B COMPUTER SCIENCE
M PARALLEL AND DISTRIBUTED COMPUTER SYSTEMS

FACULTY OF SCIENCE

VRIJE UNIVERSITEIT AMSTERDAM

QANU
Catharijnesingel 56
PO Box 8035
3503 RA Utrecht
The Netherlands

Phone: +31 (0) 30 230 3100
E-mail: support@qanu.nl
Internet: www.qanu.nl

Project number: Q0745

© 2020 QANU
Text and numerical material from this publication may be reproduced in print, by photocopying or by any other means with the permission of QANU if the source is mentioned.

CONTENTS

REPORT ON THE BACHELOR'S PROGRAMME COMPUTER SCIENCE AND THE MASTER'S PROGRAMME PARALLEL AND DISTRIBUTED COMPUTER SYSTEMS OF VRIJE UNIVERSITEIT AMSTERDAM 5

ADMINISTRATIVE DATA REGARDING THE PROGRAMMES 5

ADMINISTRATIVE DATA REGARDING THE INSTITUTION 5

COMPOSITION OF THE ASSESSMENT PANEL 6

WORKING METHOD OF THE ASSESSMENT PANEL 6

SUMMARY JUDGEMENT 10

DESCRIPTION OF THE STANDARDS FROM THE ASSESSMENT FRAMEWORK FOR LIMITED PROGRAMME ASSESSMENTS – BACHELOR'S PROGRAMME COMPUTER SCIENCE 14

DESCRIPTION OF THE STANDARDS FROM THE ASSESSMENT FRAMEWORK FOR LIMITED PROGRAMME ASSESSMENTS – MASTER'S PROGRAMME PARALLEL AND DISTRIBUTED COMPUTER SYSTEMS 25

APPENDICES 37

APPENDIX 1: DOMAIN-SPECIFIC FRAMEWORK OF REFERENCE 39

APPENDIX 2: INTENDED LEARNING OUTCOMES 40

APPENDIX 3: OVERVIEW OF THE CURRICULUM 42

APPENDIX 4: PROGRAMME OF THE SITE VISIT 45

APPENDIX 5: THESES AND DOCUMENTS STUDIED BY THE PANEL 46

This report was finalised on 17 April 2020

REPORT ON THE BACHELOR'S PROGRAMME COMPUTER SCIENCE AND THE MASTER'S PROGRAMME PARALLEL AND DISTRIBUTED COMPUTER SYSTEMS OF VRIJE UNIVERSITEIT AMSTERDAM

This report takes the NVAO's Assessment Framework for the Higher Education Accreditation System of the Netherlands for limited programme assessments as a starting point (September 2018).

ADMINISTRATIVE DATA REGARDING THE PROGRAMMES

Bachelor's programme Computer Science

Name of the programme:	Computer Science
CROHO number:	50426
Level of the programme:	bachelor's
Orientation of the programme:	academic
Number of credits:	180 EC
Location(s):	Amsterdam
Mode(s) of study:	full time
Educational minor:	applicable (second degree qualification)
Language of instruction:	English
Submission deadline NVAO:	01/05/2020

Master's programme Parallel and Distributed Computer Systems

Name of the programme:	Parallel and Distributed Computer Systems
CROHO number:	60802
Level of the programme:	master's
Orientation of the programme:	academic
Number of credits:	120 EC
Location(s):	Amsterdam
Mode(s) of study:	full time
Language of instruction:	English
Joint programmes (double degree):	University Politehnica of Bucharest (Romania) Amrita University (India)
Submission deadline NVAO:	01/05/2020

The visit of the assessment panel Computer Science to the Faculty of Science of Vrije Universiteit Amsterdam took place on 6 and 7 November 2019.

ADMINISTRATIVE DATA REGARDING THE INSTITUTION

Name of the institution:	Vrije Universiteit Amsterdam
Status of the institution:	publicly funded institution
Result institutional quality assurance assessment:	positive

COMPOSITION OF THE ASSESSMENT PANEL

The NVAO has approved the composition of the panel on 15 april 2019. The panel that assessed the bachelor's programme Computer Science and the master's programme Parallel and Distributed Computer Systems consisted of:

- Em. prof. dr. T. (Theo) D'Hondt, emeritus professor in Software Languages and Software Engineering at the Faculty of Sciences and Bioengineering Sciences of Vrije Universiteit Brussel (Belgium) [chair];
- Prof. dr. ir. W.E.A. (Wim) van Petegem, professor and policy coordinator Learning Technologies at the Faculty of Industrial Engineering Technology of KU Leuven (Belgium);
- Prof. dr. S. (Sjouke) Mauw, professor in Security and Trust of Software Systems at the Department of Computer Science of the University of Luxembourg (Luxembourg);
- Drs. L. (Lennart) Herlaar, owner/director at Redbits.nl, a company specialised in software development and IT consultancy, and assistant professor Computer Science at the Faculty of Science of Utrecht University;
- E. (Evi) Sijben BSc, Master's student Computing Science in the specialisation track Data Science at Radboud University [student member].

The panel was supported by M. (Mark) Delmartino MA, who acted as secretary.

WORKING METHOD OF THE ASSESSMENT PANEL

The site visit to the bachelor's programme Computer Science and the master's programme Parallel and Distributed Computer Systems at the Faculty of Science of Vrije Universiteit Amsterdam was part of the cluster assessment Computer Science. Between June and December 2019 the panel assessed 29 programmes at 10 universities. The following universities participated in this cluster assessment: Leiden University, Delft University of Technology, University of Utrecht, Eindhoven University of Technology, Open University, University of Amsterdam, Vrije Universiteit Amsterdam, Radboud University, University of Groningen and University of Twente.

On behalf of the participating universities, quality assurance agency QANU was responsible for logistical support, panel guidance and the production of the reports. P.A. (Peter) Hildering MSc. was project coordinator for QANU. P.A. (Peter) Hildering MSc. and M. (Mark) Delmartino MA acted as secretary in the cluster assessment.

During the site visit at Vrije Universiteit Amsterdam the panel was supported by M. (Mark) Delmartino MA, a certified NVAO secretary.

Panel members of the cluster assessment Computer Science
The members of the assessment panel were selected based on their expertise, availability and independence. The panel consisted of the following members:

- Em. prof. dr. T. (Theo) D'Hondt, emeritus professor in Software Languages and Software Engineering at the Faculty of Sciences and Bioengineering Sciences of Vrije Universiteit Brussel (Belgium) [chair];
- Prof. dr. ir. W.E.A. (Wim) van Petegem, professor and policy coordinator Learning Technologies at the Faculty of Industrial Engineering Technology of KU Leuven (Belgium);
- Prof. dr. S. (Sjouke) Mauw, professor in Security and Trust of Software Systems at the Department of Computer Science of the University of Luxembourg (Luxembourg);
- Prof. dr. J.J. (John-Jules) Meyer, full professor Computer Science and Artificial Intelligence at the University of Utrecht;
- Drs. L. (Lennart) Herlaar, owner/director at Redbits.nl, a company specialised in software development and IT consultancy, and assistant professor Computer Science at the Faculty of Science of Utrecht University;

- T.A. (Tonny) Wildvank, owner/CEO at Wildvank, Management en Advies, specialised in IT-management and -consultancy;
- Prof. dr. J. (Jan) Aerts, full professor Visual Data Analysis at the University of Hasselt and associate professor Visual Data Analysis at the faculty of Engineering Science at KU Leuven (Belgium);
- Drs. H.C. (Jeroen) Borst, senior consultant Smart Cities at TNO;
- Prof. dr. P. (Petros) Koumoutsakos, full professor Computational Science at ETH Zürich (Switzerland);
- Prof. dr. ir. J.M.W. (Joost) Visser, Chief Product Officer at Software Improvement Group (SIG) Nederland and professor Large-scale Software Systems at the Radboud University Nijmegen;
- Ir. E.A.P. (Ewine) Smits, Senior Manager in Advanced Analytics & Big Data at KPMG Nederland;
- Prof. dr. D.P. (Danilo) Mandic, full professor Signal Processing at the department of Electrical and Electronic Engineering of Imperial College London (United Kingdom);
- Dr. ir. J.C. (Job) Oostveen, Research Manager at the Department Monitoring and Control Services at TNO;
- Prof. dr. B.A.M. (Ben) Schouten, full professor Playful Interactions at Eindhoven University of Technology;
- Dr. ir. N. (Nico) Plat, owner/CEO at Thanos IT-consultancy and architecture.
- N. (Nienke) Wessel BSc, master's student Computing Science and bachelor's student Mathematics and Linguistics at Radboud University [student member];
- E. (Evi) Sijben BSc, master's student Computing Science in the specialisation track Data Science at Radboud University [student member];
- B. (Baran) Erdogan, third-year bachelor's student Computing Science at University of Amsterdam [student member];
- M. (Martijn) Brehm, third-year bachelor's student Computing Science at University of Amsterdam [student member].

