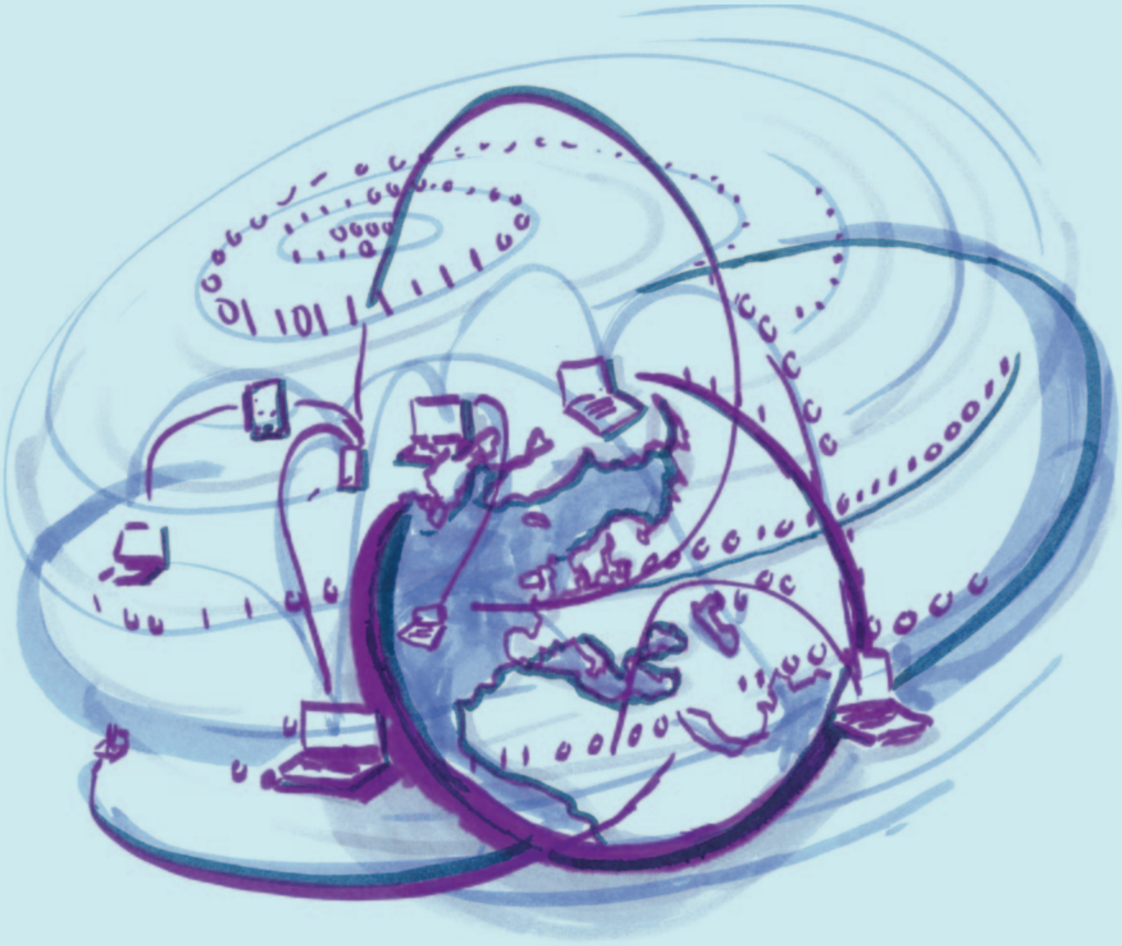

Fundamentals of trusted digital partners

We are evolving towards a situation in which socio-technical systems are trusted digital partners. Imagine here the autonomous provisioning of energy resources, robotics for homecare or autonomous public transportation.

What if something 'goes wrong'? How do we come to trust socio-technical systems, from both a technological and a societal perspective? How do we ensure that they are safe, secure, reliable, robust, maintainable, transparent and verifiable, and that they will respect and adapt to (changes in) social values?

And, of equal importance, how do we ensure that they evolve while still fulfilling their original intent? This concerns things such as the correctness and completeness of the involved data and software, or assurances that vulnerable citizens will not be abused, but rather attain a higher quality of life.

Strengthening the foundations for a strong digital society

ICT is one of the pillars of modern society. Indeed, there are scarcely any areas of society in which ICT does not play a pivotal role. This ranges from the everyday use of email, websites, smartphone apps and teleconferencing tools to wholly automated systems of production, mobility, logistics, energy, planning, billing, security and sales. Today, ICT and society are intertwined to such an extent that they have become wholly inseparable. We are at the point at which large parts of society would be unable to function if digital systems were to fail.

On the other hand, digitalization is also creating novel business, social and behavioural forms, including, amongst other things, the virtualization of retail markets, the proliferation of digital social networks, online lifelong education and energy 'prosumption'. These opportunities open up new horizons as well as creating new challenges to be addressed, such as the need to tackle fake news and filter bubbles, the erosion of privacy and the danger of power outages in electricity networks.

Fund fundamental research

Research has a critical role to play in addressing the challenges arising from digitalization and the digital transformation, and in terms of shaping the emergent possibilities for a safe, prosperous, comprehensive and sustainable future. For ICT, fundamental research has formed the basis of digitalization and digital transformation for quite some time. The results of this research were groundbreaking technologies that were routinely used for alternative purposes than originally intended and, indeed, in some cases for purposes that were simply unimaginable before. Innovations like artificial intelligence, which is now opening up an abundance of new societal and business opportunities, have evolved out of a solid fundamental research infrastructure that was put in place several decades ago.

Recent years have seen ever-increasing attention paid to applied research and valorization, at both the national and European level, resulting in dedicated investment and well-defined areas of focus. While this is undoubtedly of the utmost importance, equivalent levels of investment in fundamental research have thus far been lacking. The prioritization of application-oriented research has also come at the expense of supporting curiosity-driven research. Moreover, ICT is too often viewed as an enabler of innovation, rather than a field that requires innovation in and of itself. Since fundamental research forms the basis of almost all of the substantial developments driving both our current and future digital society, this imbalance must be corrected.

For computer scientists, fundamental challenges lie ahead in terms of creating new paradigms. Critical research areas include: supporting autonomy within prescribed ethical intent as well as trustworthy decision-making (the latter being based on automated processing, (large volumes of) data, multiple (business) interests and keeping humans in the loop); hybrid intelligence; developing software technology that is reliable, sustainable and energy efficient; eliminating disruptive behavioural models; protecting people's privacy and assurance of security of systems and sectors by design. The most pressing fundamental research questions defined by ICT researchers across a range of fields are described in more depth in the research agendas outlined in table on page 5.

Educate society

In order to keep pace with the digital revolution, it is of paramount importance that we educate a sufficient number of experts and increase the overall level of digital literacy. Currently, Dutch computer science programmes are facing a steep incline in student numbers, without a corresponding growth in staff numbers. At the same time, people working in industry are struggling to keep abreast with the latest developments, which, in turn, highlights the need for academia to develop lifelong learning opportunities for the professional IT community.

In computer science, the student-staff ratio is 35. This is higher than any other STEM discipline, and is around twice as high as the ratio in the humanities and social sciences programmes, and four times as high as the ratio in the medical sciences.

If the Netherlands has the ambition to educate computer scientists to an acceptable level, then the student-staff ratio in computer science must be decreased significantly.

Dutch computer scientists have identified four main challenges that require immediate action in the upcoming decade (see page 6: Challenges in Education): Aligning supply and demand; Increasing the diversity of the workforce; Accommodating lifelong learning and professional development; and Increasing general and specific digital literacy. Structural investment is required to both tackle these challenges and to empower people, companies and societal organizations to survive and thrive in our digital society.

Act now

At the moment, investment in fundamental ICT research lags substantially behind its societal and scientific importance. Moreover, university researchers are becoming overloaded with educational tasks as a result of the immense growth in the number of computer science students.
In order to ensure a bright and sustainable future for our digital society, there is an urgent need for:

- structural investment in fundamental ICT-research, in order to create future (societal) game changers; and
- educating new ICT talents, alongside the investment needed to achieve this.

As the main point of entry to ICT research in the Netherlands, IPN's goal is to further these two objectives, in collaboration with key decision-makers in government, industry and society.

Appendix 1: Overview of ICT-related research agendas (in order of publication)

Theme	Main research challenges	Aim	Publication date
Dutch Blockchain Research Agenda Published by: Dutch Blockchain Coalition	Distinguishing between blockchain characteristics, which all require a better understanding: • Decentralization of a distributed, immutable ledger • Automation and standardization of transactions • Digital Scarcity • Disintermediation Specifically, three overarching concerns need to be addressed, in order to align analytic and design challenges for the creation and adoption of blockchain technology that realizes positive societal outcomes: • Trustworthiness • Sustainability • Governance	Blockchain research is best directed at identifying and creating the conditions to steer the development of blockchain technology towards maximizing its potential for societal good; and to the exclusion or remediation of undesirable developments. These conditions arise from ethical, technological, economic, legal and societal perspectives, all of which are closely inter-related. Blockchain research, therefore, must adopt a systems perspective.	May 2018
National Cyber Security Research Agenda III Published by: Betrokken: SIG Cyber Security IPN	The NCSRA III describes the research challenges in cybersecurity and privacy in relation to five key areas: 1. Design 2. Defence 3. Attacks 4. Governance 5. Privacy	Shapes the research future of the field, creating new technologies, solutions and routines that will make our society safer in the digital domain.	June 2018
Dutch AI Manifesto Published by: SIG AI IPN	AI Foundational Priorities • Autonomous Agents & Robotics • Computer Vision • Decision-Making • Information Retrieval • Knowledge Representation & Reasoning • Machine Learning • Natural Language Processing Multidisciplinary challenges for sustainable next-generation AI systems: • socially-aware AI • explainable AI • responsible AI	Identify priority areas that require investment to ensure AI research in the Netherlands is able to establish and maintain its leading role on the global stage.	September 2018
National Quantum Technology agenda Published by: TNO	Realizing breakthroughs in research and innovation • Quantum computing • Quantum simulation • Quantum communication • Quantum sensing • Quantum algorithms • Post-quantum cryptography	The agenda describes what is needed to both further develop quantum technology and to translate it into yielding new economic value for the Netherlands. • To achieve breakthroughs in research and innovation • To develop ecosystem development, market creation and infrastructure • Human capital: education, knowledge and skills • o begin societal dialogue on quantum technology	September 2019
AI Research Agenda for the Netherlands (AIREA-NL) Published by: NWO	The agenda is focused on the four stages of an AI algorithm, and on common multi-disciplinary themes. Simply put: • Creating AI components • Creating AI systems • AI systems and humans • AI systems and society	Create both focus and connectivity in the Dutch AI research field, and strengthen it.	November 2019
Manifesto on Software Research and Education in the Netherlands Published by: VEReniging Software Engineering Nederland (VERSEN; SIG IPN)	Software reliability: • Software Maintainability and Evolution • Efficient Engineering of Software • Software Education	Goals: • Increase the number of software engineers graduating from higher education institutes. • Increase the quality of graduates and employees. • Provide easier access to development opportunities. • Increase the diversity of both the student population and workforce.	March 2020
Future Computer Systems and Networking Research in the Netherlands: a Manifesto Published by: Future Computer Systems and Networking (SIG IPN)	Four grand societal challenges related to Computer systems: 1. Manageability; 2. Responsibility; 3. Sustainability; 4. Usability	Highlight the grand societal, technological, and scientific opportunities and challenges in future computer systems and networking (the CompSys area), and to outline how to maintain the leading position the Netherlands has in this area.	October 2021
DSPN vision 2021 Published by: Data Science Platform Netherlands (DSPN; SIG IPN)	• Data Systems & Data Integration • Knowledge Representation & Provenance • Data Mining and Exploration • Information Retrieval • Responsible Data Science: FACT & FAIR	This document was authored by the Data Science Platform Netherlands (DSPN) to answer the following questions: • What is data science (and how is it different from AI)? • Why is data science relevant, in science and society? • What are the main data science challenges in research and education? • What will DSPN do in the Dutch data science community to address these?	October 2021

Appendix 2:

Challenges in Education

IPN represents all Dutch academic research groups that have ICT science at their core and, as such, is responsible for the education of the next generation of computer scientists and engineers. In the coming decade, we want to tackle the following challenges.

1 Aligning supply and demand

Currently, Dutch computer science programmes are facing a steep incline in student numbers, thus leading to clear and urgent scaling problems. This mismatch between supply and demand within education has to be solved. To make education more scalable, blended and e-learning methods should be considered.

At the same time, the labour market is craving people with in-depth knowledge of ICT. Moreover, industry sometimes requires other forms of expertise than those taught within the academic curricula. Therefore, new methods should be developed to assess what skills are needed by industry in our current and future society. Curricula should be flexible and adaptable to changing needs and a changing student population. Also, research is needed to develop new educational practices: what is the best way to teach students new concepts, so that they learn and understand them more efficiently?

2 Increasing the diversity of the workforce

Given that digitalization shapes society, the people who develop new digital technologies should be representative of a wide variety of perspectives and social values. This means that we must attract people from a variety of backgrounds – in terms of gender, nationality, level of education, socio-economic backgrounds and ethnicity – to computer science education.

The initial stage in this process is to put multidisciplinarity first and promote the options for greater diversity in talent development. It is not only computer whiz kids but also other kinds of people who are motivated by solving societal problems that we want to attract to study computer science.

Further, in order to establish a workforce that is trained in using socio-technical systems, basic knowledge about topics like security and data management practices should be incorporated as basic skills into every higher education programme.

3 Accommodating lifelong learning and professional development

Since ICT develops at an incredible speed, it is impossible for people working in industry to keep abreast with the latest developments. Despite this, they are still expected to be able to incorporate the latest views and technologies into their products and services. We need to develop solutions to provide lifelong learning opportunities for the professional IT community, so as to enable them to keep up to speed with developments in, for example, design, languages, security, frameworks or tools. E-learning could play a pivotal role in this regard.

4 Increasing general and specific digital literacy

In a digitalized society, virtually all professions deal with information in a digital format, which is why basic skills are needed to make proper ICT-related judgements. To empower people and to make them ICT aware, not only in their professional capacity but also in their personal lives, ICT should form part of everyone's basic education, from primary school onwards. In secondary education, informatics should become a compulsory examination subject, in precisely the same way that Dutch and mathematics are.

At the same time, computer science education itself should be more focussed on the societal impact of technical developments. Within higher education, the focus should shift away from the technology itself towards what people are going to do with it, and what its potential impact on society could be.

To educate a broader public, and to provide a counterbalance against ill-advised or unsubstantiated news about ICT-driven changes and developments, computer scientists must take the lead in public discussions about their field of expertise.

What is needed?

A key indicator of the quality of education is the student-staff ratio. For the STEM disciplines (Bèta-techniek sector), this ratio has gradually increased from 12.3 in 2007 to 18.8 in 2017 [see 'Ruimte voor investeringen en talent', VSNU, Sept. 2018; p. 22], and has not decreased since. Among the STEM disciplines, computer science especially has seen an impressive increase in student numbers, without a corresponding growth in staff numbers. A recent estimate of the student-staff ratio in computer science is 35 [Sectorplan Onderwijs, 4TU, 2020, p. 8], which is higher than in any other STEM discipline, around twice as high as the ratio in the humanities and social sciences, and four times greater than the ratio in the medical sciences. If the Netherlands has the ambition to educate computer scientists to an acceptable level, then the student-staff ratio in computer science must be reduced to acceptable levels.

Even if the financial hurdles for hiring new teaching staff are removed, there is the added complication that talented computer scientists are a scarce commodity, who are in high demand throughout the labour market. In this respect, universities have to compete with companies that offer excellent employment packages. One of the best arguments in terms of convincing a young computer scientist to embark upon an academic career is to emphasize the freedom that they will have to pursue their own research interests. However, this argument loses its appeal if the balance between teaching and research is largely skewed towards teaching. Thus, in order to both attract and retain high-quality staff, the number of FTEs devoted to teaching should not exceed the number of FTEs devoted to research. Given that only a small portion of research time can be funded by resources intended for education, a thriving academic community requires funding resources for academic research that are at least comparable to the level of educational funding; moreover, it should grow at the same pace as the increase in student numbers. This clearly has not been the case for computer science in recent decades and, hence, a catch-up operation is long overdue!

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IPN (ICT Research Platform Nederland) is a platform that unites scientists in the academic ICT field 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 unites, strengthens and advocates academic research and education on ICT in The Netherlands, to help realize high-quality digitalization agendas that enable society to face the ICT challenges of today and tomorrow.

IPN builds and maintains a national community, and develops policy to advance the field. The platform actively enhances diversity in ICT by stimulating the participation of women and minorities. IPN advocates the importance of ICT for our current society.