4TU.NIRICT – *Netherlands Institute for Research on ICT*

Objectives

ICT research at universities primarily concentrates on the renewal and prioritisation of individual subdisciplines. The 4TU.NIRICT research centre explicitly focuses on integrating, positioning, and prioritising all aspects of ICT research in multidisciplinary and chain approaches in a rapidly digitising world. Since more than 50% of ICT research in the Netherlands is done at universities of technology, the research centre can effectively devote itself to strengthening the national ICT research network. In doing so, the decision was made to focus on researchers who are at the start of their careers. Another objective is to encourage cooperation in emerging research and educational topics that will be important for ICT in the future.

Results

The 4TU.NIRICT research centre endeavours to achieve these goals using a three-pronged approach: community building, educational collaboration, and research portfolio management. The objectives for each of these three areas have been achieved. The following sections will provide more information regarding the objectives, activities and results per approach.

Community building

In order to promote cooperation between universities of technology, it is vital to establish and develop a network in which all participants are aware of and have mutual respect for each other's ICT research. The emphasis here is on researchers who do not yet have an extensive national network. In addition to the annual community meeting, a network of younger ICT *faculty* members has been set up under the name ICT*ng* (ICT next generation). In doing so, close cooperation was sought with the FES COMMIT/ programme (coming to an end in 2017), which pursued similar objectives. Led by Przemek Pawelczak, a core team of young researchers from several Dutch universities was created. COMMIT/ and 4TU.NIRECT also helped organise and provided funding for a series of meetings which featured inspiring speakers and discussions.

Educational collaboration

All of the universities of technology develop their own curricula and educational activities, the development and implementation of which can help to strengthen each other in some areas. Educational collaboration is particularly necessary to help increase the efficiency of educational development and teaching (where possible). An inventory of programmes, courses, materials and MOOCs has been made. As a result, ICT researchers from universities of technology are better informed about their colleagues' activities and resources, which in turn helps promote collaboration and the sharing of best practices. A bottom-up educational initiative, which was (financially) supported by the research centre, was the best-practices workshop MOOC. This was created by colleagues for colleagues. In 2015, 4TU.NIRICT sponsored the European School of Information Theory. In 2016, a joint contest was held whereby the four most enterprising ICT students from universities of technology could win the chance to take part in the European Innovation Academy summer school. As part of the 4TU.BSR programme – the research centre's largest and independent research programme – a winter school was organised in October 2016 entitled "Big software on the run: where software meets data", which attracted more than 80 participants. Finally, the universities of technology are jointly responsible for implementing and designing the Master's degree programme in Innovation offered by EIT Digital. The director of research represents 4TU.NIRICT on the EIT Digital General Assembly.

Research collaboration

The research centre promotes and provides funding to stimulate bottom-up initiatives for

collaboration on thematic research projects. In this way, the research centre develops and maintains a research portfolio, which can be accessed and used by the universities of technology, of promising issues which ultimately have a reasonable chance of receiving external (public-private, top sector, EU, industrial, ...) funding. From 2014 to 2017, the universities of technology collaborated on the following topics: Data Science, Cyber Security, Antenna Research, Empathic Lighting, Wirelessly-Powered Autonomous Systems, Smart Industry/IoT, Green ICT, Human Computation and Crowdsourcing, and GPGPU. Various activities were developed as part of these partnerships, such as joint workshops, seminars and representation in the Dutch ICT landscape. The universities also collaborated on (successful) joint project applications. There were a number of exchanges between young researchers and fact-finding investigations were also carried out at various companies.

4TU.BSR: Big Software on the Run programme (http://www.3tu-bsr.nl/)
4TU.NIRICT's largest research programme is the Big Software on the Run (BSR) project. BSR is an independent research programme in which seven research groups from the University of Twente (UT), Delft University of Technology (TU Delft) and Eindhoven University of Technology (TU/e) are taking part. BSR arose from a national gravity proposal which was submitted (and rejected) in 2013 by 4TU.NIRICT, RUN and VU Amsterdam. The aim of BSR is to analyse software "in the wild" using big data methods, and to use the results to improve software development. Software forms an integral part of the most complex things that are built by people. That's why BSR is developing innovative technologies which discover how systems actually work, check where and when systems deviate from the expected behaviour, predict reliability, performance and security, and make recommendations to address problems. This approach requires a huge amount of data ("Big Data") and very complex software ("Big Software"). The participating research groups cooperate extensively. A specific example of this is that PhD students are supervised by promotors from two different universities of technology. The groups also use the same infrastructure: in Eindhoven the groups compute large data sets in a single machine, and in Enschede the focus is on distributed computing. This efficient use of resources has also been organised with the future in mind, so that it can respond to developments within joint projects in the coming years. Integrating the different disciplines and methods has provided new insights, creativity and healthy friction. Unexpected new developments have cropped up, such as the collaboration between the security groups in the field of privacy in software analysis. External funding is essential for some sub-activities within BSR so as to maintain the network of collaboration which has been built up. Parties involved, however, would like to see the BSR project – as a comprehensive programme – continue in the future.

Organisation

Prof. Inald Lagendijk is the director of research of 4TU.NIRICT. He is a member of the board, along with Dr Birna van Riemsdijk, Prof. Marieke Huisman, Prof. Maarten van Steen, Dr S. Stuijk and Prof. Johan Lukkien. It should also be noted that Prof. Van Steen is also chairman of the Dutch ICT research platform (IPN). Eveline Vreede is secretary of the research centre. The board meets every two weeks via Skype and several times a year for face-to-face meetings. The deans of relevant EEMCS/M&CS/E faculties provide coaching and guidance for the 4TU.NIRICT board in twice-yearly meetings. Prof. Maarten van Steen and Dr Birna van Riemsdijk are responsible for managing the research portfolio. Each of the research projects within the portfolio is led by three researchers, one from each 4TU or other knowledge institutions. Development of the network for young researchers is being led by Dr S. Stuijk. Prof. Marieke Huisman and Prof. Johan Lukkien are responsible for educational cooperation. BSR is led by Prof. Wil van der Aalst, Prof. Arie van Deursen and Prof. Jaco van de Pol. Talks are currently underway with Prof. Bedir Tekinerdogan, ICT professor at Wageningen University & Research (WUR), about expanding 4TU.NIRICT.

Communication (internal and external)/Branding

Forms of consultation

The aim of 4TU.NIRICT is to approach the ICT community in an inclusive way, precisely because there is no single definition of ICT. With that in mind, communication for the initiative takes place in the following way.

- *Annual Community Day*, which brings the research community together and focuses on important issues and topics. More than 50 academic staff usually participate in the event. The programme includes presentations from the business community, discussions with the ICT top team, round-table sessions on ICT and the future, information about leading national policy developments such as NWA and Dutch Digital Delta, but also European structures such as H2020.
- *ICTng meetings,* giving the new generation of ICT researchers the chance to network and work together to increase the national and international visibility of ICT. It will take time to build up this network. Researchers are currently cooperating on the following important topics: career development, educational innovation, putting ICT issues on the agenda, and technologies of the future. The older generation also plays a role here: how they can ensure that the next generation can take on the mantle?
- *Theme-specific events* linked to the research projects that have received funding, such as the NARF Smart Antennas and Propagation conference, An Innovative Truth, two National Cyber Security workshops, Data Science seminars, and the GPU meetings.

Branding

- Sponsorship of the national ICT conference ICT.OPEN 2016 & 2017, contributing content to tracks and references to 4TU.NIRICT on the website and other publications.
- 4TU.NIRICT was presented at a number of international events, such as the Hannover Messe and IoTAsia 2016 (research and the 3TU Master's degree programme), and it also participated in a cyber security forum in Tokyo during which the activities of the collaborating universities were discussed.
- A number of national cyber security workshops were organised in collaboration with the Netherlands Organisation for Scientific Research (NWO). International speakers were invited and workshops were well attended.
- A fact-finding mission to WUR, attended by about 30 researchers from TU/e, UT and TU Delft, with tours and discussions about working together.

Collaboration

4TU.NIRICT as a direct partner

In its role as a direct partner, 4TU.NIRICT aims to set the agenda by connecting with partners to tackle specific issues.

- EIT Digital: innovation, education and knowledge transfer. 4TU.NIRICT is EIT Digital's key partner and serves on various committees within this European partnership. Several EIT Master's programmes are led by participating departments such as the successful Data Science tracks in Eindhoven, Cyber Security in Twente and Digital Media Technology and Cloud Computing in Delft.
- The Hague Security Delta (HSD): cyber security programmes, research and public-private cooperation.
- IPN (the Dutch ICT Research Platform): 4TU.NIRICT was a member until 2016. After IPN's restructuring, this evolved into a collaboration in the form of a network.
- Discussions with UvA, VU, WUR. Focused on community, staff exchanges, and bottom-up research investigations.
- Future of Technology Foundation (Stichting Toekomst der Techniek): Concerns the future of

digital education.

4TU.NIRICT participates as a partner in innovation, often in joint staff roles
The intention behind this form of cooperation is that scientists represent the interests of technical ICT research in the Netherlands in influential committees in their network. Here 4TU.NIRICT takes on the role of network organisation, and provides support and acts as a sounding board.

- Dutch Science Agenda (Nationale Wetenschapsagenda NWA) (i) "Digital society" contribution by Profs Aarts, Lagendijk, Apers to TU Delft/TNO/STW "Agenda voor Nederland – Inspired by technology" manifesto. (ii) Organisation of information sessions about the NWA for researchers from participating universities. (iii) Encourage researchers to participate in route workshops. (iv) NWA Big Data route, with figurehead Prof. Inald Lagendijk and with contributions from Profs Geert-Jan Houben, Wil van der Aalst and Maarten van Steen. (v) NWA Smart Industry route with contributions from Profs Boudewijn Haverkort and Johan Lukkien.
- RVO PIB (Partners in Business), Singapore and Japan. Set-up of the structure and substantive investigations of these PIB collaborations. Representation of technical ICT research in the Netherlands. Collaborating on this are: Institute for Mathematics and Computer Science (CWI), the Rotterdam/The Hague Metropolitan Area, TNO, dcypher.

BSR works with various partners in the fields of application and data usage
BSR acted as a catalyst during the establishment of the NWO research programme Big Software, which encourages innovation in the fields of theories, methods, tools and technological cooperation. BSR has partnerships with ASML and Eclipse, among others.

Outlook for the coming years: Continuation of 4TU.NIRICT

Academically speaking, the Netherlands is doing well with regard to ICT, as was evidenced by recent visits to the computer science and electrical engineering departments, and various international reports. At the same time, scientific ICT research is under pressure due to a number of factors: (i) the positive effect of a significant increase in the number of students; (ii) the scope of funding for research is lagging behind compared to the increased importance of ICT. IPN manifesto "*ICT – Digital Science for the Digital Society: A five-point plan for the Netherlands*"[1] provides a clear explanation about this. In order to be able to respond to future challenges, not only are additional resources essential, as stated in the manifesto, but the – relatively younger generation of the – ICT community also needs to develop further and consolidate its place as an independent scientific discipline and the "innovator of innovators in all sectors", as mentioned in the AWTI report "*Ready for the Future? Towards a comprehensive strategy for ICT*" (2015).

The Dutch ICT landscape has therefore benefited from the community-enhancing activities initiated by 4TU.NIRICT, and will continue to benefit in the future. 4TU.NIRICT will use the three approaches to continue its commitment to strengthen the ICT research community. Partnerships with universities of technology are a starting point, but it will also increasingly establish collaborative relationships with other (mainly) ICT research groups in the Netherlands. The focus here will be on gender diversity and senior and junior leaders in the community coaching each other – facilitated by 4TU.NIRICT – to become role models, for example in the composition of boards, ICT*ng*, and – increasingly in the future – leadership roles in (the development of) national programmes.

Thanks to the close relationships that have been forged between the 4TU.NIRICT community, the board and national organisations which promote and plan research programmes (such as NWO, the

[1] http://www.ictonderzoek.net/binaries/content/assets/bestanden/ipn/2016-ict-digital-science-een-vijfpuntenplan-voor-nederland.pdf

Ministry of Economic Affairs/various top teams, KNAW), the knowledge and innovation agenda in the field of ICT (including Commit2Data), HighTech (including Smart Industry and high-tech agri-food) as well as NWA routes (big data, smart industry) is consistent with the research priorities of the universities of technology. Thanks to mutual knowledge, respect, prioritisation and collaboration – all of which have an obvious technical character –, the 4TU organisations are able to influence the agenda together. This network effect must continue in the future, and it will have to take on an even more influential role as an agenda-setting platform for some activities. 4TU.NIRICT doesn't aspire to be a partner in projects itself, but wants to continue to ensure that there are sufficient opportunities and resources available for researchers to find and work on projects together.

ICT science education as well as education with modern ICT is changing quickly. It is no longer feasible for each of the universities to offer all specialisations. Therefore, there will be an increasing need for more collaboration, distance learning, information sharing, and online education such as MOOCs. Thanks to the network, 4TU.NIRICT can play a proactive and partly executive role in these developments.

ICT research at the universities mainly focused on areas such as high-tech industry, robotics, smart cities and health. The emergence of WUR paves the way for expertise within a completely new sector: the agri-food sector. Initial investigations into possible collaboration, namely in the fields of robotics, big data and blockchains in the agri-food sector, are currently underway. This collaboration can be expanded further in the coming years by linking the WUR and TU/e, UT and TU Delft networks; a tasks that would fit in seamlessly with 4TU.NIRICT's ambitions. Parties are also striving for broader ICT and agri-food research programmes in the above-mentioned areas, similar to the character of the 4TU.BSR programme.