Preparation
On March 21st, 2019, the panel chair was briefed by QANU on his role, the assessment framework, the working method, and the planning of site visits and reports. A preparatory panel meeting was organised on May 9th, 2019. During this meeting, the panel members received instruction on the use of the assessment framework. The panel also discussed their working method and the planning of the site visits and reports.

The project coordinator and secretary composed a schedule for the site visit in consultation with the Faculty. Part of the visit was dedicated to the joint Master's programme Computer Science, which the Vrije Universiteit Amsterdam is organising together with the University of Amsterdam. The panel's findings on this joint programme are reported in a separate document. Prior to the site visit, the Faculty selected representative partners for the various interviews. See Appendix 4 for the final schedule.

Before the site visit to Vrije Universiteit Amsterdam, QANU received the self-evaluation reports of the programmes and sent these to the panel. A thesis selection was made by the panel's chair and secretary. The selection consisted of 15 bachelor's theses and 15 master's theses and their respective assessment forms, based on a provided list of graduates in the academic years 2016-2017, 2017-2018 and 2018-2019. A variety of topics and a diversity of examiners were included in the selection. The secretary and panel chair assured that the distribution of grades in the selection matched the distribution of grades of all available theses. After studying the self-evaluation report, theses and assessment forms, the panel members formulated their preliminary findings. An additional 4 master's theses were selected before the site visit to complement the panel's view on the exit level of the programme (see Standard 4). The secretary collected all initial findings and questions and distributed these amongst all panel members.

Site visit
The site visit to Vrije Universiteit Amsterdam took place on 6 and 7 November, 2019. At the start of the visit, the panel discussed its initial findings, identified the key issues to be discussed during the sessions, and agreed on a division of tasks during the site visit. During the visit, the panel studied additional documents provided by the programmes. An overview of the materials can be found in Appendix 5. The site visit schedule included a tour across the campus visiting programme-specific learning facilities. The panel also conducted interviews with representatives of the programmes: students and staff members, the programme's management, alumni and representatives of the Board of Examiners. It also offered students and staff members an opportunity for confidential discussion during a consultation hour. Nobody made use of this opportunity. The panel used the final part of the site visit to discuss its findings in an internal meeting. Afterwards, the panel chair publicly presented the panel's preliminary findings and general observations. The visit was concluded with a development conversation, organised jointly by VU and UvA, in which panel members and programme representatives discussed various development routes for the respective programmes. The result of this conversation is summarised in a separate report.

Consistency and calibration
In order to assure the consistency of assessment within the cluster, following measures were taken: the panel composition ensured regular attendance of (key) panel members, including the chair, and the project coordinator was present at the panel discussion leading to the preliminary findings of each programme at all site visits.

Report
After the site visit, the secretary wrote a draft report based on the panel's findings and submitted it to the project coordinator for peer assessment. Subsequently, the secretary sent the report to the panel. After processing the panel members' feedback, the project coordinator sent the draft report(s) to the Faculty in order to have it/these checked for factual irregularities. The project coordinator discussed the ensuing comments with the panel's chair and changes were implemented accordingly. The report was then finalised and sent to the Faculty and University Board.

Minor in Education
The Minor in Education leading to a second degree teaching qualification will be covered in-depth during the assessment of the academic teaching programmes (admission deadline:1 November 2021).

Definition of judgements standards
In accordance with the NVAO's Assessment framework for limited programme assessments, the panel used the following definitions for the assessment of the standards:

Generic quality
The quality that, from an international perspective, may reasonably be expected from a higher education Associate Degree, Bachelor's or Master's programme.

Meets the standard
The programme meets the generic quality standard.

Partially meets the standard
The programme meets the generic quality standard to a significant extent, but improvements are required in order to fully meet the standard.

Does not meet the standard
The programme does not meet the generic quality standard.

The panel used the following definitions for the assessment of the programme as a whole:

Positive
The programme meets all the standards.

Conditionally positive
The programme meets standard 1 and partially meets a maximum of two standards, with the imposition of conditions being recommended by the panel.

Negative
In the following situations:
- The programme fails to meet one or more standards;
- The programme partially meets standard 1;
- The programme partially meets one or two standards, without the imposition of conditions being recommended by the panel;
- The programme partially meets three or more standards.

SUMMARY JUDGEMENT

Bachelor's programme Computer Science
This evaluation concerns the bachelor's programme Computer Science, a three-year full-time 180 EC programme offered by the Faculty of Science at the Vrije Universiteit Amsterdam.

The programme aims at preparing students for both an academic master's programme and a relevant position on the labour market by offering a broad basis in computer science and at the same time it reflects the specific research profile of the Computer Science Department at VU. These ambitions are reflected in the intended learning outcomes: the formulation of the exit qualifications is adequate in terms of domain, level and orientation of the programme, and clearly related to the five European-wide Dublin Descriptors. The panel welcomes the recent exercise by the curriculum team and encourages the programme to include the domain-specific characteristics of the ACM curriculum more explicitly in the programme learning outcomes. The professional field is involved in keeping the bachelor's programme up to date. According to the panel, the functioning of the Advisory Council for Professionals can be enhanced by extending its membership to cover the entire domain of computer science and by meeting more regularly.

The teaching-learning environment of the programme is up to standard. In fact, the panel appreciates the curriculum with its clear focus on areas of research interest at VU while still educating all-round computer scientists. Offering the bachelor's programme in English has enhanced the international composition of the student body and contributes, together with the international staff body, to the atmosphere and the quality of the programme. The programme is feasible for those students who are fully dedicated to their studies. The number of Dutch and international students is growing yet remains within manageable dimensions for the current staff. The teaching staff is highly qualified, introduces students to a wide range of research domains and is appreciated for its dedication, guidance and supervision. The panel noticed furthermore that students and staff are actively involved in safeguarding the quality of the courses and the programme. Four issues require attention and/or action, according to the panel: students should be exposed more to research methodology skills throughout the programme; the depth and detail of certain courses is jeopardised by opening these up to student audiences with diverse backgrounds; the growing student numbers may impact on the quality of course delivery unless teaching materials and methods are redesigned; and the organisation of the academic year should not refrain students from taking a short break somewhere in-between blocks 3 and 6.

Student assessment is well organised in the bachelor's programme Computer Science. The programme features a robust faculty-wide examination policy. The course assessments are valid, reliable and transparent. The programme is taking fraud seriously. Based on its own sample review, the panel considers that overall the assessment process of the thesis is adequate. If used properly, the evaluation format is relevant. While several assessors complete the evaluation form in an insightful way, the panel welcomes the decision of the programme management to have all assessors provide qualitative feedback. The members of the faculty-wide Examination Board, its subcommittee for the computer science programmes and its assessment committee have good expertise to deal with their respective tasks. The panel suggests that the assessment committee verifies in its thesis review sample that the scores on the evaluation form are always motivated in an insightful way.

Bachelor students who graduate from the Computer Science programme are adequately prepared for a follow-up study or a position on the labour market. Having established that each thesis in the sample meets at least the minimum requirements of what can be expected of a final project at bachelor level—and often is of higher much quality—it is fair to state that the intended learning outcomes of the programme are achieved at the end of the bachelor's curriculum. The panel welcomes the attention of the programme for its bachelor graduates and considers that these alumni constitute a good basis for information and advice on the quality and relevance of the programme.

Across all standards, the panel noticed that there have been various small developments to the programme and that the programme has done a good job in addressing the recommendations of the previous accreditation committee. Hence the panel's overall positive appreciation of the programme quality. Nonetheless, one major change—a merger with the UvA—did not come about: this means that two universities in the same city continue to offer separate bachelor's programmes in computer science. According to the panel, the bachelor's programme at VU would benefit from a strategic vision on its future, taking into account the needs and interests of the programme, the staff and the research groups.

The panel assesses the standards from the *Assessment framework for limited programme assessments* in the following way:

Bachelor's programme Computer Science

Standard 1: Intended learning outcomes	meets the standard
Standard 2: Teaching-learning environment	meets the standard
Standard 3: Assessment	meets the standard
Standard 4: Achieved learning outcomes	meets the standard
General conclusion	positive

Master's programme Parallel and Distributed Computer Systems
This evaluation concerns the master's programme Parallel and Distributed Computer Systems, a two-year full-time 120 EC programme offered by the Faculty of Science at the Vrije Universiteit Amsterdam.

The master's programme has a unique position in the higher education landscape because of its focus on PDCS, on scientific research and on preparing students for research-oriented careers. The programme ambitions are reflected in its intended learning outcomes, which are formulated adequately in terms of domain, level and orientation and which take into account the five European-wide Dublin Descriptors. If anything, the programme could improve the functioning of the current Advisory Council of Professionals by turning it into a dedicated sounding board for PDCS.

The teaching-learning environment of the programme is up to standard. In fact, the panel thinks highly about most components of the curriculum, staff and facilities, and was struck by the sheer enthusiasm of the students for 'their' programme that is living up to the highest expectations. The curriculum reflects the objective of the programme to offer students an in-depth education on parallel and distributed computer systems, a wide range of interesting electives and plenty of opportunities to get engaged in hands-on scientific work and independent research. Moreover, the educational concept befits the objective of the programme to educate students for research-oriented positions. The panel appreciates the international composition of the student and staff body, which contributes to the atmosphere and the quality of the programme. The teaching staff on the programme are highly qualified in terms of know-how and research and are appreciated by the students for their dedication, intensive guidance and supervision. The programme has access to adequate research infrastructure within and beyond VU. Students and staff are actively involved in safeguarding the quality of the courses and the programme. Three issues require attention: the programme could indicate more explicitly in the curriculum where students acquire research methodology skills and ensure that all students do acquire these skills prior to starting the master project; the admission and selection criteria for the double degree students coming from two universities in Romania and India need to be enforced in line with the Memorandum of Understanding; and the mandatory courses could be distributed better across the education blocks to have students benefit even more from the wide range of interesting electives.

Student assessment is organised properly in the master's programme PDCS. The programme features a robust faculty-wide examination policy. The course assessments are valid, reliable and

transparent. The programme is taking fraud seriously. The members of the faculty-wide Examination Board, its subcommittee for the computer science programmes and its assessment committee have adequate expertise to deal with their respective tasks. Based on its own sample review, the panel considers that the grading process of the PDCS master project is up for improvement: the current evaluation form does not invite assessors to motivate their appreciations and grades. This in turn reduces the accountability of the assessment towards external parties, an issue that requires even more attention in this programme because the only tangible element, the thesis text, accounts for only one third of the final grade. The panel welcomes the intentions of the management to adjust the thesis evaluation form accordingly and encourages the assessment committee to verify as part of its quality assurance activities that the written feedback is systematic and insightful.

Master students who graduate from the PDCS programme are adequately prepared for a career in industry or academia. It is to the credit of the programme that graduates find attractive positions with a wide range of employers, be them universities, public bodies, R&D departments or (tech) companies. The panel considers that the marginally satisfactory quality of two final projects is due to specific and exceptional situations in the past, which are not likely to happen again in view of the measures announced for admission of new students. Furthermore, the panel would have expected more theses of excellent academic and scientific quality, given the explicit research-oriented profile of the programme and the position of the graduation project in the curriculum. The panel therefore welcomes the increased attention in the curriculum to academic research skills training. Notwithstanding these reservations, the panel considers that the majority of final projects is of sufficiently high quality and demonstrably prepares students very adequately for an academic or professional career. Finally, the panel welcomes the attention of the programme for its graduates and considers that these alumni constitute a good basis for information and advice on the quality and relevance of the programme.

While there have been some developments in the programme since the previous accreditation visit, the major change—a merger with the UvA—did not come about. The panel considers that the current master PDCS is a stand-alone programme of adequate quality that faces a number of important challenges. The panel therefore welcomes the current reflection of the management on the domain-related focus of the programme and suggests it elaborates this exercise into a proper strategic vision on the future. When doing so, the management should take into account the enthusiasm of both students and graduates that the PDCS programme in its current format is a relevant and challenging top master programme.

The panel assesses the standards from the Assessment framework for limited programme assessments in the following way:

Master's programme Parallel and Distributed Computer Systems

Standard 1: Intended learning outcomes	meets the standard
Standard 2: Teaching-learning environment	meets the standard
Standard 3: Assessment	meets the standard
Standard 4: Achieved learning outcomes	meets the standard
General conclusion	positive

The chair, Em. Prof. Dr. T. (Theo) D'Hondt, and the secretary, M. (Mark) Delmartino MA, of the panel hereby declare that all panel members have studied this report and that they agree with the judgements laid down in the report. They confirm that the assessment has been conducted in accordance with the demands relating to independence.

Date: 17 April 2020

DESCRIPTION OF THE STANDARDS FROM THE ASSESSMENT FRAMEWORK FOR LIMITED PROGRAMME ASSESSMENTS – BACHELOR'S PROGRAMME COMPUTER SCIENCE

Standard 1: Intended learning outcomes
The intended learning outcomes tie in with the level and orientation of the programme; they are geared to the expectations of the professional field, the discipline, and international requirements.

Findings
The bachelor's programme Computer Science at the Vrije Universiteit Amsterdam (VU) is offered in its current format since the academic year 2002-2003. Most staff members teaching on the programme are part of the Computer Science Department in the Faculty of Science. This programme, as well as the bachelor's programmes Artificial Intelligence and Information Sciences, are coordinated by the Department and embedded in the College of Information Sciences of the Faculty of Science.

The previous accreditation visit took place in October 2013. At that time, there were plans to form a joint Amsterdam Department of Informatics at one central location on the current VU campus and to re-organise the portfolio of degree programmes accordingly. These intentions developed into very concrete plans until the co-decision bodies (*medezeggenschapsraad*) at university level did not approve the envisaged merger in April 2017. Once it became clear that the merger would not take place, both universities have reviewed their strategy focusing on the needs and interests of their respective department/institute.

The bachelor's programme in Computer Science (BCS) aims to provide students with sufficient theoretical and practical knowledge, understanding of and experience with computer science to enter a relevant master's programme or to start working as a computer science professional. The panel learned from the self-evaluation report that the BCS programme at the VU distinguishes itself from other programmes through the attention it pays to theory that is rooted in computer science, to how data is collected, stored and processed intelligently, and to how humans interact with computers.

The panel noticed that the programme objectives are reflected in the intended learning outcomes (ILOs), which are listed in Appendix 2 to this report. According to the panel, the formulation of the 9 ILOs is clear and relevant; moreover, each learning outcome is related to and motivated by one or more Dublin Descriptors. The panel appreciates the explicit reference (in the fourth ILO) to making students aware of the role of computer science in society, including the related ethical issues.

There is a common understanding among Dutch universities offering computer science programmes that the so-called ACM Computer Science Curricula 2013 serve as domain-specific framework of reference for undergraduate programmes. This reference document is provided in Appendix 1 to this report. The panel gathered from the discussions that in the case of the BCS programme at VU, this reference was mostly implicit until the Programme Director tasked three teaching staff early 2019 to provide a curriculum advice. This document featured a mapping of all courses against the ACM curriculum and a comparison of the ACM graduate characteristics with the intended learning outcomes of the BCS programme. With regard to the latter, the panel learned that the current ILO's do not always contain dedicated exit qualifications for each of the fourteen ACM graduate characteristics, while the characteristics themselves are addressed in the curriculum. The panel appreciates the work of the curriculum team and welcomes its advice to adjust the set of ILO's to cover more explicitly the respective ACM graduate characteristics. Furthermore, the panel agrees to the finding of the curriculum team that compared to the international reference document, the academic perspective of the BCS programme stands out in two intended learning outcomes, i.e. on research and development and on empirical aspects of computer science.

It is an explicit aim of the programme to offer its bachelor students a decent preparation for a position on the labour market. According to the panel, this ambition is confirmed in the exit qualifications, notably but not exclusively in the third ILO: "to have students gain experience in the practical skills that are relevant to the field of computer science and enable students to apply these skills in specific and common professional situations." Furthermore, the panel noticed that the programme monitors the developments in the professional field in different ways, informally via staff contacts with industry, and formally through an alumni survey and the Advisory Council of Professionals (*Werkveldadviesraad*). The panel learned that these formal inputs have been enhanced recently. It welcomes in this regard the efforts of the programme management and the Faculty to address the recommendation of the previous accreditation committee to make more and better use of the input of alumni. While it acknowledges both the contacts with the professional field and the relevant expertise of the individual members of the Advisory Council of Professionals, the panel encourages the programme management to extend the council's membership to cover the entire domain of computer science and have dedicated meetings to discuss strategic developments that impact specifically on the courses and the future graduates of the bachelor's programme.

The panel noticed during the discussions that the envisaged but non-realised merger with UvA has been an important issue for the management of both faculties, for the respective VU, UvA and joint VU-UvA programmes, and for the staff in the computer science department and institute at the two institutions. Several interviewees indicated that it did not only require a lot of effort to prepare for the merger, but once the plans were dismissed it also took time to focus on the needs and interests of the respective institutions and programmes. With regard to the latter point, the panel acknowledges that there is a focus in the bachelor's programme (and for that matter also in the two other programmes under accreditation review) but thinks that this focus requires further elaboration in a proper strategic vision on the future of the respective programmes on offer at VU. In so far as the bachelor's programme is concerned, this vision could start from the current strengths of the programme, take into account the recommendations of the recent curriculum advice, and reflect the situation where two universities in the same city offer separate computer science programmes.

Considerations

The panel considers that the bachelor's programme Computer Science offers not only a broad basis in computer science but also reflects the specific profile of the Computer Science Department at VU. The programme explicitly aims at preparing students for both an academic master's programme and a relevant position on the labour market. According to the panel, these ambitions are reflected in the intended learning outcomes: the formulation of the exit qualifications is adequate in terms of domain (computer science), level (bachelor) and orientation (academic) of the programme. Moreover, there is a clear relation between the ILOs and the five European-wide Dublin Descriptors. The panel welcomes the recent exercise of the curriculum team to map the exit qualifications to the domain-specific characteristics of the ACM curriculum, acknowledges the results, and encourages the programme to implement the suggestions that were put forward in this regard in the advisory document.

While there have been some developments to the programme since the previous accreditation visit, the major change—a merger with the UvA—did not come about. The panel considers that the current bachelor's programme is of sufficient quality. Nonetheless, the situation with two universities in the same city offering separate bachelor's programmes in computer science requires a strategic vision for the future of the programme at VU. This vision could start from the current strengths of the programme and take into account the recommendations of the recent curriculum advice. Furthermore, the panel suggests to discuss the new vision with the Advisory Council of Professionals in order to not only receive relevant input but also to enhance its functioning and ensure the Council's contribution to the programme in the long run.

Conclusion

Bachelor's programme Computer Science: the panel assesses Standard 1 as 'meets the standard.'

Standard 2: Teaching-learning environment
The curriculum, the teaching-learning environment and the quality of the teaching staff enable the incoming students to achieve the intended learning outcomes.

Findings

Curriculum
The bachelor's programme Computer Science (BCS) amounts to 180 EC, which are distributed uniformly across three years of six blocks each. The first two years of the curriculum consist entirely of obligatory courses; the third year includes a minor (30 EC), a bachelor project (15 EC) and three compulsory courses. Appendix 3 to this report provides an overview of the curriculum.

Studying the materials in the self-evaluation report and its annexes, the panel found that the curriculum is coherent. This coherence is enhanced by six learning trajectories: (i) Programming and Software Engineering; (ii) Networks and Systems; (iii) Mathematics and Theory; (iv) Intelligent Systems and Data; (v) Human-Computer Interaction; and (vi) Academic Skills. The panel noticed that the first three trajectories are common to most bachelor's programmes in computer science, while the fourth and fifth trajectory are distinguishing features of the programme at the VU. In this respect, the panel found that the programme has a clear focus on certain important areas within computer science—theory, data science and human-computer interaction—and dares to make choices according to this focus while still delivering on the promise and requirement of educating all-round computer scientists at bachelor level.

The panel noticed with appreciation that topics in mathematics required for the BCS programme are taught within computer science courses: in this way the programme limits the number of 'math only' courses and improves student motivation. Moreover, there is ample attention in the curriculum to topics that could be considered contextual to computer science, such as the history of science, philosophy and ethics, but are nonetheless important to make future computer scientists aware of the role of computer science in society and the dilemmas that come with it. The panel did notice though that there is not so much attention in the curriculum to functional programming, graphics, logics and theoretical computer science.

The previous accreditation committee recommended the programme to encourage students to study abroad. The panel gathered from the discussions with both staff and students that there are opportunities to do so in the curriculum, notably in the fifth semester featuring the minor, and that students are properly and timely informed about this. Nonetheless very few students decide to spend a study period abroad: several international students travelled to the Netherlands for this BCS, while Dutch students prefer the quality of the VU bachelor and the city of Amsterdam over a travel abroad that may not bring the envisaged added value in terms of learning experience. Moreover, students mentioned that several minors are particularly attractive to extend their knowledge on topics such as Deep Programming, Web Services and Data, Data Science or Bioinformatics and Systems Biology.

Students who desire more challenges can sign up for additional courses and projects in the context of the Honours Programme. The panel learned that within specific limits students have considerable freedom in composing their own additional programme of 30 EC: usually an honours package consists of computer science related courses, extra-departmental courses and research work that comes on top of the bachelor thesis. The panel spoke to one honours student, who appreciated the breadth of the optional courses and the additional exposure to research work. Furthermore, students can join extra-curricular contests, such as the Benelux Programming Contest or Hack-in-the-Box. Students interested in education can opt for a 30 EC minor, leading to a second degree teaching qualification.

Before the visit, the panel studied the 'Advice for BS-CS curriculum' document, which three staff members had prepared early 2019 on request of the Programme Director. The panel thinks highly of this document, as it provides an accurate description of the current status of the programme, the issues at stake and possible developments in the short-term and the long-term. Among others, the

document covers two elements which the panel had picked up from other materials and its discussion with students: firstly, the programme pays attention to academic skills, but the curriculum components focusing on research methodology skills that should give students a good basis to start the bachelor project are either lacking or not visibly incorporated in the curriculum. As a result, the panel thinks that the programme should ensure that research skills are embedded in several courses throughout the curriculum, not only in the Introduction to Computer Science course. Secondly, students mentioned that several discipline-specific courses in the learning trajectories are potentially interesting but do not live up to the expectations because of the broad audience to which they are taught. The contents of for instance the Advanced Programming courses are difficult to balance if the audience consists of BCS students with a background in data structures and algorithms, and Business Analytics students who follow the course without prior required background. The panel learned that in the meantime this course has been split and is now offered separately to both audiences and that the management is considering splitting other courses, as well. The panel fully supports these measures.

During the visit, the panel looked into several course materials and found these to be of good quality and at the proper level for an academic bachelor's programme. Moreover, the panel gathered from the curriculum document that altogether, the compulsory courses in the BCS cover nearly all 18 knowledge areas of the ACM curriculum. In this regard, the panel endorses the suggestions of the 'curriculum team' to make some of the ACM knowledge areas (e.g. Graphics and Visualisation and Information Assurance and Security) more visible in the curriculum and to pursue a more in-depth mapping of the bachelor curriculum in relation to the ACM knowledge areas. The materials studied demonstrated according to the panel that altogether the courses cover the intended learning outcomes of the bachelor's programme Computer Science. Further to its considerations on the exit qualifications, the panel found that the Computer Science curriculum is in alignment with the programme profile, the ILOs and the international domain-specific requirements.

Language of instruction
In line with all other degree programmes of the Computer Science Department at VU, the language of instruction in the BCS is English. The panel understands from the self-evaluation report that apart from alignment, there are also other merits for this choice: the programme aims to prepare students for an international job market, to have international staff teach at all levels, and to create an international atmosphere among students and staff. It also aligns with the vision of VU on internationalisation and its ambition to grow towards a community with an international culture where students and employees from different backgrounds meet. Students indicated that they are satisfied with the level of English of the teaching staff. The panel subscribes to the rationale for offering the programme in English. The discussions on site, moreover, have demonstrated according to the panel that the international student and staff body is a value added for the programme.

Educational concept
The panel gathered from the information materials and the discussions that throughout the curriculum, students are exposed to a wide range of teaching formats. For each course the form(s) of instruction correspond(s) to the didactic aim. Many courses are structured as plenary lectures with exercise classes; programming and software engineering courses consist for a significant part of practical work, where students get individual assignments or work in small teams; the four week blocks usually consist of project-type courses featuring a mixture of teaching formats; moreover, students make several group presentations throughout the curriculum, as well as individual presentations in the Introduction to Computer Science course and during their work on the bachelor project; finally, the panel heard about gamification, a teaching technique that uses social gaming elements to deliver education, which was designed in-house and is implemented in the Systems Architecture and Computer Network courses.

Students indicated that the set-up of the curriculum is adequate in view of the transition from secondary school to higher education: the study opens with an approachable first year where introductory courses help students without prior experience become comfortable with the basics of

computer science. In this way everybody is able to tackle the more in-depth courses. Further to its findings on the coherence of the curriculum, the panel found that from an educational point of view the programme structure is sound.

Students mentioned moreover that they appreciate the different teaching formats, but mentioned that the organisation of the academic year in blocks of eight and four weeks hardly allows for any 'breathing space' between Christmas and Summer holiday. In fact, when trying to fit the academic year and its blocks into the calendar year, there is often no break between two semesters, which means that blocks 3 until 6 are scheduled back-to-back. The panel understands this concern and recommends the programme to look for a pragmatic solution.

Furthermore, several teaching staff indicated that due to the growing number of students in information studies related bachelor programmes, their audiences become bigger and bigger. While the current (and increasing) size of the computer science cohorts still suits the character and educational concept of the programme, the number of students in other programmes taking the same courses is also growing and together these student numbers challenge the effectiveness of teaching methods, guidance, thesis supervision and assessment. The panel gathered from the discussions that there are possibilities within the university to re-design courses in an innovative way in order to make these compatible for growing student audiences. It welcomes these initiatives and thinks it is worthwhile investing resources for innovative course materials that serve bigger audiences.

Intake
The panel learned that since the previous accreditation visit, the number of enrolments has been growing from 48 students (in 2012) to 185 (in 2018). In this same period, the share of female students increased from less than 10% to almost 25%. Detailed figures on the nationality of incoming students show that for the last three years, on average 40% of the students are Dutch.

Students indicated that they appreciate the strong international environment in the programme: students from all over the world gather in Amsterdam and study the degree programme together. This allows students to meet people from new cultures and to broaden their perspectives on education, society, and life in general. The panel appreciates this international atmosphere and thinks that the combination with an international staff team adds to the quality of the programme.

Feasibility
Further to the above-mentioned findings on the approachable first year and the sound structure of the curriculum from an educational point of view, the panel gathered that students appreciate the guidance they receive from the teaching staff, the staff and student tutors and the study advisor. According to the students the workload is in line with what can be expected of a full-time study. There are no specific courses that systematically hinder a smooth and timely realisation of the curriculum. Hence, students consider that the overall programme is feasible.

The panel noticed that this is confirmed by the data available on success rate: on average 65% of the students obtain a positive Binding Study Advice (BSA), while 25% drops out during the first year. Overall, 40% of students who enrol in year 2 graduate within the nominal period of three years, while another 15-20% does so in four years. Given the recommendation by the previous assessment committee that the average study duration (54 months) was too long in 2013, the panel discussed the current situation with management, staff and students. It seems that on the one hand more students finish the programme in time or with a slight delay due to the introduction of BSA, the stricter organisation of the bachelor project and the better admission criteria for international students. On the other hand, a smaller group of students takes an increasingly longer time to graduate. These students often combine study with a (IT-related) job and had no intention to finish the programme in time. The panel appreciates the efforts of the programme to reduce the average study length and is fully aware that very often reasons for completing the study with a considerable delay are outside the control of the programme.

Staff
The panel learned that 20 permanent staff members play an important role in teaching the BCS: 16 staff members belong to one of the research groups (computer systems, software engineering, theoretical computer science) while four members focus primarily on teaching. All permanent teaching staff either have a teaching qualification or are in the process of obtaining one. The panel noticed with appreciation that all staff members are expected to teach both a bachelor's and a master's course within their area of expertise. While the English language skills of teaching staff is adequate, according to students, the panel appreciates that there is an English language proficiency requirement of C1 level for new staff. According to the panel it is very important for a truly international programme to set the bar high in terms of language skills.

The panel gathered from the discussions that students appreciate the quality of the staff, both in terms of know-how and didactics. Based on its meetings with the enthusiastic teaching staff, the panel fully subscribes to this appreciation. Moreover, students indicated that staff cares about them, an impression that was confirmed when listening to the teaching staff.

The programme management indicated that the current size of the cohort still suits the character and educational concept of the programme. However, any further growth should be met with additional staffing to maintain the quality of the education and safeguard the interaction between students and staff in class and during thesis supervision. The panel learned that new permanent staff is being hired and that new research groups are built within the Department. Moreover, several junior lecturers have been appointed on fixed-term contracts to support course coordinators in delivering education. According to the panel, the programme has sufficient staff for now and is well prepared to accommodate further growth of the student numbers.

Facilities
The programme uses common facilities on the VU campus. As the current building is out-of-date, the programme will move to modern educational facilities in 2020. The panel noticed furthermore that the Faculty of Science offers a high-tech laboratory (Intertain Lab) for student projects, which facilitates research on the use and effects of technology by and on humans and offers a natural environment with many possibilities for user-centred experiments.

The panel gathered from the information material and the discussions that students play an important role in the quality system of the programme. They fill in course evaluations and are an active part of the Programme Committee. At several occasions during the visit, the panel noticed that this committee of students and staff takes its role seriously and has grown in stature compared to the previous visit of the accreditation committee. Moreover, students indicated that because of the approachable—and safe - education environment they feel taken seriously by the teaching staff and the programme management, and are at ease to address issues of concern.

Considerations
The panel considers that the teaching-learning environment of the bachelor's programme Computer Science is up to standard. In fact, the panel thinks highly of most components of the curriculum, staff and facilities: the programme is both relevant and coherent, with a clear focus on areas of research interest at VU while still educating all-round computer scientists at bachelor's level. From an educational point of view the programme structure is sound. Furthermore, using English as the language of tuition has enhanced the international composition of the student body, which together with an international staff body contributes to the atmosphere and the quality of the programme. The programme is feasible for those students who are fully dedicated to their studies. The number of Dutch and international students is growing yet remains within manageable dimensions for the current staff, who are highly appreciated by the students for their dedication, guidance and supervision. The permanent staff is very qualified and introduces students to a wide range of research domains. Students and staff are actively involved in safeguarding the quality of the courses and the programme.

In addition to these positive elements, the panel identified four issues that require attention and/or action: students should be exposed more (visibly and explicitly) to research methodology skills throughout the programme; students would benefit more from the depth and detail of certain courses if these would be taught only/separately to computer science students; the growing student numbers may impact on the effectiveness of teaching methods unless teaching materials and methods are redesigned; and the organisation of the academic year in six blocks should not refrain programme management from offering students some breathing space somewhere in-between blocks 3 and 6. It goes to the credit of the programme management that these issues either were already on their agenda or have been added to their priority list during the site visit.

Conclusion
Bachelor's programme Computer Science: the panel assesses Standard 2 as 'meets the standard.'

Standard 3: Student assessment
The programme has an adequate system of student assessment in place.

Findings

Assessment system
The panel noticed in the self-evaluation report that the assessment system of the bachelor's programme Computer Science is based on the provisions set by the Faculty of Science. The Faculty provides guidelines on how to set up valid tests and assessments. There is a clear link between the content of the course, the learning goals to be assessed and the chosen assessment method, which ranges from written exams to reports, presentations and practical assignments. Most courses use multiple assessment types in order to stimulate the active learning process of students. Written exams consist usually of open questions, although some exams also feature multiple-choice questions. Several courses include formative assessments that do not count towards the final grade: in these cases, students make automatically generated exercises in an online environment and receive right away the correct answers as feedback.

In 2014, the Faculty of Science established an examination policy for all degree programmes requiring each course to have two examiners and each course coordinator to keep documentation of the exam, including the answer model, assessment matrix and graded results. Because this examination policy was still being rolled out according to the self-evaluation report, the panel inquired about its status in several sessions: it concluded that by now the principles of the policy are clear to all course coordinators / examiners and that this common understanding is reflected in the level of completeness of the individual course dossiers. However, keeping track of the course dossiers is difficult: archiving a complete hardcopy of each dossier with the education office proved to be too laborious, while maintaining a digital dossier is not sufficiently secure. The Faculty is now looking into other options to ensure that the course dossiers can be archived and thus retrieved easily for quality control and completeness. Based on the discussions, the panel thinks that making the course dossiers digitally available would be an efficient solution for both course coordinators/examiners and quality control bodies.

The panel gathered from the information material and the discussions that bachelor students are informed about fraud and plagiarism, but that there is nonetheless a relatively large number of fraud cases in some courses. Students and staff indicated that most fraud cases occur in the first courses at the very start of the programme: students who are not yet used to the university study pace run into time pressure before the first deadlines and resort to copying programmes from each other or from the Internet. In order to counter the number of incidents, the Examination Board published an information leaflet on fraud; students indicated that they are aware of this leaflet and emphasised that academic integrity is covered extensively in the introductory course of the programme and that each lecturer addresses fraud and plagiarism in class. According to the panel, these initiatives contribute to students taking fraud and plagiarism seriously.

Course and thesis assessments
The panel noticed that the assessment principles underlying the bachelor's programme are sound and have been implemented in all courses. On site the panel looked into course files and their respective assessment forms and found these to be appropriate: the questions were valid and reliable. Students indicated during the visit that assessment is transparent: they know in advance what they need to study for the exam and how they will be assessed.

As part of its thesis review, the panel studied a sample of 15 bachelor's projects and their respective assessment forms. Every thesis is graded by two assessors who are staff members of the Department and use a dedicated form with 10 criteria clustered around three components: executed work, thesis and presentation. Each criterion has its own weight within the component and each component contributes to the overall grade: in this way, the scores assessors give per criterion are translated into one grade per component and one overall grade for the entire thesis project. Assessors can motivate their scores in writing per criterion and per component. According to the self-evaluation report, the two assessors attend the final presentation and determine grades for the three components independently, after which they need to come to a consensus on the final grading.

In almost all cases the panel agreed to the final score and to the constituent sub-scores per component, and found that the criteria had been completed properly. While a majority of evaluation forms contained insightful feedback that explained the grades on the different criteria, in a number of cases there was hardly any motivation in writing. In sum, the panel thinks that the evaluation form is relevant, if completed properly. Confronted with these findings, the management and staff indicated that until recently it was encouraged but not mandatory to add written feedback to the criteria and components. Students confirmed that in addition to formative feedback during the thesis trajectory, they also received extensive oral feedback after the presentation. Moreover, in the meantime evaluation forms are no longer completed in writing but have to be typewritten and uploaded; at the same time it was decided that assessors are required to provide a motivation per criterion. The programme management emphasised to the panel that they will follow-up that feedback is provided systematically. Furthermore, the panel could not establish on the basis of the evaluation forms whether the assessors had come to an independent judgement before settling for a common final grade after the thesis presentation. The panel therefore suggests to the programme management to reflect how the independent opinions can be reported on the evaluation form.

Examination Board
The quality of assessment and the end level of the bachelor's programme Computer Science are safeguarded by a subcommittee of the Examination Board at faculty level. There is one subcommittee, which consists of three members, for all bachelor and master programmes. In order to safeguard the quality of assessment and implement the above-mentioned examination policy, the Examination Board has established an assessment committee which is composed of one member per subcommittee. Its tasks are to check through samples of courses and theses that examiners adhere to the provisions of the examination policy.

The panel gathered from the discussion with representatives of the Examination Board and assessment committee that the quality assurance of student assessment is organised properly and that the individual members have adequate experience to fulfil their various tasks. The panel learned that the assessment committee's course controls led to a recommendation to improve the role of the second assessor and to harmonise the assessment matrices. The committee performs regular checks on the quality and grading of the bachelor's theses, and reported no particular concerns. In view of its findings on the evaluation form, the panel suggests that the assessment committee, when reviewing bachelor theses in the future, also looks into the quality of the written feedback.

Furthermore, the panel learned that notwithstanding the existing regulations on fraud and plagiarism and the extensive communication to students, the customised automated fraud detection system uncovers many possible fraud cases. In line with what students and staff had already mentioned, the Examination Board representatives emphasised that most fraud cases happen indeed at the very

start of the programme. The panel supports the efforts of the Examination Board in terms of awareness raising with students on what constitutes fraud.

Considerations
The panel considers that student assessment is well organised in the bachelor's programme Computer Science. The programme features a clear faculty-wide examination policy that is respected by the course coordinators and controlled by the assessment committee, but still requires a secure administrative reporting system. According to the panel, this examination policy will provide a strong fundament for the quality and validity of the assessment when it has been fully implemented.

The policy and principles underlying course assessments are up to standard. The course assessments are valid, reliable and transparent. Moreover, the panel appreciates that the programme is taking fraud seriously.

Based on its own sample review, the panel considers that overall the assessment process of the thesis is adequate. If used properly, the evaluation form is relevant and can be used as inspiration / good practice model for other programmes. While multiple assessors complete the evaluation form in an insightful way, the panel welcomes the decision of the programme management to require that all assessors provide qualitative feedback to motivate their scores. Moreover, the panel suggests to further increase the quality of the thesis assessment by asking assessors to report their independent opinion separately on the evaluation form.

According to the panel, the quality of the assessment is safeguarded properly by the faculty-wide Examination Board, its subcommittee for the computer science programmes and its assessment committee. The individual members have good expertise to deal with their respective tasks. The panel encourages the assessment committee to verify in its thesis review sample that the scores on the assessment criteria and components are always motivated in an insightful way.

Conclusion
Bachelor's programme Computer Science: the panel assesses Standard 3 as 'meets the standard.'

Standard 4: Achieved learning outcomes
The programme demonstrates that the intended learning outcomes are achieved.

Findings

Thesis quality
In order to establish whether students achieve the intended learning outcomes, the panel has reviewed a sample of fifteen bachelor's theses that were accepted in the academic years 2017-2018 and 2018-2019. The bachelor project is an individual research project of 15 EC and meant as a final proof of competence. Students are expected to select a suitable thesis subject and find a staff member who acts as supervisor, upon which student and supervisor agree on a plan in terms of both contents and organisation. Students who wish to do so, can perform their thesis research at a company. Each student presents an advanced draft of his/her work to colleagues in the bachelor seminar, and presents the entire thesis to the assessors at the defence.

The panel found that each of the fifteen theses were of a quality that can be expected of a final project at bachelor's level. In several cases the quality of the work was very high and the topics were varied and interesting. The theses that according to the panel deserved a high score had a strong research question, a decent methodological approach and a thorough theoretical study. Those at the lower end of the continuum all deserved to pass but did less well on the research question and the scientific approach. In a few cases the panel thought that the size of the thesis was rather limited for the envisaged study load.

In a previous section, the panel considered that through the individual courses, the curriculum allows students to acquire the programme's intended learning outcomes. Having reviewed a selection of bachelor projects, the panel considers that students who successfully pass the thesis have indeed achieved all intended learning outcomes. Moreover, the panel considers that the thesis delivers on its rationale: it is a final test where students demonstrate through an individual research endeavour that they have the competences to bring together the knowledge and insights they have acquired before.

Alumni
In addition to verifying the quality of the final deliverables, the academic and/or labour market performance of bachelor graduates is another way to establish whether students achieve the intended learning outcomes upon completion of the programme. Both the information material and the discussions indicated that most bachelor's graduates move on to a master's programme, mostly at the VU. Nonetheless, there is a significant minority of alumni—about one third according to survey data—that enters the labour market and reportedly does so quickly and successfully. In this regard the programme fully delivers on both ambitions preparing students for a follow-up study and a professional career.

Furthermore, the panel welcomes the efforts of the programme, in reply to the recommendation of the previous accreditation committee, to develop an alumni network and organise alumni events, together with the study association, in such a way that alumni become role models for current computer science students.

Considerations
Based on its review of the final thesis projects and the discussions on site, the panel considers that bachelor's students who graduate from the Computer Science programme are adequately prepared for a follow-up study or a position on the labour market.

Having established that each thesis in the sample meets at least the minimum requirements of what can be expected of a final project at bachelor level—and often is of higher quality—it is fair to state that the intended learning outcomes of the programme are achieved at the end of the bachelor's curriculum.

The panel welcomes the attention of the programme for its bachelor graduates and considers that these alumni constitute a good basis for information and advice on the quality and relevance of the programme. Furthermore, the panel appreciates that some of the recently initiated events by the programme and the study association are set up in such a way that alumni become role models for current computer science students.

Conclusion
Bachelor's programme Computer Science: the panel assesses Standard 4 as 'meets the standard.'

GENERAL CONCLUSION

In the previous sections, the panel has come to the conclusion that the bachelor's programme Computer Science at the Vrije Universiteit Amsterdam fulfils the quality requirements with regard to each of the four standards set by the NVAO's Assessment Framework for the higher Education Accreditation System of The Netherlands for limited programme assessments: intended learning outcomes, teaching-learning environment, student assessment, and achieved learning outcomes. Hence, the panel's overall assessment of the *bachelor's programme Computer Science* is 'positive'.

DESCRIPTION OF THE STANDARDS FROM THE ASSESSMENT FRAMEWORK FOR LIMITED PROGRAMME ASSESSMENTS – MASTER'S PROGRAMME PARALLEL AND DISTRIBUTED COMPUTER SYSTEMS

Standard 1: Intended learning outcomes
The intended learning outcomes tie in with the level and orientation of the programme; they are geared to the expectations of the professional field, the discipline, and international requirements.

Findings

The master's programme Parallel and Distributed Computer Systems (PDCS) is offered at the Vrije Universiteit Amsterdam (VU) since 2004-2005. It is coordinated by the Department of Computer Science of the Faculty of Science at VU and embedded in its Graduate School of Information Sciences. Staff teaching on the programme are mainly member of the Computer Systems group in the Department. The master PDCS has strong ties with the joint VU-UvA master's programme in Computer Science. As further elaborated in standard 2, the PDCS programme also features double degree arrangements with two universities, in Romania and India.

According to the description in the self-evaluation report, parallel computing systems aim to solve problems that have a large computational demand or that need to process large amounts of data. Distributed systems consist of many loosely coupled resources, ranging from sensor networks to grids and clouds. Both types share several fundamental challenges, such as scalability, reliability, performance and security.

The master's programme aims to educate students for research-oriented positions at a PhD level or with international research institutes. The panel understood from the information materials and the discussions that the PDCS programme focuses on scientific excellence and takes up a unique position in the higher education landscape of the Netherlands and abroad, and this for a combination of four reasons: the entire programme is dedicated to parallel and distributed computer systems; the staff has extensive teaching and research experience in PDCS; students are actively prepared for scientific research-oriented positions; and the programme has selective entry requirements accepting only a limited number of top quality students. The panel learned furthermore that following the National Student Survey results, the master PDCS was awarded the 'Top Programme' predicate in both 2017 and 2018.

The panel noticed that the objectives of the programme—knowledge of parallel computing systems, distributed computing systems and security; focus on the scientific component; preparation for research-oriented careers—are reflected in its intended learning outcomes (ILOs), which are listed in Appendix 2 to this report. According to the panel, the twelve exit qualifications are described precisely and formulated adequately for an academic programme at master's level. Moreover, each learning outcome is clearly related to one or more Dublin Descriptors, and each of the five descriptors is addressed in several exit qualifications. Furthermore, the panel learned that the programme's focus on performing independent scientific research is in line with the educational vision of the university to create a community of learners: programmes at VU enable students to achieve core competences in their area of expertise, to familiarise themselves with a research culture, and to develop the skills they need to become academic professionals.

According to the information material, the programme educates its students first and foremost to access a PhD programme or another scientific research-oriented position. However, graduates with such research skills are also valuable in industrial and commercial sectors. The panel noticed that the programme monitors the developments in the professional field in different ways, informally via

staff contacts with industry, and formally through an alumni survey and the Advisory Council of Professionals (*Werkveldadviesraad*). The panel learned that these formal inputs have been enhanced recently. It welcomes the efforts of the programme management and the Faculty to address the recommendation of the previous accreditation committee to make more and better use of the input from alumni. While it acknowledges both the contacts with the professional field and the relevant expertise of the individual members of the Advisory Council of Professionals, the panel encourages the programme management to extend the council's membership to cover the entire domain of parallel and distributed computer systems and have dedicated meetings to discuss strategic developments that impact specifically on the courses and the future graduates of this master's programme.

The panel understood from the information materials and the discussions that notwithstanding the positive feedback from students, alumni and the professional field, the programme is attracting fewer students than before. Because parallel and distributed systems are not seen as a 'hot topic' by computer science students, the management is considering to refocus the programme more toward security and possibly rename the programme. The panel learned from the students that the programme focus is already broader than purely PDCS-courses and that they very much appreciate the current structure of the programme and its focus on research and excellence.

In line with its findings on other VU, UvA and joint VU-UvA programmes it reviewed in the framework of this cluster assessment, the panel also thinks that the focus of this PDCS programme requires further elaboration in a proper strategic vision of its future. This vision could start from the current strengths of the programme, benchmark it against an international domain-specific reference framework (or other consensus document on PDCS) and elaborate on what it takes to re-brand the programme while maintaining its feature of top/excellence programme.

Considerations
The panel considers that the master's programme Parallel and Distributed Computer Systems has a unique position in the higher education landscape because of its focus on PDCS, on scientific research and on preparing students for research-oriented careers. According to the panel, the emphasis on independent scientific research aligns with the educational vision of the university. Moreover, the programme ambitions are reflected throughout its intended learning outcomes, which are formulated adequately in terms of domain (parallel and distributed computer systems), level (master) and orientation (academic). Furthermore, there is a clear relation between the ILOs and the five European-wide Dublin Descriptors.

While there have been some developments in the programme since the previous accreditation visit, the major change—a merger with UvA—did not come about. The panel considers that the current master PDCS is a stand-alone programme of adequate quality that faces a number of important challenges. The panel therefore welcomes the current reflection of the management on the domain-related focus of the programme and suggests it elaborate this exercise into a proper strategic vision of the future. According to the panel, the vision should start from the current strengths of the programme, including its attention to excellence, and re-brand it to remain viable in the long run. Furthermore, the panel suggests discussing the new vision with the Advisory Council of Professionals; the discussion will not only provide relevant input but also enhance the functioning of the council and ensure its contribution to the programme in the long run.

Conclusion
Master's programme Parallel and Distributed Computer Systems: the panel assesses Standard 1 as 'meets the standard.'

Standard 2: Teaching-learning environment
The curriculum, the teaching-learning environment and the quality of the teaching staff enable the incoming students to achieve the intended learning outcomes.

Findings

Curriculum

The master's programme Parallel and Distributed Computer Systems (PDCS) amounts to 120 EC, which are distributed uniformly over two years of six blocks each. The curriculum consists of compulsory courses (30 EC), mandatory seminars (12 EC), one constrained elective course (6 EC), the master project (30 EC) and electives (42 EC). Appendix 3 to this report provides an overview of the curriculum.

Studying the materials in the self-evaluation report and its annexes, the panel found that the curriculum is coherent. The compulsory courses all revolve around PDCS, while the broad choice of electives allows students to widen their knowledge and/or finetune their competences in view of the topic of their master's project. In addition to the in-depth coverage of the domain of PDCS, the curriculum offers a lot of opportunities for scientific work and independent research. In this regard, it is worth mentioning the seminar Research Proposal Writing, where students are trained in analysing, evaluating, drafting and defending (PhD) research proposals. Moreover, through the theory and lab courses, students interact with different researchers from the Computer Systems group. Students indicated both in the self-evaluation report and during the visit that the programme really lives up to the expectations: there is a focus on the overlap of security with parallel and distributed computer systems, the curriculum is very challenging and very much oriented towards research. Furthermore, students appreciate the broad range of relevant and interesting electives—among others in the field of theoretical computer science, performance engineering and big data processing—which include courses at the UvA taught in the framework of the joint master's programme in Computer Science.

Notwithstanding the explicit attention of the programme to research, it was not clear to the panel where and how in the curriculum - besides the seminar Research Proposal Writing - students are trained and can practice academic skills and research methodology skills. Given its findings on the master's thesis quality (see standard 4), the panel advises the programme to make this more explicit and visible in the curriculum, and ensure that by the time they start the master's project, all students have acquired these skills up to the high level expected.

The previous accreditation committee recommended the programme to encourage students to study abroad. The panel gathered from the discussions with both staff and students that there are opportunities to do so in the curriculum and that students are properly and timely informed about these. Nonetheless, very few students decide to spend a study period abroad: international students have travelled to the Netherlands for this programme, a few students were already abroad during the bachelor's programme, and others indicated they prefer the (top) quality of this PDCS master over a travel abroad that may not bring the envisaged added value in terms of learning experience.

While this was not entirely clear from the self-evaluation report, it is to the credit of the students that they managed to sketch precisely and convincingly the difference between the Parallel Computing Systems track of the joint master's programme Computer Science and this stand-alone master's programme PDCS. The panel was moreover informed about two double degree master programmes, which attract yearly a few additional students from Amrita University in India and the Polytechnic University of Bucharest. According to the respective Memorandums of Understanding, students who successfully completed the first year (60 EC) of the master's programme at their home university are eligible for the so-called Short Track Master Programme in Parallel and Distributed Computer Systems. This track consists of taking several advanced courses in PDCS and in the preparation of a master's thesis under the supervision from the host university.

Finally, the panel noticed a clear link between the curriculum and the programme objectives / exit qualifications: the learning goals at a course level are strongly connected to the learning outcomes at a programme level. This finding was confirmed when the panel looked into several course files during the visit: the panel found that these materials are of good quality and at the proper level for an academic master's programme. Based on the sample review and the self-evaluation report, the panel is confident that altogether the curriculum allows students to achieve the intended learning outcomes of the master's programme PDCS.

Language of instruction
In line with all other degree programmes of the Computer Science Department at VU, the language of instruction in the master PDCS is English. The panel understands from the self-evaluation report that apart from alignment, there are also other merits for this choice: the programme aims to prepare students for an international job market, to have both Dutch and non-Dutch staff teach at all levels, and to create an international atmosphere among students and staff. It also aligns with the vision of VU on internationalisation and its ambition to grow towards a community with an international culture where students and employees from different backgrounds meet. Students indicated that they are satisfied with the level of English of the teaching staff. The panel subscribes to the rationale for offering the programme in English. The discussions on site, moreover, have demonstrated according to the panel that the international student and staff body is an added value for the programme.

Educational concept
The panel noticed that the teaching concept underlying the PDCS programme is very much in line with the objective of the programme to educate students for research-oriented positions: students on the one hand are provided with advanced courses on parallel systems, distributed computing and systems security, while they are on the other hand increasingly integrated in the ongoing research of the Computer Systems section of the Computer Science Department at VU. Teaching methods vary but usually consist of interactive forms of tuition. Moreover, students deal with complex problems in lab sessions where they get hands-on experience, learn to approach problems individually and reason logically and analytically. Furthermore, the curriculum allows for individual projects and an internship in industry.

During the visit, both students and staff confirmed that this incremental exposure to and interaction with research happens indeed in the day-to-day reality of the programme and constitutes a particular strength of the master PDCS. Given the limited number of students on the programme and the fact that several courses are only open to PDCS students allow for intensive staff-student interaction and make students feel that they are part of the community of researchers. Moreover, students appreciate the scientific and social activities that are organised for them and think highly of the programme director and coordinator who facilitate their integration in the research group. The panel noticed in this regard the enthusiasm of both master's students and their teaching staff. Further to its findings on the coherence of the curriculum, the panel found that from an educational point of view the programme structure is sound.

Intake
The panel learned that since the previous accreditation visit, the number of enrolments has been relatively stable between 10 and 15 per year, but has gone down in the past few years. In September 2018, only 7 students enrolled. A detailed breakdown of student enrolments showed that throughout the years, only a handful of students with a degree from the VU or UvA entered the programme; moreover, in recent years most—and in one year all—students were non-Dutch. Given the small intake numbers, it proved difficult to establish a pattern in the proportion of female students: every year there is at least one female student, but the 2016 cohort included 6 female students among the 12 enrolments. Further to what was already mentioned under the previous standard, the panel shares the concern of the programme management with regard to the long-term viability of the programme and welcomes the dynamic approach of the programme director in this regard who envisages a re-focus of the programme.

Furthermore, the panel obtained detailed information on the admission criteria and entry requirements: students with an academic bachelor's degree in Computer Science or Computer Engineering, with proven proficiency in English and an ability and motivation for studying in a research-oriented context can apply. All applications are individually evaluated by the Programme Coordinator based on diplomas, grades, programming experience, motivation, and recommendation letters. The aim is to select those students who promise both potential and motivation for the programme. The Examination Board for Computer Science admits or rejects students. Looking at the outputs from (former) students and discussing with current students, the panel found that the programme succeeds in attracting the envisaged target group of high potential research-oriented students.

Students in the double degree programme are selected by the partner universities in Bucharest and Amrita. After following a one-year curriculum at these universities, the selected students can follow their second year and perform their master's thesis at VU. Given its findings on the thesis quality (see Standard 4: in addition to several well performing double degree students there were two students who only just reached the minimum quality level), the panel discussed with the programme management about the selection criteria for these students. According to the Memorandum of Understanding with the two partners, the host university will decide to accept a student based on a transcript of records and a letter of recommendation from the home university. However, the programme management indicated that it proved very difficult in the past not to accept students who had been recommended by the partner university. While the panel understands this situation, it nonetheless strongly recommends the management to enforce the provisions of the memorandum, as the same quality standards should be applied to all students graduating from the VU programme. Following the discussion, the panel welcomes the reaction of both programme and faculty management that the admission and selection of students for the double degree programme will be implemented in full respect of the Memorandum and the top-level ambitions of the PDCS programme.

Feasibility
The panel gathered from the discussions that on the one hand the workload of the programme is high; on the other hand, the programme is well structured and its small-scale character includes extensive student-staff interaction which in turn allows to monitor progress and obstacles to finishing the programme in time. Students mentioned to the panel that they appreciate the guidance they receive from the teaching staff, the programme director and coordinator and the study advisor. While according to the students every course is challenging, there are no specific courses that systematically hinder a smooth and timely realisation of the curriculum. Hence, students consider that overall the programme is feasible.

The panel noticed that this overall feasibility is confirmed by the data available on success rate: while the dropout rate is very limited, an overwhelming majority of students finish the programme within the nominal period or with a delay of maximum one year. According to the most recent figure, 10 out of 14 students from the 2016 cohort graduated within two years. According to the panel, this is a good success rate.

Students, however, indicated to the panel that the positioning of the mandatory courses could be improved by spreading these more across the entire two year curriculum (or at least the first three semesters); by doing so, students would have more options to choose the elective courses they really like. The panel understands the viewpoint of the students and therefore welcomes the swift decision of the management to move as of 2019-2020 one mandatory course from the first to the second semester; it moreover invites management, students and staff to identify other possible enhancements of the course schedule.

Staff
The panel learned that 9 permanent staff members of the Computer Systems group form the core teaching team of PDCS as responsible lecturers of the key courses. They all either have a teaching qualification or are in the process of obtaining one. While the English language skills of teaching staff

is adequate, according to the students, the panel appreciates that there is an English language proficiency requirement of C1 level for new staff. According to the panel it is very important for a truly international programme to set the bar high in terms of language skills.

The panel gathered from the discussions that students appreciate the quality of the staff, their dedication to the educational concept of intensive student-staff interaction in courses, lab sessions and research, and the intensity of the graduation project supervision. Based on its meetings with the enthusiastic teaching staff, the panel fully subscribes to this appreciation. Moreover, students indicated that the staff cares about them, an impression that was confirmed when listening to the teaching staff.

Facilities
The programme uses common facilities on the VU campus. As the current building is out-of-date, the programme will move to modern educational facilities in 2020. The panel noticed furthermore that the programme has access to a good research infrastructure and collaborations supporting research: several courses and master projects use the Distributed ASCI Supercomputer (DAS), which reportedly is a unique experimental facility for Dutch computer scientists. The programme also benefits from strong collaborations with the ICT-related institutes at the Science Park campus, such as CWI, NLeSC and SURFsara.

The panel gathered from the information materials and the discussions that students play an important role in the quality system of the programme. They fill in course evaluations and are an active part of the Programme Committee. On several occasions during the visit, the panel noticed that this committee of students and staff takes its role seriously and has grown in stature compared to the previous visit of the accreditation committee. Moreover, students indicated that because of the approachable—and safe - education environment they feel taken seriously by the teaching staff and the programme management, and are at ease to address issues of concern.

Considerations
The panel considers that the teaching-learning environment of the master's programme PDCS is up to standard. In fact, the panel thinks highly about most components of the curriculum, staff and facilities, and was struck by the sheer enthusiasm of the students for 'their' programme that is living up to the highest expectations.

The panel considers that the curriculum reflects the objective of the programme to offer students an in-depth education on parallel and distributed computer systems, a wide range of interesting electives and plenty of opportunities to acquire hands-on scientific work and independent research. In this regard, there is a clear relation between the learning goals at course level and the learning outcomes at programme level. Moreover, the educational concept befits the objective of the programme to educate students for research-oriented positions. The panel appreciates the international composition of the student and staff body, which contributes to the atmosphere and the quality of the programme. The programme is challenging but feasible. According to the panel, the teaching staff of the programme are highly qualified covering a wide range of research specialisms and are appreciated by the students for their dedication, intensive guidance and supervision. The panel considers furthermore that the programme has access to a good research infrastructure and that students benefit from relevant research collaborations, also with institutes outside VU. