Self-assessment report for Research Evaluation Informatics 2009-2014 Amsterdam

Informatics Institute (UvA) & Computer Science Department (VUA)

UNIVERSITEIT VAN AMSTERDAM

VU VRIJE UNIVERSITEIT AMSTERDAM

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This self-assessment was written in close collaboration between the *Department of Computer Science of the VU University Amsterdam (VU-CS)* and the *Informatics Institute of the University of Amsterdam (IvI)*. The retrospective parts concerning the reporting period 2009-2014 (Chapters 1 and 2) were written independently, with a minimal alignment of the definitions for the quality measures used and the exact interpretation of the assessment dimensions. Since the two organisations are planning to merge between now and 2019, parts of this self-assessment (Chapter 3) concerning future cooperation were written together.

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1 Informatics Institute UvA

1.1 Introduction

The Digital is literally everywhere. Data, information, and knowledge, the three main ingredients of computer science, have come closer to man than ever before. Where in the old days, one had to be privileged to go to sources of information and knowledge, now that comes to all. The changes the digital era brings are exciting almost without exception, and most of them have a large, positive impact. We at the Informatics Institute are thrilled to be part of this revolution.

The Digital has an impact on all aspects of life. It is not easy to think of any part of modern life that is not affected by messaging, media, information, structure, processing, or simulation. The impact on the economy is self-evident; easily visible in the way other sciences and humanities are being conducted, thus permeating individual behaviour. But the Digital also begins to seep into what is being traded in the economy, into what is being considered as important in the structure of society, and into what is being researched in science. In this context the Informatics Institute focuses its research on the most prominent emerging challenges: the control over data and data processing, especially on processing the semantic meaning in the data.

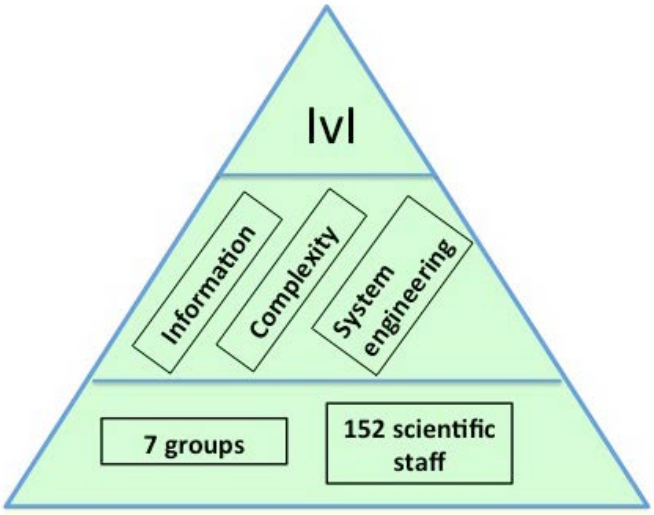
The Informatics Institute's overarching goal is to produce research that has a clear impact in computer science and from there on science and society. The Institute has obtained recognition for this effort: the Institute has been listed on position 50-100 on the QS-ranking for Computer Science in 2014/2015, and on position 75-100 in the Shanghai university ranking in 2014. In the Amsterdam region ICT is the most important industry; in rankings based on the 3 driving factors of innovation —talent, technology and tolerance — Amsterdam does well.

The Informatics Institute most prominent strategic response to digital developments is the cooperation with the Computer Science department of the VU University Amsterdam. The scale and the joint planning of science directions to participate in will establish the combined institute as the best response to the increasing internationalization of computer science. In addition, it will offer a large institute in the Dutch topsector-landscape. Ultimately, it will allow the members of the Institute to focus on scientific depth and proper response in times of many personal grants becoming available.

1.2 Research area and objectives

1.2.1 Research area and research lines

In the digital era, the Institute focuses research in three main areas: information, complexity and systems engineering.



This is the era of information, prone to discovering fundamental algorithms and processing mechanisms for the understanding of information, be it lingual, visual, multimedia, social, or natural; and for the learning of hidden rules by machine learning. This is the era of complexity, offering inspiration to unravel the fundamental aspects of complex systems, (systems') performance, programmability, management, and security. This is also the era of systems engineering at a new scale, where our research tackles open issues in the modeling of smart and safe data processing infrastructures along with issues of trust and privacy.

The 152 research staff members conduct research in these larger goals, focused around seven groups. The Institute is empowering all of its staff members, where possible, to perform and lead their own research and seek collaboration with colleagues, in the recognition that this autonomy represents the most effective means for research volume and impact.

1.2.2 Vision, mission and objectives

The Institute's vision identifies three main driving forces behind research. (1) *Create impact from concept to application.* The Institute strives to cover the complete research and valorization chain, from fundamental research to knowledge ready to be introduced into society: ideas, research projects, and proof of concepts by demonstration. (2) *Create high quality by setting high standards.* The Institute strives for high standards in research as well as in teaching. It aims at collaboration with others in a well-chosen balance to be inspired and to inspire, to have impact and to be impacted by their data. (3) *Create contact by being inspired in society.* The Institute considers it a compelling task to address the needs of the digital society by raising the interest in informatics, by educating students to be open-minded, and by broadcasting the modern capabilities of informatics to companies, not-for-profit organizations, and society at large.

Each of the mission drivers translates into objectives. To create *impact* we strive to produce top quality research published in the best conferences and journals; produce usable software and participate in open-innovation competitions; produce usable cases, based on open data sets and publications; and engage in collaborations with high-end industry and advanced societal groups. To create *quality*, we attract talent from outside, foster an international atmosphere, and produce the scientific leaders of the future by setting an example. To create *contact* with society, we participate in a large variety of long-term co-operations and short-term projects with a broad range of disciplines within the university.

1.2.3 Strategy

The Informatics Institute has taken the following steps to achieve its objectives. For *impact* the Institute focuses on acquiring external projects. The members of the Institute are encouraged to apply for projects within their own strategic agenda, anywhere and anytime. For *quality* the Institute fosters talent by assisting in the application of personal and general grants wherever possible. When personal grants are being rewarded, candidates are allowed to strongly focus on their research in order to develop themselves into the scientific leaders of the future. For *contact* with society, the Institute actively takes a leading role and has a lasting relationship with the city of Amsterdam, with national policy-making, as well as contacts with industry. These are time-consuming activities, which require endurance to succeed.

The freedom to operate diligently in acquisition has paid off in *volume* and *impact*. The Institute maintains a Russia-funded PhD-program with 7 already graduated students and 10 more to come. The Institute has participated in 34 FP7-projects; it has already acquired 9 grants in H2020, despite the low acceptance rates, for a total of M€ 4.95 EU-H2020 funding. The Institute has acquired M$ 4.0 funding 10 PhD-students from the USA government. By *fostering talent*, the institute has received in and around the evaluation period 1 Pioneer recipient, 2 ERC-Starting grant researchers who have also been awarded a VIDI, 2 VICIs, 3 more VIDI's, 4 VENI's and 1 McGillavry recipient. For *contact* with society, the Institute has derived 10 PhD-students from the COMMIT/-program in which it cooperates with the (non-)profit sector such as KPMG, KLM, CIENA, ASML and TNO.

Naturally, some issues in the Institute require attention. In several topical areas — software engineering, gaming, human-machine interaction, and the management and organisational side of business information systems — our Master programs attract quite a number of students, thereby creating a tension between the (fluctuating) interest of students and the (steady) research foci we have. Also, some of the sections feature a structural weakness regarding research-funding acquisition, and the solution of this issue will involve the discontinuation of certain activities in the years ahead. The latter policy is quite sensitive to the precise way in which our joint future with the Department of Computer Science of the VUA will take shape.

1.2.4 Research environment and embedding

As a consequence of the strategy to play an active leading role, in the past six years members of the staff of the Institute have held several prestigious positions.

Within science, the Institute provides the chair and one member of the section “Informatics” of the Academia Europaea. It holds one member of the Russian Academy of Science. It holds one member of the KNAW and one of the KHMW. The Institute has provided the chair of the IPN – the national advisory committee for ICT-research. The Institute provides the director of COMMIT/, the M€ 110 national public-private program for ICT-Research. The Institute has provided a member for the ICT cluster of the Amsterdam Economic Board. Staff members have led or participated in European Networks of Excellence and served as reviewers for ERC, NWO at all levels of funding, STW and H2020. In short, the Informatics Institute is well connected.

Internationally there are long lines with the University of California San Diego, NSF and the Department of Energy on networking research, with the University of California Irvine on machine learning, with the University of Illinois Chicago, with St. Petersburg University and with Singapore University on computational science and complex systems science, and with Columbia University on multimedia city data. Exchange of staff with these and other institutes provides fruitful ideas. Former faculties of the Institute currently work at KU-Leuven, University of Edinburgh, INRIA, Oxford University, Google, Twitter, Microsoft, Yahoo, and others. The Institute has a healthy international portfolio.

The Informatics Institute is well embedded in the Faculty of Science, the University and in the Amsterdam area. It cooperates for data processing with astronomy, the social sciences, the humanities, and local industry. There are long-standing relations with CWI in software engineering and in databases and information retrieval research. The Institute cooperates with TNO to bring research into application particularly in the areas of network programmability, smart cities, and the creative industries. The effectiveness of regional contacts can be improved.

The Informatics Institute participates in each of the three national research schools IPA, SIKS and ASCI, and promotes their merger into a national institute for PhD-student education.

1.3 Resources and facilities

The Informatics Institute (IvI) maintains an advanced cyber infrastructure essential for system, networking and visualization research. It hosts shared national infrastructure such as the DAS-4 clusters, which makes good use of facilities such as the ones provided by SURFnet (the Dutch National Research and Education network) and SURFsara (the national e-infrastructure provider). The OpenLab from the SNE group connects optically directly to the worldwide Lambda Grid and it has been pivotal in many demonstrations and prototypes showcased at international venues such as the SuperComputing conferences held annually in the USA.

We also co-own and use the Tech labs VU & UvA consisting of the Intertain Lab (VU), the Game Cella’ Lab (VU), the Media Lab (VU), the RoboLab (UvA) and the UX/Gaming Lab (UvA).

1.3.1 Researchers

IvI currently employs 152 research staff as indicated in Appendix 4.1, equivalent to 55.7 research FTE organised in seven research groups of varying size, depending on their external funding power. PhD students and postdocs are almost exclusively employed on external grants. The external funding has been constant in the evaluation period.

Eight professors have been appointed in the evaluation period. Profs de Laat, Afsarmanesh and Gevers have been promoted to full professor. In 2013 prof. Welling was appointed as a new professor in Machine Learning. Six tenure-track appointments have brought new impulses.

Four senior staff members of associated organisations and companies have become endowed professors, typically for one day a week. They are: prof. Meijer on behalf of TNO, prof Kröse on behalf of the Amsterdam University of Applied Sciences, prof. Klous on behalf of KPMG and prof. Geradts on behalf of the National Forensics Institute.

The Institute has increased the number of female staff members with two assistant professors, including a McGillavry university laureate. The Institute has the only female full professor in the faculty (prof. Afsarmanesh).

1.3.2 Research funding

The Institute has been successful both on the national and international funding arena as indicated in Appendix 4.2, both in terms of money acquired as well as in the positions covered in these externally funded projects.

In the period 2009-2014, the Institute's funding acquired from external sources was more than two thirds of the total budget. The current effort is directed towards maintaining the level of funding at the same percentages of direct and indirect funding.

1.4 Research quality

The institute mission and strategies to *create impact* and *create quality* are reflected in the research products, their use by peers and the mark of recognition we received.

Research products for peers in science

The majority of Informatics Institute publications are conference contributions; this is in line with the need to communicate in a quick manner the scientific discoveries made. The number of journal contributions is also significant and roughly one third of the total production.

Several publications have appeared in high impact journals, such as the two articles by prof. Sloot in the Scientific Reports of Nature (2013 and 2014), and have received journal awards, such as one article from prof. Worring in IEEE Transactions on Multimedia in 2012.

IvI has received numerous best paper awards at prestigious conferences: one for prof. Welling in the International Conference Machine Learning conference in 2012; one for dr. Snoek in ACM Multimedia in 2014; seven awards for the SNE section, latest being one from dr. Varbanescu in the 5th ACM International Conference on Performance Engineering; three in the ILPS groups, most notable one SocInfo2013.

The productivity of IvI in this dimension can be estimated by considering the total number of research products per year, divided by research FTE. This leads us to a ~8 products/FTE yearly which reflects the direct effort of the staff, as well the output produced by their PhD and postdocs and other collaborating research staff.

Use of research products by peers

The number of citations of the Institute's staff members confirms the scientific visibility of the Institute, once one accounts for scientific seniority.

Three of the IvI full professors have an H-index of ~50 or higher (prof. Smeulders, prof. de Rijke and prof. Bergstra). Some of the younger associate professors have high impact in their respective communities, among them dr. Snoek (H-Index of 30).

In the course of the years IvI has produced a number of software products and datasets that have attracted users from all over the world.

The MonetDB software, the well-known open source column-oriented database management system from prof. Kersten receives ~10,000 downloads monthly.

Other tools and datasets well known in the research community are:

- The "ColorDescriptor software" for the evaluation of color descriptors in images, downloaded ~8,000 times;
- The "Sensor network datasets" from AMLAB, with 1,550 unique visits and more than 400 citations;
- LibDAI, a free/open source C++ library that provides implementations of various (approximate) inference methods for discrete graphical models, with ~40,000 unique views and ~7,700 downloads;
- The "Sesame modeling and simulation framework" from SNE, with more than 1,000 downloads during the course of the years since its release;
- The RepLab (2012-2014) from the ILPS group, with ~500 users.

Marks of recognition from peers

There are a total of 57 editorial boards positions and 65 high level appointments in scientific committees covered by the Institute members.

Noteworthy are the leading positions of prof. Smeulders as Program Chair of the ACM Multimedia conference 2013 and the appointments as General Chairs of dr. Snoek and prof. Worring of ACM Multimedia 2016. Prof. Welling was program chair (2013) and general chair (2014) for the Conference on Neural Information Processing Systems, the top conference in the field with an attendance of 2000 people.

Prof. Bergstra is member of the Academia Europaea (Informatics section) and his chairmanship there since Nov 2013. Prof. Bergstra is also member of the KNAW (section Wiskunde/Math).

Prof. Sloot is editor-in-chief of the Elsevier FGCS journal and Computational Science journals; Prof. de Rijke of ACM Transactions on Information Systems. Prof. Welling was associate editor in chief for IEEE Transaction on Pattern Analysis and Machine Intelligence from 2011-2015, one of the highest impact journals in Computer Science.

In the past few years several Informatics Institute staff members have received awards and prizes, such as best paper awards at international conferences or best PC member award for dr. Oliehoek at the AAMAS conference (2012) .The strength of the Institute's research in the area of image processing is testified by the accomplishments of the group of dr. Snoek 2011 in the NIST TRECVID video event detection as best performer in 2014, 2013 and 2010 and runner up in 2012 and 2011.

The international research community has recognized the individual research contributions of a few IvI members: Prof. Kersten was awarded the 2014 SIGMOD Edgar F. Codd Innovations Award, the most prestigious prize for researchers who have made innovative and significant contributions to database systems and databases; prof. Sloot received the Russian Leading Scientist award for his pioneering work in the area of computational science.

Finally it's worth mentioning that in the evaluation period several Institute's members have received personal grants awarded by NWO to researchers that have a clear track record of excellence and pioneer novel and ground breaking research in their field. Likewise, a number of personal grants' recipients moved from other universities to conduct their research in our institute. Currently the Institute hosts two VICI (prof. Gevers and Prof. Portegies-Zwart now in Leiden), five VIDI (dr. Snoek, dr. Monz, dr. Postma, dr. Whiteson and dr. Mooij) and four VENI recipients (dr. Snoek, dr. Varbanescu, dr. Mooij and dr. Oliehoek). Dr. Varbanescu received a Faculty of Science McGillavry fellowship in 2013.

1.5 Relevance to society

IvI's research is oriented to the outside world and aligns with the institute mission of *creating contacts*. The work done in the institute has significant relevance for a diverse group of societal groups: the system and networking community (SNE group), the biomedical and financial industry (SCS group), collaborative methodology and systems supporting production and services (FCN group), and the Big Data industry (ISIS, IAS, ILPS, SNE groups).

Appendix 4.5 provides a concise summary of the most relevant societal outputs of the Institute.

Research products for societal target groups

The effort made by IvI to reach these relevant societal target groups has increased in the 2009-2014 period. The number of publications and demonstrations to the general public has grown from a minimum of 8 in 2009 reaching a total of 35 in 2014. These research products brought to the public a broad range of IvI's research topics, such as the effect of visual analysis on emotion recognition or the use of robots in daily life.

IvI produced laymen roadmap booklets in the context of several European projects, such as the ones produced by the FCS group for ePAL in 2010 and BRAID in 2012.

In the past years several IvI members have appeared in national and international news to present their research. Just looking at 2014: prof. Welling and Kröse were interviewed in the Dutch TV program VPRO/NTR 'De Kennis van Nu' ; prof. Gevers was on the radio and in several national newspaper talking about his work on "Smile reveals consanguinity". Participation in programmes by prof. Sloot on Dutch television are now available via YouTube.

Use of research products by societal groups

The importance of the work done by IvI for society is particularly evident if we consider the amount of contract research produced by the institute in the evaluation period: contract grants have consistently provided one fifth (20%) of the total funding of the institute.

IvI's members have created a total of seven spin-off companies:

- Euvision (2012), Neurensics AI (2012), Sightcorp (2013) and 3DUniversum (2014) founded by ISIS members;
- Talking Trends (2009) and 904Labs (2013) by ILPS;
- Scyfer BV (2013) by IAS that has already 8 employees and a turnover of k€ 400/year.

These spin-offs see immediate applications of our research results in solution to companies and business problems: for example, through Scyfer we have developed an application that helps the ANWB — Dutch Road Service — to predict the number of car break-downs, the NOS to organize their news feeds, the ING bank to predict which service is of interest to a user and the supermarket chain Albert Heijn to predict how profitable a new store will be.

An important event for the institute that has attracted attention from the national press has been the sale of Euvision to Qualcomm in 2014.

IvI has developed four patents between 2009 and 2014. Two software patents come from the SCS group, namely the "Program system for analysis and modeling of information processes in social networks" Software (SD/Dynamics) and the "Program system for data mining and data analysis in social networks" (SD/Crawler); one patent from the ISIS group on "Gaze estimation"; and one from the SNE group on Patient Health Data.

All IvI professors, as well as some of the other staff members, have advisory roles in several industry and societal bodies. Among these we highlight the international ones: the one for the Global Science and Technology (BGST), at the United States National Academy of Science (2011-2013) of Prof. Afsarmanesh, and the one from Prof. De Laat as member of the Energy Sciences Network (ESnet) Policy Board (EPB) at the Lawrence Berkeley National Laboratory and of the Cyber Infrastructure panels at NSF.

Marks of recognition by societal groups

Recognition has come nationally for prof. Smeulders who won the ICT personality award of the year in 2012; prof. Meijer who received the Innovation Award from the Ministry of Economic Affairs and prof. Klint who was appointed Officer in the Order of Oranje-Nassau by the Dutch King. Prof. Sloot received the WorldComp award in 2009 and the Dutch I/O award for the most visible outreach scientist in 2010.

The Institute has received M€ 1,0 funding for valorization activities between 2009 and 2014. Several funded partnerships with industry are in place and provide a fruitful synergy: SNE groups works extensively with CIENA (on network virtualization in the SARNET project), with KLM (on network security and trust models in SARNET and COMMIT), with KPMG (on Big Data in the BDBS project), and with Thales and ASML on modeling and predicting extra-functional system behavior.

Four professorial appointments receive contributions from external parties and industry, e.g. TNO (prof. Meijer), KPMG (prof. Klous), the Amsterdam University of Applied Sciences (prof. Kröse) and the National Forensics Institute (prof. Geradts).

2 Computer Science Department VUA

2.1 Introduction

The last couple of decades have brought forth major changes to our society. Perhaps the most prominent one is the proliferation of computing devices. By 2015 it is safe to say that the number of computing devices exceeds the number of human beings in any given living or work space in the developed world. A closely related trend is that of connectivity. Devices and their owners are connected, forming a world wide web. The global network, also known as the Internet, is augmented by local ones in virtually all homes and offices. Our lives are not only interwoven with computers, but also inherently networked. It is this background that sets the scene for the Department of Computer Science of the VUA.

> We live in a Connected World, where networked computing devices outnumber humans.

In the following sections we elaborate on our department consisting currently of 10 research groups that cover six research themes: Artificial Intelligence, Bioinformatics, Computer Systems, Information Management & Software Engineering, Theoretical Computer Science, and Knowledge Web & Media. Appendix 5.7 shows the full listing of the themes, group leaders, and group sizes.

2.2 Research area and objectives

2.2.1 Research area and research lines

Our research program is concerned with understanding the foundations, the mechanisms, and the technologies for developing and deploying advanced information-processing systems. These systems are networked, they operate in open environments in which humans generally play a prominent role, and they are often characterized by their dynamic nature. In an international and highly competitive playing field, we aim to lead in understanding software systems that scale, that behave intelligently, that are dependable, and that can be either autonomous or have humans in the loop. Modern computer science also needs to address questions about the inherent social relevance, value and nature of the technology itself. Our mission and strategy are a response to these challenges.

2.2.2 Vision, mission and objectives

The department's vision regarding the computer science research agenda is specific in two ways. First, by extending beyond technical artefacts, it recognizes that computer science is rapidly becoming an essential element of domains grounded in social science, the humanities, and economics, where data-intensive research and computational methods are increasingly recognized as being key to success. Along similar lines, there is a strong focus and integration with the natural sciences, where computational complexity and demanding data-processing techniques have triggered substantial and often foundational progress in computer science.

Second, rather than trying to exhaustively cover too wide a range of areas of computer science, we concentrate on specific emerging computational challenges in the sciences and in society. In particular, our research focus is on "The Networked World", further split into two specifically strong fields of research within this focus: much of modern core computer science is covered by our research in *computer systems*, with emphasis on security, high-performance computing, and distributed systems; further significant research effort is put into what is known as *Web Science*, where techniques from traditional artificial intelligence, logic and reasoning, knowledge representation, and intelligent information systems are combined to tackle the new problems that originate from the now all pervasive Web.

The mission of the VUA Department of Computer Science is characterized by:

1. A research focus on the theme of "The Networked World".
2. Scientific and societal relevance by:
    a. high-impact publications;
    b. development of experimental and prototype software;
3. Strong collaborations with scientists and other experts in various application domains, as well as between the different research groups within the department.

The overarching theme of the Networked World comprises the global relations that arise as a result of ICT networks connecting systems, people, and organisations, as well as local connectivity and interactivity (as exemplified by what is known as ubiquitous computing, or smart environments). The department's programs combine fundamental, strategic, and application-oriented research within this thematic setting.

2.2.3 Strategy

Properly addressing these research challenges cannot be done through an insular approach where research groups operate separately. Our scientific research is therefore often collaborative, linking knowledge from many fields within and outside computer science. As part of our departmental policy, we actively stimulate such collaborations by funding Ph.D. positions on topics that link the research interests of different groups, both within the department, but also across faculty boundaries. These have led to synergy and fruitful collaborations, notably between bioinformatics, theoretical computer science, computer systems, and the semantic web groups. We are also investing in experimental research infrastructures such as the Intertain Lab[1] and the DAS-4 distributed supercomputer[2] to further stimulate a collaborative environment and to showcase our research results.

We undertake various initiatives beyond the department that aim at a strong interdisciplinary outreach and impact. Within the VUA, the most prominent of these initiatives is the establishment in 2008 of the Network Institute[3], the VUA interdisciplinary research collaboration concerned with the Networked World that also includes the faculties of Humanities, of Economics and Business, and of Social Sciences. The Network Institute has been initiated, and is being led by, our department. A recent sign of our commitment to cross-disciplinary collaboration is the Amsterdam Data Science initiative (ADS)[4], where the UvA, the VU, CWI and the HvA are collaborating on data science research. It also hosts the recently funded Amsterdam Academic Alliance Data Science programme (AAA-DS)[5], which broadens the ADS collaboration to include researchers from the humanities, the life sciences, economics and medicine. The AAA-DS programme is jointly lead by computer science researchers from VUA and UvA.

We are major contributors to strengthening and improving the profile of the Dutch scientific community in computer science research, both with respect to other disciplines and to the international, and especially European landscape. We work on a daily basis with external national and international partners including a wide range of private and public organisations (as witnessed by our long list of NWO, FES, and EU projects).

Collaborating with relevant external partners has become a mainstream activity in our research. We have leading roles in each of the KNAW-accredited national research schools in computer science (ASCI, IPA, SIKS), and in the national bioinformatics & systems biology research school (BioSB), which play a significant role in PhD education and excellence. Our research is well aligned with the various strategic research agendas, such as that of the EU's ICT research framework, and we have actively contributed to defining these agendas. For instance, two Proactive Initiatives of FET have been co-developed by our professors: FP7 ICT-2011.9.10, Fundamentals of Collective Adaptive Systems and H2020 ICT-2013.9.6 FET Proactive: Evolving Living Technologies. It is our ambition to assume a proactive and leading role in helping shape and modernize computer science research along these lines.

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[1] http://www.networkinstitute.org/tech-labs/intertain-lab/
[2] http://www.cs.vu.nl/das4/
[3] http://networkinstitute.org
[4] http://amsterdamdatascience.nl/
[5] http://amsterdamdatascience.nl/aaa-data-science-program/

To meet these challenges and building on the multitude of existing collaborations with colleagues of the UvA Informatics Institute (IvI) we are now in the process of establishing a joint UvA-VU Department of Informatics. We have a detailed plan for a joint department to be fully operational by 2019. Professorial appointments at UvA and VU Computer Science have been aligned since the seventies, resulting in expertise areas being almost completely complementary between the two organisations. As of 2015 the bulk of our Master education has taken the form of joint UvA-VU programs. The New University building at the South campus (formerly: the VU campus) will house this UvA-VU Department of Informatics and will provide leading-edge research, and educational facilities, including an iconic ICT Lab (see appendix 7). The formation of a joint department has the explicit support of the two university boards and of the faculties involved. Given this development UvA and VU Computer Science have jointly written the sections of this document pertaining to the future.

2.2.4 Research environment and embedding

Our research environment reaches further than the department, the university and the country. At the university level, we are the coordinating department in the inter-faculty Network Institute, we are partners within IBIVU, the VU centre for Integrative Bioinformatics, in AIMMS, the Amsterdam Institute for Molecules, Medicine and Systems, in ACBA, the Amsterdam Center for Business Analytics, that incorporates several other faculties and departments (e.g. Social Sciences, Economics and Business, Humanities, Psychology, Biology, Mathematics), and in the Amsterdam Data Science research initiative ADS. Nationwide, we play a leading role in each of the national graduate schools: we provide the chairman for 3 of the 4 schools (IPA, SIKS, BioSB) and the scientific director of ASCI. Also, the department plays a leading role in COMMIT, where we lead 3 out of the 14 projects.

Internationally we collaborate in many EU projects including several coordination actions and networks of excellence such as AgentLink, AWARE, ENFIN, FOCAS, and SysSec. On the global level, we have special partnerships with several countries, such as Brazil, China, India, South Africa, and the United States. The department has also nurtured extensive collaboration with industry and applied research outside the university. Our project partners include Google, Microsoft, Amazon, Symantec, Philips, Rijksmuseum Amsterdam, Yahoo!, SAP, IBM, CISCO, INFOSYS, etc. In addition the department is involved in many local industries.

Our research culture is focused on collaboration and on quality above quantity. For instance, we have special instruments to foster joint projects of our staff, such as the “innovation PhD” scheme that supports a full PhD scholarship of high quality projects if proposed jointly by two different research groups within the department or by a CS research group and another faculty or university. To cultivate quality we encourage and facilitate researchers to apply for competitive personal grants (e.g. the national Veni/Vidi/Vici program) or in the EU (e.g. the ERC grants). To this end, we offer personal coaching tracks that help in various ways, such as feedback on the proposal text by experienced researchers and presentation training. In the reporting period we obtained five Vici/Veni grants, and two ERC grants. Finally, the department has funding to support large (European) project proposals. Such funding helps researchers in the preparation and consortium-forming phase.

“The Networked World” forms our overarching research theme. Our research culture is focused on (cross-disciplinary) collaborations and quality above quantity.

2.3 Resources and facilities

Our department maintains an advanced infrastructure essential for research, such as the INTERTAIN Home Lab that provides an environment for research which involves user-centered, distributed, interactive and intelligent multi-device applications. Furthermore, we coordinate shared national infrastructure such as the DAS-4 clusters and we make good use of facilities such as the ones provided by SURFnet and SURFsara. We also co-own and use the Tech labs VU & UvA consisting of the Intertain Lab (VU), the Game Cella’ Lab (VU), the Media Lab (VU), the RoboLab (UvA) and the UX/Gaming Lab (UvA).

2.3.1 Researchers

In 2014 the department consisted of 10 research groups with 214 research staff members (amounting to 40,5 research fte's)[6] collaborating on the following six themes: Artificial Intelligence, Bioinformatics, Knowledge, Web & Media, Computer Systems, Information Management & Software Engineering and Theoretical Computer Science. The department is directed by a management team of four members. At the time of writing the management team consists of Guus Schreiber (head of department), Wan Fokkink (educational portfolio), Frank van Harmelen (research portfolio) and Kris de Jong (department manager). An important instrument in our collective decision making is the monthly seniors' lunch attended by all full professors, associate professors, and the department manager. Junior staff meets also at a monthly lunch meeting, with the head of department present.

The total number of researchers was rather constant between 2009 and 2014 (Table D3a in Appendix 5.1). We have maintained a healthy ratio of 1 to 3 between tenured staff and project-based staff with limited contracts (50:164 as of December 2014), even though Direct Funding has decreased dramatically (Table D3c in Appendix 5.2). Unfortunately, the support staff shrunk by 22% which implies that our work load in secondary areas has increased.

2.3.2 Research funding

The most apparent trend is the decline of Direct Funding over the whole period, from 74 M€ in 2009 to 26 M€ in 2014 (Table D3c in Appendix 5.2). In the same period, the externally acquired funding increased from 8.3 M€ to 48.7 M€ (Table D3c in Appendix 5.2). This increase by a factor six has been achieved by a constant number of tenured staff (Table D3a in Appendix 5.1). This indicates our steadily increasing earning capacity. Comparing the ratio of Research Grants to Contract Grants we can see a shift from a ratio of 3.3 in 2009 to 1.2 in 2014. This shows that the role of funding from business and industry has increased. In 2014 the Direct Funding, Research Grants, and Contract Grants amounted to one third of the Total Funding (35%-35%-30%). This is a dramatic change from the 90%-8%-2% distribution in 2009. The Other Costs (representation, travel expenses, equipment, office costs) decreased significantly, from € 2.9 M to € 1.1 M.

We faced a dramatic decline in facilities and support between 2009 and 2014. Other Costs fell to less than half of the level in 2009, support staff shrunk by one fifth. Nevertheless, the externally acquired funding increased by a factor six, while the number of staff remained constant.

In the section "Marks of recognition from peers" we list three major externally funded research projects. In order to facilitate research activities we have invested in our basic infrastructure. In 2013 we have invested in extra storage for our research data to compensate for the limited capacity offered by the university.

Regarding the future we expect that external funding will remain the financial basis of a significant part of our staff. Given our performance in the past, we have every reason to expect that we can maintain this in the long term.

[6] Cf. the table "Research staff composition" in Section 5.1, Appendix 5. The total FTE there includes student assistants (46.4) that are not counted here (40.5).

2.4 Research quality

In line with our aforementioned priority "quality above quantity" we chose to mention only the real top achievements in this overview. We present performance indicators of research quality grouped around (i) products for peers, (ii) usage by peers, and (iii) marks of recognition by peers. The detailed data are listed in table D1 in Appendix 5.3. In this section we only emphasize a few specific indicators from each group (i.e., products, usage, and marks of recognition) and we reflect on the earning capacity as a whole.

Research products for peers

Our top 15 consists of 12 journal papers and 3 conference papers (all 3 winners of Best Paper Awards), exhibited in Appendix 5.6. This paper selections reflects the span of research within the department. A selection of the top 3, by the reputation of the journal and the ranking of the paper in the given journal, is given below in chronological order:

- K. Dentler, R. Cornet, A. ten Teije, N De Keizer, Comparison of reasoners for large ontologies in the OWL 2 EL profile, **Semantic Web Journal** 2 (2), 71-87, 2011 (paper is no. 8 most cited of the journal)
- G. Urdaneta, G. Pierre, M. van Steen, A survey of DHT security techniques, **ACM Computing Surveys** (CSUR) 43 (2), 8, 2011
- E. Haasdijk, N. Bredeche, and A. E. Eiben, Combining Environment-Driven Adaptation and Task-Driven Optimisation in Evolutionary Robotics, **PLOS One**, 9(6): e98466, doi:10.1371/journal.pone.0098466, 2014

In terms of scientific output, the yearly number of publications hovers around 320 (300-351) with an average of 16 PhD theses per year, 85 refereed journal articles, 192 conference articles. Table D3b in Appendix 5.3 shows the exact numbers. As a department we are aiming a high quality publications, even if this implies fewer papers.

Our top 3 generic software products are IBIS (distributed programming software), MINIX (operating system), and SWI Prolog (programming language). In the category software tools, our most important products are Argos (a whole-system taint analysis solution), OpenPHACTS (a semantic data integration platform for drug discovery,) and Praline (a multiple sequence alignment tool).

Use of research products by peers

For the citation analysis based on H-indices we refer to the table in Appendix 5.4 and the benchmark analysis in Section 3.3.1. The most important indicators of the uses of our research products are the download and usage figures of our software and hardware tools. Regarding hardware, our staff coordinated the development of the Distributed ASCI Supercomputer (DAS) that has been used for over a 100 PhD theses and numerous papers and awards over the past 18 years. During 2009-2014, it has been used for over 40 PhD theses nationwide. The three most popular software products for our department are MINIX, OpenPHACTS, and SWI Prolog. MINIX 3.3.0 has been ported to the BeagleBone boards, which are popular open source computers costing $ 45 and are widely used in many applications. There have been over 3 million hits to the MINIX 3 Website and over 600,000 downloads of the software in all. SWI Prolog is the leading open-source Prolog implementation. It is downloaded around 150,000 times per year from its main web site, is part of Linux distributions and appears on Windows and MacOS software download sites. The OpenPHACTS Discovery Platform has received over 147 million API hits from 500 organisations between March 2013 and December 2014, with roughly 25% academic users and 75% commercial users (such as GSK, AstraZeneca, Entagen and Johnson & Johnson). Two other software tools with substantial impact are the Praline multiple sequence alignment software (used 100,000 times) and the JavaGAT component from the IBIS distributed programming software (60,000 downloads).

Marks of recognition from peers

Full details can be found in Appendix 5.3. Here we highlight only the categories (i) science awards and prizes, (ii) grants, (iii) journal editorial boards, (iv) number of invited keynote lectures, and (v) marks of recognition for long term achievements.

In the reporting period members of our department have won 49 awards on conferences for best papers and prizes in challenges. We chose not to count awards for best posters, nor nominations or honorable mentions, and only report major prizes and awards. The International Semantic Web Conference proves to be a special forum, with VU researchers winning a prize at every conference since 2006. We are also proud of the five awards for the best PhD Thesis. Particularly noteworthy is that the award for the best PhD thesis in Computer Systems in Europe went to our PhDs in 2010, 2011, and 2013. No other Department has won this prize more than once.

In the reporting period our staff has won two ERC grants and five personal grants from NWO (Veni and Vici). Our ability to attract research grants has been discussed in detail in Section 3.2 from the perspective of earning capacity. For this section regarding marks of recognition, we want to highlight the international EU projects where our staff was or is the coordinator :

- Contrail, EU FP7, 2010-2014 (Kielmann)
- EvoBody, EU FP7, 2010-2011 (Eiben)
- NoTube, EU FP7, 2009-2012 (Schreiber)
- ICT4Depression, EU FP7, 2010-2013 (Treur)

The top 3 research grants according to the amount of money budgeted for our department are:

- Contrail, EU FP7, 2010-2014, € 1.430.666
- Data2Semantics, COMMIT P23, 2010-2016, € 931.550
- NoTube, EU FP7, 2009-2012, € 879.835

The international recognition of our staff is also reflected in the membership of the editorial boards of 50 high quality journals (we chose not to count guest editorships in the overview) and in the number of invited keynote lectures given by our staff, which totals 53 keynotes at major events over the reporting period. Keynotes at small events have not been included in this figure (for details see Appendix 5.3).

Last, but not least, we will mention the marks of recognition for long term achievements. Prof. Bal, Prof. Klop, Prof. Van Harmelen are members of the Academia Europaea (limited to the top 5% of researchers in each discipline), profs. Klop and Tanenbaum are members of the Royal Netherlands Academy of Sciences (KNAW), and Van Harmelen is member of the Royal Holland Society of Sciences and Humanities (KHMW). Furthermore, Prof. Bal received the Euro-Par 2014 Achievement Award, Prof. Van Harmelen received the International Semantic Web 10-year impact award in 2012, Prof. Van Steen received the 10-years best paper award from the Middleware 2014 conference, Prof. Tanenbaum received an honorary doctorate from the Petru Maior University, Romania in 2011, and Prof. Teusink received the Midterm Career Award from the LAB Industrial Platform in 2014. In addition, our staff has prestigious positions as visiting professors at foreign universities: Prof. Van Harmelen at Wuhan University of Science and Technology (China), Prof. Eiben at the University of York (UK), profs. Bos and Heringa at Amrita University (ranked nr 5 in India), and Prof. Huang at Wuhan University (ranked nr 3 in China) and 5 other Chinese universities.

2.5 Relevance to society

Performance indicators of relevance to society are divided as follows: (i) products for societal groups, (ii) usage by societal groups and (iii) marks of recognition by societal groups. The detailed data are shown in the tables in Appendix 5.3.

Research products for societal target groups

Our key products here are contributions to national TV and radio, national newspapers and magazines, specialist periodicals (e.g. Automatiseringsgids), video clips for the Internet (Vimeo, You Tube), and talks for the general public.

Our staff has featured in national media on many occasions. For instance, Frank van Harmelen was the presenter in a half hour programme on Dutch TV exploring the future developments of Computing (VPRO Labyrint). We have been consulted for several TV and radio programmes such as VARA Kassa (consumer information), Het Klokhuis (aimed at grade school children), NOS journaal, RTL Nieuws, Radio 1, Business

News Radio, KRO Radio, TROS Nieuwsshow. Vrij Nederland, NRC, NRC Next, Volkskrant, Financieel Dagblad, Automatiseringsgids, Computer Idee, De Groene Amsterdammer, HP/De Tijd.

We attempt to approach the general public also through the social media. On Twitter we have a few "champions" who have 1500 to 2500 followers, which places them in the top 2-3% of Twitter users[7] and who are 95-98th percentile for re-tweet rank (indicator for Twitter influence)[8]. We are active on Slideshare: some of our presentations have more than 5,000 views (max. 19,000), and 70 of our presentations have more than 1,000 views.

Among the demos for general audience was a demo at the COBRA museum aimed at automatically tracking visitor experiences involving a few hundred people. A special presentation for the general public was the TEDx talk[9] of Prof. Eiben about Evolutionary Robotics.

We have also made important contributions to standards and patents with industrial relevance. Examples are the W3C standards OWL2 (ontology language for the Semantic Web), PROV (standard for the interchange of provenance information), RDF1.1 (Resource Description Framework), and SKOS (Simple Knowledge Organisation Systems). Members of our department were co-chairs of the working groups of the standards PROV (Groth), RDF1.1 (Schreiber). and SKOS (Schreiber). All those standards have a worldwide impact through the World Wide Web Consortium (W3C).

Use of research products by societal groups

Dr. Aroyo is one the inventors behind the European patent nr. EP 2277275 A2 for a system and method for providing an electronic program guide. We have one spin-off company from our research, 2CoolMonkeys BV Utrecht (CEO Dr. van Aart).

Our advisory role towards society is diverse. Our department is for instance involved in the Korea-China Amsterdam municipality collaboration and in the Amsterdam Economic Board (ICT core group). Members of the Department were amongst others advisors to the Council of State ("Raad van State") and advising Philips Research.

Marks of recognition by societal groups

Major remarks of recognition by society for our department are the International Press Institute "News Innovation Contest Prize" for our tool for citizen journalism from remote rural regions in Africa, and the COMMIT Valorization Award for the Data2Semantics COMMIT project. We pride ourselves on three appointments partly paid by other organisations: agro-KM, IBM, CWI and recently Google.

[7] http://radar.oreilly.com/2013/12/tweets-loud-and-quiet.html

[8] http://www.retweetrank.com/FrankvanHarmele, http://www.retweetrank.com/Pgroth, http://www.retweetrank.com/LAroyo

[9] http://tedxtalks.ted.com/video/TEDxDanubia-2011-goston-Eiben-T

3 Informatics Institute UvA and Computer Science Department VUA

3.1 PhD programmes

Supervision of junior researchers and quality control

In both departments PhD students are typically supervised on a weekly basis through direct interaction with their senior supervisors. In addition, all groups at UvA and VUA have regular group meetings and seminars (varying from weekly to monthly) to foster scientific debate. This is further enhanced by the many collaborative projects with their own technical and research meetings. For example, quarterly meetings are held with regard to our EU projects in which scientific and technical content is discussed in a focused workshop-like fashion, with all junior and senior researchers from the relevant research partners involved.

The UvA has mandatory evaluation moments at 9 months, 18 months, 24 months and 36 months for the duration of the PhD. These moments are used by the student and the supervisors to track progress and plan future research. The IvI has also recently introduced an institute-wide evaluation at the end of the first year, where all students present their initial progress to a committee of staff members. This common evaluation moment provides an independent view on the progress of all the students, allows feedback to the (co-)supervisors of possible problems and provides a clear view of the individual progress in light of the comparison to peers. VU-CS currently has annual evaluation moments, with a go/no-go decision after year 1, but intends to follow the UvA model in the near future, giving a unified quality control mechanism across the two institutes.

For PhD students the research schools SIKS, ASCII, IPA and recently BioSB form a nation-wide platform for advanced education, scientific exchange, as well as for research quality control. The procedures for safeguarding PhD education are documented in the schools' self-assessment reports in national evaluation procedures under the SEP protocol. The national research schools run summer/winter schools and master classes for in-depth training about specific research topics. Also, the research schools offer regular courses for students to broaden their knowledge. By following these courses the students can achieve the 30 ECTs required as educational component for their graduation. Finally, the research schools offer popular (lightly peer-reviewed) conferences and doctoral consortia that give Ph.D. students an opportunity to practice writing papers and presenting their research plans and results, for example during conferences such as ICT Open. IvI and VU-CS play an active role in these research schools: the chairs of IPA and SIKS as well as the scientific director of ASCII are from Amsterdam.

Both universities offer additional courses for PhD students. Some of these target the initial stages of the PhD program, e.g. courses on presenting and scientific writing in English. Other courses such as "Career training" and "Writing grant applications" offer extra support the PhDs in their final year in their search for jobs within and outside academia. Recently, a course on startups has been added to the course portfolio.

PhD students are also involved in educational tasks, primarily in assisting and supporting the practical part of bachelor and master courses, as well as in incidentally providing lectures on their topic of expertise. PhD students may also co-supervise bachelor and master students during their graduation project. Noteworthy is that we are moving towards a model where involvement of PhD students in the education programs will not be left to the decision of the supervisors and the explicit interest of the student, but is made mandatory. This change will provide a better financial model for education, and will give all PhD students the benefit of learning how to teach.

Length and success rates of PhD programme

The length and success rate of the PhD programmes of IvI can be found in Appendix 4.5 (SEP table D3d). IvI's goal is to have two PhD theses each year in each group, with a total number of at least 15 for the institute as a whole. 54% of enrolled students obtain their degree within five years; this is considered by the faculty as an 'on time graduation'. IvI wants to increase the number of students finishing in time, without sacrificing research quality. This policy is aligned with the VUA's policy meaning that financing extensions stop after four years: this measure intends to stimulate both students and supervisors to try to maintain a proper graduation pace. The number of PhD students abandoning their position has been stable around ~20%. This number is high and IvI is working to further improve the selection procedures to reduce this.

The length and success rate of the PhD programmes of CS-VU can be found in Appendix 5.5 (SEP table D3d). VU-CS has a rather constant number of starters over the whole period (on average 20 per year), with an exception in 2010 which was lower (13), but compensated in 2011 (26). The large PhD influx in 2011 is due to the start of the COMMIT project, which involved a considerable number of PhD students. Our PhD. population has on average a 23% female participation (range 16%-31%). Only few PhD students finish in four years (on average 9%), in general it takes 4-6 years for them to graduate. The table might suggest that the percentage of discontinued PhD's is rather high (11%). This is however due to the fact that some senior staff moved to other universities, 6 PhD students consequently moved together with their supervisor and continued their work at the new location. If we do not take PhD students into account who left because they went with their supervisor to a new affiliation, we have a success rate of 92% (103 out of 111).

3.2 Research integrity

Integrity and ethics

With data becoming increasingly pervasive in society, more and more research projects within Computer Science deal with potential privacy related issues. In security research, too, we notice that a number of projects deal with ethical issues. IvI and CS have therefore established an ethical committee (ECIS) to assess project proposals which might raise ethical questions, covering both proposals for external funding as well as bachelor and master projects. The committee is composed of senior IvI and VU researchers as well as a representative of the UvA legal office. A handbook has been created with procedures and guidelines for project proposals. The guidelines have been designed on the basis of experience of all committee members as well as by contacting ethical committees within the UvA, operating in different disciplines. The guidelines make a distinction between standard research (without ethical issues or with known issues for which standard procedures apply) and non-standard research. Non-standard research is reviewed by two members of ECIS and if needed by the legal office representative. The aim of ECIS is to learn from experience and establish an exhaustive list of standard procedures. ECIS gives advice to the director of the institute who is responsible for taking the final decision concerning the project. If the director accepts the risk, the institute, rather than the researchers is liable for any ethical consequences the project may have. Submission of project proposals to ECIS is not mandatory for researchers, but as the institute is taking responsibility they are strongly encouraged to do so.

Three members of IvI and CS (Profs Bergstra, Klop, Van Harmelen) are members of a committee of the Dutch Academy of Sciences which will write recommendations on how the Computer Science field should handle the increasingly urgent ethical dimension of Computer Science research. Local experiences with ECIS constitute an important input into these national recommendations.

VU CS also complies with the VU-VUMC Academic integrity complaints regulation (July 2014). [10]

Supervision of PhD candidates

Scientific integrity deserves special attention in the PhD supervision. All VUA PhD students are since April 2015 required to complete a course on "methodology and integrity".

Data management

[10] VU-VUmc Academic Integrity Complaints Regulations July 2014

The Research Data Management (RDM) topic has received considerable attention at all University levels. At both VUA and UvA a university-wide task force has been chartered with implementing a policy and setting up an infrastructure for the handling of digital data in its entire lifecycle, aiming at a joint (or at least same) infrastructure for both universities, with a commitment to store all research data for a period of at least 10 years for datasets up to 128Tb. Some data repositories are handled by worldwide collaborations, others are well suited for the expected University-wide implementation of RDM. IvI has temporarily appointed Prof. de Laat to chair a team of technical assistants which will implement and support RDM procedures in different research groups at the institute in close cooperation with the faculty data steward.

3.3 Viability: benchmark and SWOT analysis

3.3.1 Benchmark

Benchmarking target

The goal of this benchmark is to investigate how well the combined Amsterdam research power in Computer Science compares to a world leading institution in both volume and quality. To this end we have performed a benchmarking exercise of the joint VU-UvA Departments against the Edinburgh School of Informatics. In the 2001 UK Research Assessment Exercise, Edinburgh was the only department that received the highest 5*A ranking. In the 2008 edition it ranked first in volume and tied as nationally as second on quality, and in the recent UK Research Excellence Framework (REF) 2014, it has been rated as producing more world-leading and internationally excellent research (4* and 3*) than any other university in the UK[11]. This makes the Edinburgh School of Informatics one of the leading institutions in Computer Science research in Europe and the world, making it an ambitious benchmarking target. We will compare the performance on a number of the key indicators from the SEP protocol.

Approach

From the data on the REF2014 website[12], we obtained the following data on the Edinburgh School of Informatics: headcount of permanent staff and division of staff over research groups[13], acquisition of research funding including division across national and European sources[14], and number of PhD degrees awarded[3]. From the list of names provided at the REF2014 site we were able to manually obtain Google Scholar citation profiles for 69 members of the Edinburgh staff (two thirds). Enquiry with the Edinburgh Head of School confirmed that the research effort of Edinburgh tenured staff is around 40% of their working time, making the situation comparable to Amsterdam. These data allow for a well-founded quantitative comparison between Amsterdam Computer Science and the Edinburgh School of Informatics.

Results on key SEP indicators

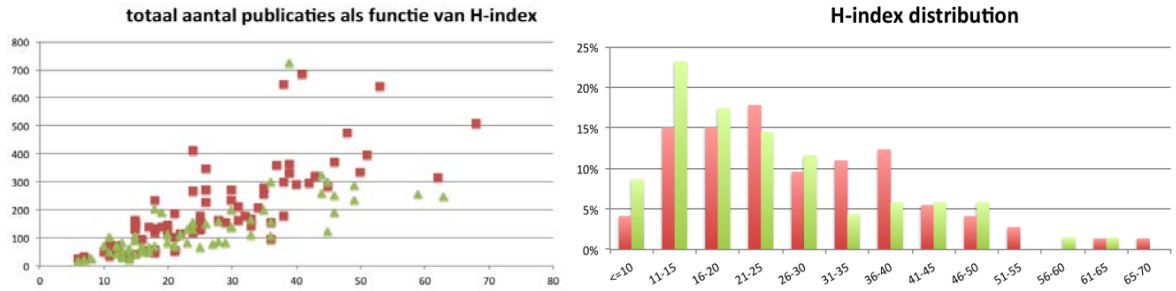
The table below (using 2013 as the most recently available benchmark year) shows that regarding size, Amsterdam is in the same bracket as Edinburgh. Amsterdam is somewhat smaller (73 vs 104 FTE), and when normalised for the number of staff, the key indicators show a comparable performance: the number of awarded PhD degrees per staff is roughly equal, and the overall funding acquisition per staff member in Amsterdam is within 15% of the Edinburgh performance. The acquisition of national funding (from NWO) is lower in Amsterdam (roughly half) than in Edinburg (EPSRC), but on EU funding, Amsterdam outperforms Edinburgh by 45% per capita. This reflects the much richer national funding landscape in the UK compared to The Netherlands.

[11] http://www.ed.ac.uk/informatics/about/research-excellence
[12] http://www.ref.ac.uk/
[13] http://results.ref.ac.uk/Submissions/StaffList/961
[14] http://results.ref.ac.uk/Submissions/Environment/961

Indicator	Amsterdam 2013	Edinburgh 2013
Scientific staff	73[15]	104
Research grants (National, European)	€ 7,0 M	€11,6 M
Research grants (National)	€ 2,2 M	€ 7,0 M
Research grants (European)	€ 4,8 M	€ 4,6 M
Research grants per staff	€ 95,6 k	€ 112 k
Research grants (National) per staff	€ 29,6 k	€ 67 k
Research grants (European) per staff	€ 66,0 k	€ 44,8 k
PhD's	27	36,9
PhD's per staff	0,36	0,35

Results on bibliometric indicators

The scatter plot below shows per tenured staff member the H-index against the number of publications. The ideal quadrant of this figure is bottom-right (small number of publications with high impact), and conversely the top-left quadrant is least desirable (many publications with little impact). Young researchers are typically in the bottom-left quadrant. The scatter plot shows a strong similarity in the distributions of Amsterdam and Edinburgh, with Amsterdam scientists publishing somewhat more papers for attaining the same impact, and Amsterdam having a higher share of its staff members in the very high impact category (H>50): 6.8% (5/73) in Amsterdam versus 2.8% (2/69) in Edinburgh.



Red Squares = Amsterdam, Green Triangles = Edinburgh

The bar chart shows which percentage of staff has an H-index in a particular bracket. Interestingly, this plot shows that the Edinburgh staff distribution over impact peaks sharply around the relatively low H=11-15 bracket, with a long tail towards the higher impact brackets. In contrast, the impact distribution of Amsterdam staff peaks around the higher H=21-25 bracket, and levels off much more gently towards the higher impact brackets (H=36-40). H-indexes are notoriously dependent on the age of the researcher. When we compensated for the academic age of our researchers, our young researchers turned out to have on average even a somewhat higher age-normalised H-index than the senior researchers with a high absolute H-index. This shows that besides high scoring senior researchers, we also have ample strong young talent.

The comparison of all these indicators (grant acquisition per staff member, PhD degree per staff member, publication volume and impact, both per staff member and across the population) shows that the combined research power in Amsterdam compares well (and sometimes even favourably) to the world-class performance of the Edinburgh School of Informatics.

[15] Counting only permanent staff and tenure track positions, for proper comparison with the UK Research Excellence Framework.

Benchmark by an independent external party

In March 2015, the Urban Innovation Network in collaboration with Elsevier Science published an independent study of the research and innovation potential of the Amsterdam region[16], benchmarked against 10 other European Cities: Barcelona, Berlin, Brussels, Copenhagen, Dublin, Hamburg, Madrid, Manchester, Stockholm and Vienna. The report identified Computer Science as a particularly strong discipline in Amsterdam. We quote from p.23 of this report[17]:

> *"Amsterdam's output in computer science nearly doubled over the past decade, from fewer than 400 articles in 2004 to over 800 in 2013. This growth rate of 9% per year easily surpassed the growth rate of Amsterdam's overall output (6.15%). In terms of publications per capita, Amsterdam's output in computer science is second among the eleven European cities. Moreover, at 85% above the world average, the relative citation impact of Amsterdam's research in computer science is higher than that of the ten other European cities."*
>
> *Usage of Amsterdam's research in computer science has also increased, in relative as well as absolute terms in recent years. Amsterdam's research in computer science from 2004 was downloaded on average 15% less than the world average, but its 2013 research has been downloaded on average 9% more than the world average. Moreover, the proportion of Amsterdam's research in computer science that is in the top decile worldwide in terms of citation count has increased from 14.5% to over 20%."*

Table 2.2 of the report shows that among the 11 benchmark cities, Amsterdam computer science ranked first on both field-weighted citation impact and the ratio of publications in the top 10% worldwide.

Our own benchmark against a world-leading institution as well as an independent comparison with 10 cities shows that the combined Computer Science research effort in Amsterdam is of internationally leading quality.

3.3.2 SWOT-analysis

Strengths

1. Both IvI and VU-CS have a strong research output of very high quality, with high peaks (witness the high citation impact scores of our top researchers), but also across the board (as shown by the high average citation impact score of the department as a whole in the citation benchmark study).
2. The leading staff of both IvI and VU-CS form a good mix of experienced leaders and young talent.
3. Both IvI and VU-CS attract significant external funding which results in many Ph.D. theses and a healthy financial position and investment capability.
4. IvI and VU-CS have shown a very good performance in core computer-science areas: adaptive systems, computational science, computer vision, information retrieval, knowledge representation and reasoning, machine learning, security, social computing and system and network engineering.
5. VU-CS has a VU-shared research vision centered on The Connected World, one of the three distinctive themes of VUA. This is operationalized in collaborative projects and shared research infrastructure by the Network Institute.

[16] http://www.elsevier.com/research-intelligence/research-initiatives/amsterdam-report
[17] All analyses in the report are based on publication data from Scopus, 2004-2013.

6. IvI has a significant track record in economic valorisation: systematic cooperation with industry, evolution of startups, entry in the international educational market.
7. IvI and VU-CS both have a significant track record in societal valorisation: open standards, software downloads, applications in culture, health care, security, and societal services.

Weaknesses

1. The ratio of male/female in the permanent staff is around 4:1, which we consider to be too low. Both IvI and VU-CS are actively working on strategies including scouting to get to a 3:1 ratio by 2020.
2. A number of senior figures have recently retired (e.g. Andy Tanenbaum), moved elsewhere (e.g. Maarten van Steen), or will retire in the next few years (e.g. Arnold Smeulders). Some of these positions have already been filled (e.g. by Herbert Bos), for others a joint strategy on replacement will have to be developed.
3. For both IvI and VU-CS it holds that there has not been a concerted and unified effort toward external parties in the region and nationally. Contacts and initiatives have in many cases been carried individually, resulting in a lack of focus.
4. IvI is not sufficiently embedded in the UvA corporate policies, for example in the area of big data and data science.
5. Sharp budget cuts within the VU as a whole on support personnel combined with the extremely poor quality of the e-services replacing these personnel have led to an significant increase in administrative workload for the VU-CS academic staff. This matter has required constant attention by the department management over the past two years.
6. The daily working environment of the VU-CS staff in terms of building and housing is below standard. The good news is that a new building is now under construction, which should be ready early 2018.

Opportunities

1. The formation of a joint UvA-VU Department of Informatics, which is planned to be effective by 2018-2019, provides ample opportunities in research and in joint research master programs because of the complementary character of IvI and VU-CS. See also the section on future strategy.
2. Good opportunities exist to expand interdisciplinary collaborations. The VU Network Institute is one instrument to capitalize on this. As the VU has adopted the Networked World as one of the core themes, VU-CS finds itself in an attractive and central position within the university as a whole. VU-CS is actively working on cooperation between the Network Institute and the UvA Centre for Creation, Content and Technology (CCCT), and Amsterdam Data Science.
3. Given the emergence of the Internet of things, wearables and the instrumentation of Smart Cities and the proven strengths of Amsterdam CS in these areas, additional funding opportunities are emerging that strengthen the our research power. This includes direct support from industry (Ahold, KPMG, Elsevier, Amsterdam city, Huawei) and funding from international bodies (the China Scholarship Council, the Russian Science Foundation and the Singapore National Research Foundation).
4. The cross-cutting nature of the ICT Roadmap in the top sectors arena provides ample opportunity for future funding for IvI and VU-CS.
5. Individual members of both IvI and VU-CS play a leading role in setting the national and international research agenda of their fields. Sometimes literally (for instance, by writing the National Cyber Security Research Agenda that was adopted by the Cyber Security Council and several Ministries) but also by serving as scientific directors of national research schools, or as members of the board of the Dutch ICT Innovation Platform (IIP), or chairs of large-scale collaborative networks or of working groups at standards bodies, etc.

Threats

1. The formation of a joint UvA-VU Department of Informatics brings also threats due to differences between the UvA and VU — for instance, with respect to the financial administration and situation, the difference in organizational structure (both in research and in education) and the culture of the two universities. Also, the formation process itself requires staff time and energy and thus drains resources away from research and education.
2. Both at IvI and VU-CS we foresee a continuing downward pressure on our direct (1GS) funding, as a result of changing financial models plus the fact that in the Netherlands science is not given a high priority in government funding.
3. There is currently a concrete risk that financial difficulties of the UvA as a whole will have an impact on IvI, for example in case the institute would be required to pay higher overhead costs or higher prices per office space.
4. Due to the lack of a long-term career perspectives and non-competitive salaries, many of the most talented postdocs and junior assistant professor candidates tend to leave academia for industry.
5. Both for IvI and VU-CS it holds that the current university rules require long term financial coverage when hiring, making it difficult to hire permanent staff, even if many projects are being acquired.
6. A 2013 report[18] from Informatics Europe shows that Dutch salaries of postocs and tenured staff is much lower than those in neighbouring countries such as the UK or Germany. We have missed out on excellent candidates in the recent past for this very reason.

3.3.3 Reference to previous assessments

UVA Informatics Institute

Previous research assessments provided a number of useful recommendations for our Institute, particularly the emphasis on broad engagement in the forming of the tight collaboration with the VU-CS. We are working on intense integration of our Institute and the Computer Science department at the VU.

Since 2012 IvI is applying recruitment policies at the Institute level. A tenure track system has been introduced to hire new staff, evaluated on predefined performance criteria. New staff positions are recruited at the level of the Institute rather than at the group level where the opportunity arose. We believe this to be the best human resource model for this era.

The number of professors in IvI has increased. De Laat, Gevers and Afsarmanesh became full professors and Welling has succeeded Groen. We have hired junior female staff (Grosso and Varbanescu). At the same time, strong group separation has been replaced by a jointly defined Institute-wide research strategy consisting of thematic clusters at a level above groups. The most prominent of these being data science combining the work of five groups, and system engineering, combining the work of two. Within these themes, people thrive by ad-hoc cooperation to solve externally posed inspirations. We believe this model to be the best response to the trend to larger programs in funding, as well as task-focusing suiting the intense collaboration with the VU.

What was a problem in 2009, to broaden the participation in decision making and increase awareness of the institute's challenges and directions, is no longer there: IvI has since long introduced an extended Management Team, which meets bi-weekly. This has notably reduced the perceived distance within the Institutes. In addition, IvI introduced a Staff Council and PhD student Council.

Changes in funding models within the UvA have actually made the Institute stronger. NWO, STW and EU projects, as well as COMMIT, are currently financially more rewarding. The remarkable budget cuts of 2010 have threatened IvI's operations. The Institute has been able to cope thanks to an increasing student numbers and increasing external funding, a very positive trend indeed, but we do not see the near absence of a so-called "vaste voet" as a long-term viable situation.

[18] http://www.informatics-europe.org/images/documents/informatics-education-europe-data-2008-2013.pdf

The Institute puts an emphasis on fundamental contributions in Artificial Intelligence and Computer Science alike. Applications generally serve as an illustration to deeper computational or methodological aspects, which we seek to uncover.

VUA Computer Science

We have made progress in line with several recommendations of the previous research assessment in 2008. In an effort to identify external collaborative research opportunities we heavily invested in the collaboration with the University of Amsterdam, as regards research as well as bachelor and master programs. This joint self-assessment document is a sign of the advanced state of our collaboration.

To professionalize the organisation across the board and improve the quality of education our staff massively followed the Basic Qualification Education (BKO) programme. PhD student supervisors are encouraged to attend the course "Supervising Ph.D. students". From 2013-14 on we offer the Computer Science Bachelor Program completely in English. To expand and keep the number of senior staff in balance, we encourage (as well as facilitate) assistant/associate professors to set up their own independent research lines, resulting in some becoming full professors (e.g. Bos and Lago). We also have an improving gender balance. In 2014, the department had around 20% female scientific staff (three female associate professors, seven female assistant professors, nine female postdocs). The percentage of female PhD students is roughly 30%. In order to improve recruitment and selection practices, we stopped working with a purely chair-centric approach. We identified two rather broad research topics to pursue, data science and socio-technical systems, and recruited through a "wide-angle lens". A specific M.O. in this direction is appointing a department-wide advisory commission for each new tenure-track and other strategic positions. The previous average of about 10 PhD students per year increased significantly to an average of 16 (see table "Research quality: Research products for peers" in Appendix 5.3).

The one dimension where we could not improve as advised is the administrative and technical support staff. In fact, the situation has worsened, because the support staff (inclusive IT support) is shrinking due to university-wide budget cuts. In the SWOT analysis (section 8.2) this is identified as a clear danger.

The last issue to mention is the mismatch between the idea of the committee concerning the computer science field and the idea of our department. The committee mentioned that core CS is very important and that the VUA is too focused on the multidisciplinary character of computer science, while neglecting the importance of core CS. The department recognizes the importance of the core CS component, but clearly sees the need and the value of integrating part of this research in applied topics including its role in the Network Institute; we find this has also helped us improve our gender balance. At the same time the core CS sections are quite successful in publishing their research in top venues in their field.

3.3.4 Future strategy

In recent years the two Informatics departments in Amsterdam have intensified their collaboration. In the educational sphere we have established joint Master programs in Computer Science, Computational Science, Artificial Intelligence and Information Science/Studies. There are a large number of research projects in which both institutes jointly participate. We have set up the Amsterdam Data Science center19, together with CWI and the Amsterdam University of Applied Sciences. The boards of the two universities are actively supporting this collaboration; recently 3M€ funding from the Amsterdam Academic Alliance was allocated to a Data Science program in which the two Computer Science institutes have the lead. The collaboration profits from

[19] http://amsterdamdatascience.nl/

the fact that staff appointments at both institutes have for years been mainly in complementary field of expertise.

These developments have led to concrete process to form a joint UvA-VU Department of Informatics[20], with support from the respective faculty and university boards. The new department will be housed at the South Campus (the current VU campus) in the New University building (see appendix 7). This building is now under construction and will be available early 2018 [21].

The mission of the UvA-VU Department of Informatics is to be a premier league research center with a high world-wide visibility. The benchmark comparison with Edinburgh and the independent external benchmark by Elsevier indicates that this is a realistic target. The objectives of the joint department build on the strengths of the constituting groups:

- *Research quality*. Indicators: high-impact publications, prizes, awards, individual national and international grants, keynote presentations.
- *Grant acquisition*. Indicators: high level of external research grants; reputation as reliable and productive project partner
- *Economic valorization*. Indicators: spin-off companies, player in the Amsterdam economic region, strategic partnerships with key companies
- *Societal valorization*. Indicators: software downloads, contributions to open standards, strategic partnerships with key non-profit organizations
- *Educational quality*. Indicators: national and international training center for computer science professionals, PhD program collaborations with international parties.
- *Diversity*. Indicators: cultural and gender diversity of staff (at all levels) and of students (bachelor, master, PhD).

The mission of the UvA-VU Department of Informatics is to be a premier league research center with a high world-wide visibility.

Our strategy for realizing these objectives with the new joint department is based on the following cornerstones:

- The department will have a flat structure, consisting of a limited number of research clusters of 30-40 researchers each[22]. Tentatively, we have identified six clusters: computer systems, socio-technical systems, automated learning systems, foundations of informatics, intelligent systems, and computational science. Clusters will have a physical presence in the office space.
- The department will have light-weight mechanisms for creating virtual organization overlays, in which people of different clusters work together, typically also with external parties. Such virtual organizations will get modest seed funds as incentives for new activities and collaborations. The Network Institute and the Amsterdam Data Science Centre are already examples of such virtual organizations.
- The senior staff of the two departments has identified three primary research foci, which we view as key for our external profile:
    1. **Data & Decisions**. This focus builds on the combined excellence of the researchers in data science, computational science, machine learning and intelligent systems.

[20] See for example http://wiki.cs.vu.nl/department/PvE_18_March_2015
[21] https://www.youtube.com/watch?v=WUyTsqxCuww
[22] 40 is a well-known upper limit for social interaction within a group

2. **Performance & Security**. This focus builds on our excellence in parallel and distributed networked systems as well as security.
3. **Socio-Technical Systems**. This focus builds on our excellence in Web intelligence, socially-aware computing, and business informatics.

These foci identify target areas for grant acquisition, external visibility and valorization. The foci are deliberately not linked to clusters, since research on these foci will typically require contributions from multiple disciplines within and outside the department.

- The department will have facilities for start-ups such as training programs for PhD students, support for business plans and possibilities for office space.
- The department will have career development support in place for each phase of the academic career, from Master student to full professor. This support is institutional, so goes well beyond the standard support by direct supervisors. Help with acquiring personal research grants is an integral component of this.

The fulfillment of the mission also requires a professional administrative and financial infrastructure. This part has been identified as a potential weakness in the SWOT analysis. We are actively working on this in the current department-formation phase (for details see the Program of Requirements [23]).

[23] http://wiki.cs.vu.nl/department/images/7/72/PvE_IS_versie_1.2.def.pdf (in Dutch)

4 Appendix Informatics Institute UvA

4.1 Appendix 1 Research staff composition

The following table reports on the staff of the IvI. We provide the headcount for PhD students and visiting fellows. We provide additionally the amount of FTE for the research staff, following the conversion of 40% for all tenured and tenure-track personnel and 90% of the post-docs.
An online version of this table can be found at "Research staff composition"

	2009		2010		2011		2012		2013		2014	
	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE
Scientific staff	38	12,5	37	12,0	37	11,9	35	11,1	36	11,2	36	11,2
Post-docs	33	27,9	26	24,9	26	20,3	33	20,4	34	26,4	26	23,9
PhD students	87	------	80	------	89	------	84	------	88	------	90	------
Total research staff	**158**	**40,4**	**143**	**36,9**	**152**	**32,2**	**152**	**31,5**	**158**	**37,6**	**152**	**35,1**
Support staff	50	29,1	40	28,0	37	33,5	30	27,6	30	24,4	26	20,6
Visiting fellows	35	------	33	------	33	------	27	------	52	------	48	------
Total staff	**243**	**69,5**	**216**	**64,9**	**222**	**65,7**	**209**	**59,1**	**240**	**62,0**	**226**	**55,7**

4.2 Appendix 2 Funding

An online version of this table can be found at "Funding".

	2009		2010		2011		2012		2013		2014	
Funding:	FTE	%	FTE	%	FTE	%	FTE	%	FTE	%	FTE	%
Direct funding	46,8	26%	49,3	30%	32,3	21%	38,2	19%	41,8	23%	46,3	25%
Research grants:	75,2	42%	64,5	39%	70,2	45%	52,8	26%	41,8	23%	42,1	23%
- EU							15,6	8%	13,7	8%	19,4	11%
- NWO, STW, FOM							37,2	18%	28,1	15%	22,8	13%
Contract grants	38,1	21%	32,7	20%	34,6	22%	39,0	19%	37,8	21%	30,5	17%
Other	18,8	11%	20,0	12%	19,3	12%	18,9	9%	19,1	10%	21,2	12%
Total funding	178,9	100%	166,5	100%	156,4	100%	201,7	100%	182,3	100%	182,3	100%

Expenditure:	M€	%	M€	%	M€	%	M€	%	M€	%	M€	%
Personnel costs	10.008	66%	8.965	65%	8.209	63%	7.940	58%	7.721	57%	7.711	60%
Other Costs	5.149	34%	4.835	35%	4.735	37%	5.704	42%	5.814	43%	5.226	40%
Total expenditure	15.157	100%	13.800	100%	12.944	100%	13.644	100%	13.535	100%	12.937	100%

4.3 Appendix 3 Output indicators

Research quality: Research products for peers

An online version of this table can be found here. For the hardware and software products see the table "Use of research products by peers".
The raw data for this table can found in the Folder "Raw Data UvA".

	2009	2010	2011	2012	2013	2014
Refereed journals	85	79	96	67	83	88
Peer reviewed conference papers	160	181	166	171	160	185
Books	0	1	0	2	1	1
Book chapters	14	18	21	10	14	5
PhD theses	11	20	19	12	15	21
Software & hardware						
Total	**270**	**299**	**302**	**262**	**273**	**300**

Research quality: Use of research products by peers

An online version of this table can be found here.

Soft- & hardware, datasets, research facilities	**Usage**
MonetDB, an open source column-oriented database management system	**~10000 downloads/month** (https://www.monetdb.org/)
ColorDescriptor, software for the evaluation of color descriptors in images.	**~8,800 downloads**. (http://koen.me/research/colordescriptors/)
PSF Toolkit for process algebra, **PGA Toolset,** an algebraic framework for sequential programming. **Garp3,** for Qualitative Reasoning and Modelling, **DynaLearn,** Individualised and Engaging Cognitive Tool for Acquiring Conceptual Knowledge.	These are **specialized tools**, intended to **support education and research**, and to lead to scientific publications. (https://staff.fnwi.uva.nl/b.diertens/psf/ http://tcs.science.uva.nl/WebToolset/ http://www.garp3.org http://www.DynaLearn.eu)

LibDAI, a free/open source C++ library that provides implementations of various (approximate) inference methods for discrete graphical models	**~40,000 views** and ~**7700 unique downloads**. (www.libdai.org)
Molecular Biology and Evolution dataset, on the organic matrix involved in biomineralization	Since 2013 **~400 download** of the article and associated dataset. (DOI:10.10983/molbev/mst109)
Activity recognition datasets from Sensor networks	**440 citations** to the data sets, **>1500 unique visits** to dataset website (https://sites.google.com/site/tim0306/datasets)
RepLab, facility for the a competitive evaluation exercise for Online Reputation Management systems	~**500 users,** in the edition 2012-2014
Sesame, modeling and simulation framework for System-Level Design of Multi-Processor System-on-Chip platforms	**~1000 downloads** (http://daedalus.liacs.nl)
Two of the **DAS-4 clusters**, used for cutting edge research on distributed computing .	During 2009-2014, the DAS system has been used for over **40 PhD theses**. IvI will host again two clusters of the DAS-5 recently awarded by NWO. http://www.cs.vu.nl/das4/
OpenLab, a facility that provides an open experimentation environment for Software Defined Networking (SDN).	Since its creation in 2013 OpenLab has been used in international **demonstrations** at SuperComputing conferences, involving **tens of international partners.** https://ivi.fnwi.uva.nl/sne/openlab/

Research quality: Marks of recognition from peers

An online version of these two tables can be found here.
The financial data regarding grants for this table can be found in the folder "Raw financial data IvI".The other data can be found in the folder "Raw data UvA".

	2009		2010		2011		2012		2013		2014	
Awards/prices		4		9		9		16		14		12
Keynotes		5		7		5		4		6		4
Personal grants	0,3 M€	1	€, M		€, M	0	0,9 M€	2	1,2 M€	1	1,0 M€	3
Research grants	4,4 M€	11	4,3 M€	14	3,1 M€	13	3,1 M€	10	4,7M€	16	4,2 M€	13

	2009-2014
Editorial boards	57
Scientific committees	65
Leading role in scientific societies	32
External appointments & sabbaticals	22

Relevance to society: Research products for societal target groups

An online version of this table can be found here.
The other data can be found in the folder "Raw data UvA".

	2009	2010	2011	2012	2013	2014
Publications for the general public	3	8	31	16	14	24
Professional journals	2	1	1	0	2	2
Demo's for the general public	5	5	4	9	7	11
Laymen activities	4	10	10	4	7	6
Standards	0	0	0	0	1	2

Relevance to society: Use of research products by societal target groups

An online version of this table can be found here.
The financial data regarding grants for this table can be found in the folder "Raw financial data IvI". The other data can be found in the folder "Raw data UvA".

(*Note*: The peak in 2011 is due to the granting of the COMMIT project).

	2009		2010		2011		2012		2013		2014	
Patents	0		0		0		0		3		1	
Spin-offs	1		0		0		2		2		2	
Advisory role	23 distinct advisory role over the evaluation period											
Contract research	2,2 M€	12	2,0 M€	7	7,6 M€	18	0,2 M€	2	0,7 M€	3	0,8 M€	7

Relevance to society: Marks of recognition by societal target groups

An online version of this table can be found at here.
The financial data regarding valorization funding can be found in the folder "Raw financial data IvI". The other data can be found in the folder "Raw data UvA".

	2009		2010		2011		2012		2013		2014	
Valorisation funding	M€	0	0,5 M€	5	M€	0	M€	0	0,02 M€	1	0,5 M€	6
Public prizes	2		1		0		1		1		0	
Positions paid by societal groups (bijz. hgl)	1		1		1		1		1		3	

4.4 Appendix 4 Citation analysis

The following table provides the citation data based on Google Scholar, mid 2015. We report only on the scientific staff (=tenured and tenure trackers),
An online version of this table can be found in the folder containing all the IvI tables (here).

Research quality: Use of research products by peers

Name	Position	Fractional employment	Total nr of publications	Total nr of citations	H-index	URL
Adriaans	HL	20%	115	1274	19	URL
Afsarmanesh	HL	100%	372	6794	38	URL
Belloum	UD	100%	144	1047	16	URL
Bergstra	HL	100%	480	11782	49	URL
Bethke	UD	100%	67	508	11	URL
Bredeweg	UHD	100%	266	2210	24	URL
Bubak	HL	20%	413	2416	24	URL
de Laat	HL	100%	348	3498	26	URL
de Rijke	HL	100%	644	13921	53	URL
Dorst	UD	100%	129	2261	25	URL
Gavrila	HL	25%	94	9354	37	URL
Gevers	HL	100%	306	8679	42	URL
Ghebreab	UD		51	243	9	URL
Grelck	UD	100%	137	1086	19	URL
Grosso	UD	100%	156	4352	24	URL
Groen	HL	20%	292	3967	30	URL
Hoekstra	HL	100%	279	4400	35	URL
Jesshope	HL		173	2994	20	--
Kaandorp	UHD	100%	154	1982	25	URL
Kanoulas	UHD	100%	58	1079	19	URL
Kersten	HL	20%	368	6802	39	URL
Khandai	UHD	20%	54	1391	21	URL
Krose	HL	20%	332	6306	40	URL
Lees	UHD	100%	91	702	16	URL
Marx	UHD	100%	235	3877	30	URL
Meijer	HL	20%	114	1352	15	URL
Monz	UHD	100%	95	2493	22	URL
Nack	UHD	100%	183	1576	19	URL
Pimentel	UHD	100%	140	1921	17	URL
Ponse	UHD	100%	134	2207	18	URL
Sloot	HL	100%	687	6343	41	URL
Smeulders	HL	40%	321	17681	51	URL

Snoek	UHD	20%	160	5993	30	URL
van Someren	UHD	100%	187	2807	21	URL
Varbanescu	UD	100%	73	573	11	URL
Welling	HL	100%	178	5712	38	URL
Whiteson	UHD	100%	102	1619	21	URL
Worring	UHD+HL	100%	299	12569	39	URL

Appendix 5 Length and success rates of PhD programme

The online version of this table can be found in the folder containing the IvI tables (here).

	Enrolment			Success rates (graduations, cumulative)											
Starting year	Enrolment (male/female)		Total (M+F)	Graduated in year 4 or earlier		Graduated in year 5 or earlier		Graduated in year 6 or earlier		Graduated in year 7 or earlier		Not yet finished		Discontinued	
	#	#		#	%	#	%	#	%	#	%	#	%	#	%
2006	15	1	16	1	6%	7	44%	10	63%	11	69%	1	6%	4	25%
2007	14	4	18	2	11%	9	50%	11	61%	12	67%	1	6%	5	28%
2008	8	2	10	1	10%	2	20%	5	50%	6	60%	3	30%	1	10%
2009	15	1	16	2	13%	8	50%	10	63%	-------	-------	2	13%	4	25%
2010	12	5	17	4	24%	7	41%	-------	-------	-------	-------	7	41%	3	18%
2011	23	3	26	1	4%	-------	-------	-------	-------	-------	-------	20	77%	5	19%
Total	87	16	103	11	11%	33	43%	36	60%	29	66%	34	33%	22	21%

4.5 Appendix 15 Key publications

IvI 15 key publications (in alphabetical order)

1. S. Ahn, A. Korattikara and M. Welling
   Bayesian Posterior Sampling via Stochastic Gradient Fisher Scoring,
   2012, International Conference Machine Learning (ICML2012), pp. 1591-1598
   (Winner of the ICML Best Paper Award - Citation: 62)
2. J.A. Bergstra and C.A. Middelburg
   Instruction sequence processing operators.
   Acta Informatica, 49 (3), 139-172. 2012
   (Citation: 30)
3. B. Bredeweg, F.E. Linnebank, A.J. Bouwer and J. Liem
   Garp3 — Workbench for qualitative modelling and simulation.
   Ecological Informatics, 4(5-6), 263-281. (2009)
   (Citation: 80)
4. L. M. Camarinha-Matos, H. Afsarmanesh, N. Galeano and A. Molina
   Collaborative networked organizations Concepts and practice in manufacturing enterprises
   Journal of Computers & Industrial Engineering, Volume 57, Issue 1, PP. 46-60 (2009)
   (Citation: 250)
5. S. Carter and C. Monz.
   Syntactic discriminative language model rerankers for statistical machine translation.
   Machine Translation Journal, 25(4):317–339, 2011
   (Citation: 7)
6. Q. Chen, P. Grosso, K. van der Veldt, C. de Laat, R. Hofman and H. Bal.
   Profiling energy consumption of VMs for green cloud computing
   In: International Conference on Cloud and Green Computing (CGC2011), Sydney December 2011
   (Citation: 32)
7. A Gerstlauer, C Haubelt, AD Pimentel, TP Stefanov, DD Gajski, J Teich
   Electronic system-level synthesis methodologies
   IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems (2009)
   (Citation: 109)
8. Y. Guo, M. Biczak, AL. Varbanescu, A. Iosup, C Martella and TL Willke
   How well do graph-processing platforms perform? An empirical performance evaluation and analysis.
   In IPDPS'14, Phoenix, AZ, USA.
   (Citation: 19)
9. Habibian, T. Mensink and C. Snoek
   VideoStory: A New Multimedia Embedding for Few-Example Recognition and Translation of Events”
   ACM Multimedia 2014,
   (Best paper award - Citation: 11)
10. P. Klint, T. Van Der Storm and J. Vinju
    EASY Meta-programming with Rascal
    Generative and Transformational Techniques in Software Engineering III (2011)
    (Citation: 85)
11. X. Li, C. G. M. Snoek, M. Worring.
    Learning Social Tag Relevance by Neighbor Voting.
    In IEEE Transactions on Multimedia 2009.
    (Best paper awarded in 2012 - Citation: 223)
12. E. Meij, W. Weerkamp and M. de Rijke.
    Adding semantics to microblog posts.

In: WSDM 2012: Fifth ACM International Conference on Web Search and Data Mining
(Citation: 164)

13. J. Peters, J. M. Mooij, D. Janzing and B. Schölkopf
Causal Discovery with Continuous Additive Noise Models.
Journal of Machine Learning Research 15(Jun):2009-2053, 2014
(Citation: 15)
14. P.M.A Sloot. and A.G. Hoekstra,
Multi-scale modelling in computational biomedicine.
Brief Bioinform, 2010. 11(1): p. 142-1
(Citation 53)
15. J. RR Uijlings, K. EA van de Sande, T. Gevers and A. WM Smeulders.
Selective Search for Object Recognition,
International Journal of Computer Vision September 2013, Volume 104, Issue 2, pp 154-171
(Citation: 253 - cited 100x in first year)

IvI five most important societal outputs:

1. Several groups in the institute work on improving medical diagnosis and treatment schemes. A decision support system for HIV resulting from the Virolab and Dynanets projects is currently being tested in several hospitals. Methods for the improvement of medical diagnostic imaging are being developed with advanced machine vision. In addition, we pay attention to patient records privacy in a COMMIT project.
2. We have structural collaboration with NFI – National Forensic Institute – on research and education. Forensic experts employ our machine learning, network simulation, video analysis, and information retrieval. Research on criminal dark networks has been put into practice by the Dutch national police.
3. Several groups work in international cooperations against terrorism with US- and UK-governments in the areas of intelligence analysis and video processing (Digit, REMEDI and SESAME projects), and on cyber-security (SARNET project funded with KLM, COMMIT and CIENA).
4. We are developing "Rekenen-Informatica" as a perspective on elementary arithmetic. We offer yearly our Web-school-class ``What is a program [in Dutch]?", which attracts a small and diverse audience, among which a few good future students. We have set a MOOC for the Bachelor course on “Programming” followed by hundreds of students from all disciplines.
5. Members of the institute frequently engage in outreach activities in the press, resulting in regular appearances in the national news papers (NRC Handelsblad, Volkskrant, Parool), weekly’s and well-known TV programs (DWDD , VPRO and VARA).

4.6 Appendix 7: Research themes & groups

Groups & Heads, fte (as of Dec 2014)	Description
Amsterdam Machine Learning lab (AMLAB) – *former IAS* Frans Groen (until 9-2011), Simon Whiteson (from 9-2011 till 9-2012), Max Welling (from 9-2012) • 6fte Research staff • 2.7 fte postdocs • 16 PhD	The AMLAB conducts research in the area of large scale modelling of complex data sources. This includes the development of new methods for probabilistic graphical models and nonparametric Bayesian models, the development of faster (approximate) inference and learning methods, deep learning, causal inference, reinforcement learning and multiagent systems and the application of all of the above to large scale data domains in science and industry ('Big Data problems').
Federated Collaborative Networks (FCN) Hamideh Afsarmanesh • 2 fte Research staff • 0.9 fte postdocs • 4 PhD	FCN performs research on analysis, modeling, and design of methods and systems regarding the formation, interaction, decision support, and management of collective adaptive systems. This area of research is broad and multi-disciplinary, with networks representing socio-technical ecosystems, characterized by their intrinsic decentralization, dynamics, openness, self-adaptation, and exchanged- information intensity.
Information Language Processing Systems (ILPS) Maarten de Rijke • 5 fte Research staff • 2.7 fte postdocs • 25 PhD	The section ILPS studies and develops models, algorithms, and tools for intelligent information access, especially in the face of challengingly massive amounts of online textual data. The pro-gram builds on, and contributes to, insights from information retrieval, language technology and knowledge representation and reasoning.

Intelligent Sensory Information System (ISIS) Arnold Smeulders (until 9-2011), Marcel Worring (from 9-2011) • 6 fte Research staff • 2.7 fte postdocs • 15 PhD	The prime scientific target of the research program of the section ISIS is to understand the content of images by learning from large repositories. The research area is that of semantic computer vision, cognitive vision, and interactive visualization of large picture datasets. Human cognition determines what we perceive in images and this is the basis of interaction and semantics, thus making the work of ISIS a window on several disciplines outside informatics.
Section Computational Science (SCS) Peter Sloot (until 12-2011), Alfons Hoekstra (from 2012) • 5 fte Research staff • 4.5 fte postdocs • 8 PhD	The SCS group aims to understand information processing in such dynamic multi-level complex systems. Can we detect and describe the computational structure in dynamic processes and can we provide a quantitative characterization of essential aspects of this structure? Can we then better understand emergent properties and critical phenomena such as tipping points? The ever increasing and abundant availability of data, both from science and society, drives this research. Such questions are studied in the context of multi-scale cellular automata, dynamic networks and individual agent based models.
System and Network Engineering (SNE) Cees de Laat • 8 fte Research staff • 6.3 fte postdocs • 17 PhD	The SNE group conducts research on leading-edge computer systems of all scales, ranging from global-scale systems and networks to embedded devices. Across these multiple scales our particular interest is on extra-functional properties of systems, such as performance, programmability, productivity, security, trust, sustainability and, last but not least, the societal impact of emerging systems-related technologies. Our approach to research is a practical and engineering-oriented one that regularly involves the design, implementation and maintenance of prototypical tools and proof-of-concept applications that demonstrate and promote our research results.
Theory of Computer Science (TCS) Jan Bergstra (until 12-2011), Alban Ponse from 2012 • 4 fte Research staff • 0 fte postdocs • 0 fte PhD	TCS focuses on developing theory and tools in the field of algebraic specification which can be used to specify, analyse and verify concurrent communicating and programmed systems. The program aims to support the development of better software in a systematic manner. Design and analysis on the conceptual level both are indispensable for a better understanding of programming, programming languages and programmed systems.

5 Appendix Computer Science VUA

5.1 Appendix 1 Research staff composition

This is **table D3a** from SEP protocol (all cells are research FTE, except PhD students and fellows, for which only headcount is given). The conversion for research FTE is: prof/assoc. prof/asst. prof/tenure-trackers (scientific staff) = 40%, postdoc = 90%. Staff is counted in the actual year of employment (i.e. not in the year the funding was acquired, or actually received).
An online version of this table can be found at Table "Research staff composition"

	2009		2010		2011		2012		2013		2014	
	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE
Scientific staff	49	14,5	50	14,9	47	14,4	47	13,5	47	13,3	50	13,4
Post-docs	45	28,4	46	31,4	50	29,9	52	28,9	52	28,4	51	27,1
PhD students	123	------	119	------	119	------	125	------	118	------	113	------
Student assistant		3,0		2,8		1,1		1,9		3,4		5,9
Total research staff	**217**	**45,9**	**215**	**49,2**	**216**	**45,3**	**224**	**44,3**	**217**	**45,0**	**214**	**46,4**
Support staff	18	13,5	18	13,1	17	13,8	25	14,7	20	14,2	14	11,5
Visiting fellows	39	------	50	------	69	------	58	------	43	------	37	------
Total staff	**274**	**59,4**	**283**	**62,2**	**302**	**59,1**	**307**	**59,0**	**280**	**59,2**	**265**	**57,9**

5.2 Appendix 2 Funding

This is **table D3c** from the SEP protocol. Competitive EU funding (FP7 and H20202) are included under "research grants". FTE are counted in the actual year of employment (ie not in the year the funding was acquired, or actually received).
An online version of this table can be found at Table "Funding".

	2009		2010		2011		2012		2013		2014	
Funding	FTE	%	FTE	%	FTE	%	FTE	%	FTE	%	FTE	%
Direct funding	74,0	90%	60,2	77%	54,7	65%	39,3	46%	26,1	32%	26,0	35%
Research grants	6,3	8%	13,3	17%	20,6	25%	32,7	38%	33,3	41%	26,4	35%
Contract grants	1,9	2%	4,2	5%	8,6	10%	14,3	17%	21,1	26%	22,3	30%
Other	0,0	0%	0,0	0%	0,0	0%	0,0	0%	0,0	0%	0,0	0%
Total funding	82,3	100 %	77,7	100 %	84,0	100 %	86,3	100 %	80,4	100 %	74,7	100 %

Expenditure	M€	%	M€	%	M€	%	M€	%	M€	%	M€	%
Personnel costs	€8,7 M	75%	€9,1 M	82%	€8,7 M	83%	€9,1 M	83%	€9, M	86%	€8,9 M	89%
Other Costs	€2,9 M	25%	€2, M	18%	€1,8 M	17%	€1,9 M	17%	€1,5 M	14%	€1,1 M	11%
Total expenditure	€11,6 M	100 %	€11, M	100 %	€10,5 M	100 %	€11, M	100 %	€10,5 M	100 %	€10, M	100 %

5.3 Appendix 3 Output indicators

Table D1 in the SEP protocol is covered by the 7 tables in this appendix. The first four tables correspond to the column Research quality, tables 5, 6, and 7 belong to the column Relevance to society.
See Appendix 7 for details on what to include or not include in the various fields below.

Research quality: Research products for peers

An online version of this table can be found at **Table D1, part "Research products for peers".** For the hard- & software products see the table of "use of research products by peers".
The underlying data for these total numbers, including the bibliographic information for all publications can be found here.

This is **table D3b** in the SEP protocol.

	2009	2010	2011	2012	2013	2014
Refereed journals	86	75	90	89	82	90
Peer reviewed conference papers	202	194	176	186	221	175
Books	3	6	8	15	17	9
Book chapters	20	20	13	21	20	8
PhD theses	11	22	13	19	11	18
Software & hardware						
Total	322	317	300	330	351	300

Research quality: use of research products by peers.
Note that in deviation from SEP table D1, citations to publications are not listed here. Instead, they are reported in Appendix 5.4.

Soft- & hardware tools	**Usage**
OM Ontology of Units of Measure and Quantities	used by researchers world-wide, at least twenty organisations actively
Ibis distributed programming software.	Ibis is now being deployed by the Netherlands eScience Center. One of its components, JavaGAT, obtained **60.000 downloads** so far.
Distributed ASCI Supercomputer (DAS)	We have coordinated the Distributed ASCI Supercomputer (DAS) project for the past 18 years, resulting in a long-term infrastructure for experimental Dutch Computer Science. We obtained grants from NWO/M for DAS-4 (2010) and for the next generation. During 2009-2014, it has been used for over **40 PhD theses**. In 2015, the DAS-5 has become operational.
Argos v0.7	Argos counts **12.000 downloads**. Argos was used by industry and academia from around the world.For

	instance: Symantec (in its SGNet IDS), SURFnet (in SurfIDS), Honeynet Project (Qebek), FORTH (in its Honey@Home IDS).
StreamLine I/O Architecture for fast network processing	Downloads: unkown, but it was bundled with the then popular Catapulta Linux distribution in 2008.
YASGUI toolset enables user-friendly access to SPARQL query endpoints.	The **YASGUI toolset** is used both by a large number a data publishers (including the Smithsonian museum and healthdata.gov), integrated in several tools (including three large triple-stores Apache Jena, OpenRDF Sesami and ClioPatria). and used by **5600 users** who executed 95.000 SPARQL queries on about 600 SPARQL endpoints (statistics since Oct 2012, and only including the 60% of users who enable usage tracking)
LOD Laundromat is the largest uniform point of entry to the LOD Cloud	**700 distinct users** in 2014 alone who downloaded 175.000 datasets and executed 35.000 queries
Open PHACTS Discovery Platform- a semantic data integration platform for drug discovery.	over **147 million API access** between March 2013 – Dec 2014. Number of users is 503 from which roughly 25% academic users and 75% commercial users like GSK, AstraZenica, Entagen and Johnson & Johnson.
Praline - multiple sequence alignment.	**Used 100,000+ times**
FAME - web-based tool for genome-scale metabolic modeling + vizualisation.	**12000+ sessions, 5000+ users**
PySCeS - Python Simulator of Cellular Systems. ODE based simulations including stoichiometric, time course, steady state and metabolic control analysis.	**5800+ downloads**
SWI Prolog	It is strong in education, (semantic) web research and is commercially used by dozens of companies. It receives a growing number of contributions from its research and commercial users. See https://www.openhub.net/p/swi-prolog. The system has about **150,000 downloads per year** from the main site, while it is also distributed in Linux distributions, MacOS repositories and Windows download sites.
PEERSIM, an advanced p2p simulator	Approx **3000 annual downloads**
MINIX 3.3.0	MINIX 3.3.0 got 80,000 hits within a month. (released in Sept. 2014). MINIX 3.3.0 has also been ported to the BeagleBone boards. There have been over 3 million hits to the MINIX 3 Website and over **600,000 downloads** of the software in all.

Research quality: Marks of recognition from peers.
For some indicators only the total number over the entire period are given, for others they are split per year.

An online version of this table can be found at **Table "Marks of recognition from peers"**
The underlying data for the grants can be found here, the data for the other fields can be found here.

	2009		2010		2011		2012		2013		2014	
Awards/prizes	6		10		5		7		9		11	
Keynotes	12		6		9		7		7		12	
Personal grants	€0, M	0	€0,25 M	1	€1,6 M	2	€0,25 M	1	€0,25 M	1	€1,5 M	1
Research grants	€3,7 M	11	€3,3 M	12	€5,5 M	13	€2,4 M	13	€1,3 M	11	€3,2 M	15

	2009-2014
Editorial boards	50
Scientific committees	60
Leading role in scientific societies	28
External appointments & sabbaticals	19

Relevance to society: Research products for societal target groups
An online version of this table can be found at **Table "Research products for societal target groups".**
The underlying data can be found here.

	2009	2010	2011	2012	2013	2014
Publications for the general public	29	41	58	54	57	25
Professional journals	0	0	0	0	0	0
Demo's for the general public	2	0	2	0	4	7
Laymen activities	1	1	6	4	8	16
Standards	1	0	1	0	2	1

Relevance to society: use of research products by societal target groups
An online version of this table can be found at **Table "Use of research products by societal groups"**
The underlying data can be found here

	2009		2010		2011		2012		2013		2014		Period
Patents	0		1		0		0		0		0		
Spin-offs	0		0		0		1		0		0		
Advisory role													32
Contract research	€0, M	0	€0,2 M	1	€0, M	0	€0,3 M	1	€0, M	0	€0,2 M	2	

Relevance to society: marks of recognition by societal target groups
An online version of this table can be found at **Table "Marks of recognition by societal target groups"**
The underlying data for the funding can be found here, and here for the other cells.

	2009		2010		2011		2012		2013		2014	
Valorisation funding	€0, M	0	€0, M	0	€0,9 M	1	€0, M	0	€0, M	0	€0,1 M	2
Public prizes	0		0		1		0		0		1	
Positions paid by societal groups (bijz. hgl)	1		1		1		1		1		2	

5.4 Appendix 4 Citation analysis

In the following table all data are based on Google Scholar, mid May 2015. Only filled in for the scientific staff (= tenured staff and tenure trackers). Citations is one of the indicators of research quality in particular "use of research products by peers".
An online version of this table can be found at **Table "Google Scholar scientific staff"**

Name	Position	Fractional employment	Total nr of publications	Total nr of citations	H-index	URL
Abeln	asst.prof.	100%	26	146	6	URL
Akkermans	prof.	80%	317	10757	40	URL
Aroyo	assoc.prof.	100%	267	2916	26	URL
Bal	prof.	100%	393	9111	51	URL
Boncz	prof.spec.appt.	20%	209	3925	31	URL
Bos	prof.	100%	177	5782	25	URL
Bosse	asst.prof.	100%	231	1706	18	URL
Bulterman	prof.spec.appt.	20%	270	3722	30	URL
Crispo	assoc.prof.	30%	159	3059	28	URL
de Vrijer	assoc.prof.	100%				
Eiben	prof.	100%	316	11529	43	URL
Eliens	asst.prof.	100%	130	1523	18	URL
Endrullis	asst.prof.	100%	51	545	12	URL
Feenstra	asst.prof.	100%	52	6474	17	URL
Fokkink	prof.	80%	161	3362	31	URL
Gordijn	assoc.prof.	20%	129	3992	25	URL
Groth	asst.prof.	100%	176	3988	33	URL
Haasdijk	asst.prof.	100%	55	371	11	URL
Heringa	prof.	80%	142	7726	33	URL
Hoogendoorn	asst.prof.	100%	161	727	15	URL
Kielmann	assoc.prof.	100%	251	4409	35	URL
Klau	prof.spec.appt.	10%	118	1787	24	URL
Klein	asst.prof.	80%	178	6586	32	URL
Lago	assoc.prof.	100%	225	2403	26	URL

Leopold	asst.prof.	100%	47	299	10	URL
Raamsdonk	asst.prof.	80%				
Reijers	prof.	80%	288	6500	40	URL
Schlobach	asst.prof.	100%	119	1664	20	URL
Schreiber	prof.	100%	279	13457	45	URL
Tamburrelli	asst.prof.	100%	35	750	13	URL
Tanenbaum	prof.	40%	506	31414	68	URL
ten Teije	assoc.prof.	80%	143	1546	20	URL
Teusink	prof.	20%	154	5266	36	URL
Top	prof.spec.appt.	20%	129	1074	15	URL
Treur	prof.	100%	646	7516	38	URL
Urbani	asst.prof.	100%	31	646	11	URL
van Harmelen	prof.	100%	315	26441	62	URL
van Steen	prof.	100%	371	11238	46	URL
van Vliet	prof.	100%	204	4585	34	URL
Verhoef[24]	prof.	20%	177	3851	37	URL
Voulgaris	asst.prof.	100%	40	1931	15	URL
Welty	prof.spec.appt.	20%	163	5705	33	URL

[24] Prof. Verhoef's data became available in August 2015. There are not considered in the benchmark analysis.

5.5 Appendix 5 Length and success rates of PhD programme

An online version of this table can be found at **Table "Length and succes rates of PhD programme" .** This is table D3d from the SEP protocol**.**

	Enrolment			Success rates (graduations, cumulative)											
Starting year	Enrolment (male/female)		Total (M+F)	Graduated in year 4 or earlier		Graduated in year 5 or earlier		Graduated in year 6 or earlier		Graduated in year 7 or earlier		Not yet finished		Discontinued	
	#	#		#	%	#	%	#	%	#	%	#	%	#	%
2006	15	5	20	3	15%	9	45%	14	70%	16	80%	2	10%	1	5%
2007	15	5	20	2	10%	9	45%	12	60%	14	70%	2	10%	4	20%
2008	14	3	17	1	6%	7	41%	11	65%	13	76%	2	12%	2	12%
2009	14	4	18	2	11%	7	39%	9	50%		0%	6	33%	3	17%
2010	9	4	13	1	8%	5	38%		0%		0%	8	62%		0%
2011	21	4	25	1	4%		0%		0%		0%	22	88%	2	8%
Total	88	25	113	10	9%	37	42%	46	61%	43	75%	42	37%	12	11%

5.6 Appendix 6 Key publications

Our 15 key publications on alphabetic order:

1. Bosse, T., Hoogendoorn, M., Klein, M.C.A., Treur, J., Wal, C.N. van der, and Wissen, A. van, Modelling Collective Decision Making in Groups and Crowds: Integrating Social Contagion and Interacting Emotions, Beliefs and Intentions. *Autonomous Agents and Multi-Agent Systems Journal*, vol. 27, 2013, pp. 52-84.
   (29 citations, paper 2013)
2. MH Daleke, R Ummels, P Bawono, J Heringa, CMJE Vandenbroucke-Grauls, J Luirink, W Bitter. General secretion signal for the mycobacterial type VII secretion pathway. *Proceedings of the National Academy of Sciences USA* 109 (28), 11342-11347
   (53 citations, paper 2013)
3. K Dentler, R Cornet, A Ten Teije, N De Keizer, Comparison of reasoners for large ontologies in the OWL 2 EL profile. *Semantic Web Journal* 2 (2), 71-87, 2011
   (nr 8 in the Top Cited of the journal, 85 citations, paper 2011)
4. A.E. Eiben and S.K. Smit, Parameter Tuning for Configuring and Analyzing Evolutionary Algorithms, *Swarm and Evolutionary Computation*, 1(1):19-31, 2011
   (in the Top 5 Best Cited of the journal, 158 citations, paper 2011)
5. Jörg Endrullis, Dimitri Hendriks, Transforming Outermost into Context-Sensitive Rewriting. *Logical Methods in Computer Scien*ce 6(2) (2010)
   (22 citations, paper 2010)
6. Giuffrida, C., Kuijsten, A., and Tanenbaum, A.S.: Safe and Automatic Live Update for Operating Systems. *Proc. ASPLOS 2013*, ACM, pp. 279-292, 2013.
   (19 citations, paper 2013)
7. Enes Göktas, Elias Athanasopoulos, Herbert Bos, and Georgios Portokalidis. 2014. Out of Control: Overcoming Control-Flow Integrity. *Proceedings of the 2014 IEEE Symposium on Security and Privacy (SP '14)*. IEEE Computer Society, Washington, DC, USA, 575-589. DOI=10.1109/SP.2014.43 Dutch Cyber Security Research Award for best security paper overall from the Netherlands in 2014)
   (47 citations, paper 2014)
8. E. Haasdijk, N. Bredeche, and A. E. Eiben, Combining Environment-Driven Adaptation and Task-Driven Optimisation in Evolutionary Robotics, *PLOS One*, 9(6): e98466, doi:10.1371/journal.pone.0098466, 2014
   (11 citations, paper 2014)
9. Ivano Malavolta, Patricia Lago, Henry Muccini, Patrizio Pelliccione, Antony Tang. What industry needs from architectural languages: An industrial survey*, IEEE Transactions on Software Engineering*, 39(6), 869-891, 2013
   (42 citations, paper 2013)
10. Luc Moreau, Ben Clifford, Juliana Freire, Joe Futrelle, Yolanda Gil, Paul Groth, Natalia Kwasnikowska, Simon Miles, Paolo Missier, Jim Myers, Beth Plale, Yogesh Simmhan, Eric Stephan, Jan Van den Bussche, The open provenance model core specification (v1. 1) *Future Generation Computer Systems*, 2011, vol 27, nr. 6, 743-756
    (606 citations, paper 2011)
11. WR Van Hage, V Malaisé, R Segers, L Hollink, G Schreiber,Design and use of the Simple Event Model (SEM). *Web Semantics: Science, Services and Agents on the World Wide Web* 9 (2), 128-136, 2011
    (106 citations, paper 2011)
12. Rob V. van Nieuwpoort, Gosia Wrzesinska, Ceriel J.H. Jacobs and Henri E.Bal: Satin: a High-Level and Efficient Grid Programming Model, *ACM Transactions on Programming Languages and Systems (TOPLAS),* Volume 32, Issue 3, ACM Press New York, NY, USA, 2010
    (37 citations, paper 2010)
13. Rijgersberg, H., Assem, M. van, & Top, J. L. (2013). Ontology of Units of Measure and Related Concepts. *Semantic Web*, 4(1), 3–13. doi:10.3233/SW-2012-0069
    (23 citations, paper 2013)
14. J Urbani, S Kotoulas, J Maassen, F Van Harmelen, H Bal, OWL reasoning with WebPIE: calculating the closure of 100 billion triples, *The Semantic Web: Research and Applications*, pp. 213-227, 2010,
    (citations: 138, paper 2010)
    Conference version: Scalable distributed reasoning using mapreduce, J Urbani, S Kotoulas, E Oren, F

Van Harmelen, The Semantic Web-ISWC 2009, 634-649
(215 citations, paper 2009)

15. G Urdaneta, G Pierre, MV Steen, A survey of DHT security techniques, *ACM Computing Surveys (CSUR*) 43 (2), 8, 2011
(178 citations,paper 2011)

List of five most important societal outputs:

1. W3C standards: OWL2, PROV, RDF1.1, SKOS
2. **VPRO Labyrint:** in November 2013, Prof. van Harmelen was the presenter of a half hour programme on Dutch TV exploring the future developments of Computing: the creative computer, the autonomous computer, the invisible computer.
3. **TEDx Talk** by Prof. Eiben about evolutionary robotics (2011)
4. Demos at COBRA museum aiming at automatically tracking visitor experiences (2014). Involved a few hundred people.
5. Presentation and demo of smartphone hack at laymen's presentation ("Hack the Future") in Pakhuis de Zwijger, Amsterdam, 2014.

5.7 Appendix 7: Research themes & groups

Themes, Groups & Heads, FTE / # PhD students (2014)	Description
Artificial Intelligence	The AI research programme focuses on some fundamental areas from the field of AI, all of which have connections to the departmental wide 'networked world' theme. Contributions to these areas are developed in close interaction with application areas. These are found in other scientific disciplines such as biological, medical, cognitive and social sciences, and in application areas such as finance, ambient intelligence, and the military.
Agent Systems *Jan Treur* *5,3 FTE / 9 PhD*	The Agent Systems Research Area investigates how methods and techniques for modelling and analysis of agent systems can be developed and used to contribute to progress in the area of human-directed scientific disciplines and socio-technical systems based on scientific knowledge from such disciplines.
Computational Intelligence *Guszti Eiben* *2,8 FTE/ 5 PhD*	The research activities of the CI group focus on population-based adaptive systems. Adaptivity and autonomy of the system components and lack of central control are key features, implying inherent emergence and self-organization. We focus on evolutionary techniques as provider of adaptivity in intelligent technology rather than (only) an optimiser of not necessarily intelligent systems.
Bioinformatics	The overall research mission is to understand genome-wide mechanistic behaviour of cells at all network layers. This is done by developing computational analysis and modelling methods to mine and understand data coming from many different types of data, high-throughput measurements in particular. Integrating such information may involve various layers of genomics data: from DNA sequence data via molecules and cells to patients.
Integrative Bioinformatics *Jaap Heringa* *2,1 FTE / 11 PhD*	Our mission is to develop state-of-the-art bioinformatics prediction, data mining and modelling methods that allow us to build up fundamental understanding of the networked functioning of biological systems, including cellular and multicellular systems. The methods we devise should help answer a clear-cut biological question.
Systems Bioinformatics *Bas Teusink* *0,1 FTE** *) other staff employed by Faculty of Earth & Life Sciences	Our mission is to advance science, medicine and biotechnology through understanding the *physiology of unicellular organisms* in terms of *design principles* of the underlying *biological networks*. Most biological functions emerge from the interactions of biological components. We study this emergence, and its *chance and necessity*. We combine experimental and theoretical approaches to study cellular physiology, with an emphasis on metabolic networks.

Computer Systems	Our vision is that fundamental and experimental research should be done hand in hand, together with realistic applications from a variety of domains. Our objectives are not only to publish papers in top journals and conferences, but also to produce and distribute software prototypes and to build the necessary experimental infrastructure for our research.
High-Performance Distributed Computing *Henri Bal* *3,2 FTE /14 PhD*	Modern distributed systems consist of clusters, grids, clouds, desktop grids, and mobile devices. Writing applications for such systems has become increasingly difficult, and there is an urgent need to drastically simplify the programming of such applications. The HPDC group studies fundamental problems of distributed computing (performance, heterogeneity, fault-tolerance, and connectivity) hand in hand with major applications (e.g, astronomy, bioinformatics, multimedia content analysis, distributed reasoning, distributed model checking, mobile applications).
Large-Scale Distributed Systems *Maarten van Steen* *1,7 FTE / 6 PhD* (became director CTIT Twente in 2014)	We study extremely distributed computer systems, consisting of many relatively simple devices. Our goal is to make these systems operate seamlessly as a collective, often through fully decentralized epidemic algorithms. We are interested in understanding the emergent behavior that comes from applying local-only solutions. Target domains include large-scale wireless sensor networks and Internet-scale peer-to-peer networks.
System and Network Security *Herbert Bos* *2,8 FTE / 12 PhD* (since 2011)	Our research focus is on the *systems* aspects of security: low level, close to the hardware. We develop new techniques to analyse software and find the reasons why it is vulnerable, to test for the vulnerabilities, *and* to fix them. We also extend our analysis to malicious software, by studying and, where possible, neutralizing malware and even entire botnets.
Secure and Reliable Computer Systems *Andrew Tanenbaum* *0,3 FTE / 8 PhD* (formally retired, but still active)	As computers play a greater and greater role in modern society, the reliability of software is becoming more and more important. Our research is about how to make software, in particular operating systems, more reliable and dependable. Another theme is making it more secure, especially for mobile applications.

Information Management and Software Engineering	Our research focus is on actual problems in real-life situations. Relevant theory is not always available for the challenges that organizations and society face. Our research aims at developing such theory on the basis of practical experience and exploration. Our research goes from business processes to software systems, from decision making to development practices.
Software Engineering *Hans van Vliet* *0,8 FTE / 8 PhD* (now retired)	Our two interlinked central topics are (i) knowledge management in relation to software architecture and (ii) the relation between social/organizational aspects of the development organization and technical aspects of the solution.
Software & Services *Patricia Lago* *2,7 FTE* / 3 PhD (since 2011)	The S2 group research focus is on architecture design, modelling and evaluation of software-intensive systems. These typically involve multiple technologies, operate in multi-organisational environments and influence businesses, social behaviour and society at large. Major research areas are service orientation, cloud-based software, and software engineering for energy efficiency and sustainability. Our philosophy is that research should be industrial-relevant and serve the final

	purpose of being applied in practice.
Business Informatics *Hajo Reijers* 0,1 FTE / 1 PhD (appointed Sep 2014)	Our research focus is on business process management, workflow technology, business process improvement, and conceptual modeling. We cooperate closely with companies from the services and healthcare domains.

Knowledge, Web & Media	We investigate the symbolic representation and manipulation of information and knowledge. We study a variety of knowledge types, in a variety of domains (medical,scientific, cultural), using a variety of representations (distributed graphs, centralised knowledge bases) and a variety of formalisms. Our research covers algorithms, tools, methodologies and applications. We give specific attention to the representation and manipulation of distributed knowledge and information on the Web.
Knowledge Representation and Reasoning *Frank van Harmelen* *7,2 FTE / 12 PhD*	The KR&R group investigates representation of and reasoning with different forms of knowledge in very large, open, dynamic, heterogeneous and potentially inconsistent systems. We have an interest in both applications and theory. Our most prominent application domains are the Semantic Web, medical knowledge representation, and e-science.
Web and Media *Guus Schreiber* *6,9 FTE / 20 PhD*	The W&M group focuses on distributed, Web-based multimedia collections. Ontologies as shared information models are key elements in our research. Topics include knowledge and ontology engineering, semantic enrichment, semantic search, interactive and personalized access, visualization paradigms, and distributed architectures.

Theoretical Computer Science *Wan Fokkink* *5,0 FTE / 4 PhD*	We study algebraic techniques for the specification and analysis of systems, in particular process calculi, operational semantics, term rewriting and lambda calculus. We develop and apply formal methods for the design and analysis of distributed computer systems. We have a well-established international reputation in term rewriting

6 Joint Appendix: New Building

At this moment the construction for the New University building on the VU campus is well underway, with an intended completion date in early 2018. It will be a multi-purpose, very modern and ecologically friendly building, but foremost it will be the new location for the entire Computer Science departments of both the VU and UvA and the Network Institute including the Tech Labs of both universities.

The lower floors of the building are dedicated to commercial and educational functions and are going to be built around a huge atrium with glass ceilings creating a very light and open feeling. This lower part of the building will be topped by a flora and fauna roof.

The ground floor of the building will serve as a campus community center offering several commercial functions such as bars, restaurants and shops. This floor will also give access to two large lecture rooms that will turn into cinemas during the evenings and weekends.

On the first floor the University Library will create a large learning center focusing on new technology for accessing information and areas for study, work and relaxation. It is on this floor that we encounter the first sign of the Computer Science departments. Right on one of the corners facing the Boelelaan the Iconic Lab will be build. The Iconic Lab, or Intertain Lab version 2.0, is one of the Tech Labs and will be both a research and educational lab for researchers, teachers and students as well as a show case for state-of-the-art technology. It will be a place to conduct research, but also to invite guests, to give presentations and to hold social gatherings.

The other floors in the lower part of the building will be solely for education. These floors will offer several smaller lecture and workgroup rooms, as well as areas for studying.

The upper floors of the NU.VU building will house the Computer Science departments and Tech Labs of the Network Institute.

At the moment the Tech Labs are spread out over the VU campus and the UvA Science Park. In the NU.VU building the Tech Labs will be situated between the education layer and the office layer. This means the labs will be easy to reach from both areas and will also function as a meeting place for staff members, students and visitors. By gathering the Tech Labs together inside one building and one floor (except the Iconic Lab on the first floor), the Tech Labs will profit from a much greater flexibility, more efficient use of space and equipment, full-time support just a door away and easier access for everyone.

The Tech Labs will feature several spaces, each flexible and multi-functional. Some Tech Labs will be more specific in function such as the RoboLab, but can still be used for other purposes.

Adjacent to the Tech Labs will be the SNE (System and Network Engineering) lab. This unique educational lab features a large lecture room with dual monitor setup tables for students plus direct access to a special server room where students will be able to work on computer hardware directly.

On the roof, right on top of the Computer Science offices a large and state-of-the-art server room for the Computer Science departments will be built. This server room will be separate from the general purpose IT server rooms of the university and will be able to cope with future increased demand for server space from the combined Computer Science departments.

Several other ideas are currently under investigation to use this ultra-modern building itself as a research and educational tool. As the entire inside of the building will be constructed in a 3x3 meter grid structure with a large under-the-floor space where electricity and data cables will run, there are many option of converting this Green Building into a Smart Green Building using many different types of sensors that can gather data for research. Indoor GPS-like systems could track movement of participating individuals. Temperature, sound level and other sensors could give even more data about how the building is used.

Using large touch-enabled screens displaying realistic avatars that can guide visitors throughout the building, and could add a futuristic touch whilst at the same time function as a testbed for humanoid interactive systems.

A collaboration with the University's Library new Learning Center (LLC) on the first floor has already been set up to extend the capabilities of both the Tech Labs and the LLC. This means more advanced, state of the art systems for accessing and using information provided by the Library and higher visibility of the Tech Labs and Computer Science departments.

7 Appendix: Interpretation of the KPIs

Research quality

Research products for peers

1. *Publications*: Refereed journal articles, books, book chapters, conference papers from peer reviewed conferences. For books, do not include conference proceedings. Report the number per year split per type (4 types in total).
2. *Dissertations*: completed PhD theses. Report, according to Table D3D of the SEP 2015-2021 document, pg 28.
3. *Software and hardware*: Datasets, software tools, demos/manuals, infrastructure. Only "big ones". Big is for instance, many users, many downloads. Mind the consistency with Use of research products by peers, sub use of… NB. Demos are (software) products here, not the events of showing something.

Use of research products by peers

1. *Citations*: H-index based on Google Scholar for each staff tenure and tenure-trackers. Report the data required for appendix 4.
2. *Reviews in journals*: review of a publication, such as a book in a scientific journal (not in the popular media). The same for software or hardware.
3. *Use of software /hardware tools*: quantitative indication of usage, e.g. number of users, downloads. Report the number and the unit (users or downloads, ..)

Marks of recognition from peers

1. *Science awards/prizes*: Best paper awards on international conferences, in journals, competitions..
2. *Personal grants*: national: VENI, VIDI, VICI or international: ERC.
3. *Research grants (non personal)*: all competitively acquired grants (NWO, EU) for all projects whose duration overlaps with the reporting period or are accepted in this period even if the start date is later.
4. *Invited keynotes*: high profile keynote presentations on international events. Do not count presentations on some other university you visited and gave a talk.
5. *Editorial boards*: Editorial boards of scientific journals and book series. Report all appointments even if the period of the appointment, e.g. 2008-2012, is shorter than the reporting period.
6. *Scientific committees*: Only organising committee or steering committee with a high status. Do not count programme committee's and reviewerships.
7. *Leading role in an (inter)national scientific society*: For instance, IEEE, ACM, etc.
8. *Visiting fellowships* by faculty to other institutions, part-time appointments from own faculty elsewhere and sabbaticals spent elsewhere. Only include if they cover a substantial period (ie leave out visits of just a week).

Relevance to society

Research products for societal target groups

1. *Publications/publicity aimed at the general public*: Physical = articles in national newspapers/magazines, electronic = radio/TV programmes, internet;
2. *Articles in professional journals*
3. *Demos for general audience*
4. *Laymen lectures/activities*
5. *Standards*

Use of research products for societal target groups

1. *Patents/licences: Report patent-name, year, one sentence description*
2. *Spin-offs*
3. *Contract research, for example for industry, business, TNO, STW*
4. *Advisory role / expertise for government, companies. or societal organization*

Marks of recognition by societal groups

1. *Public prizes*
2. *Valorisation funding*
3. *Appointments/positions paid for by societal groups, for example bijz. hgl.*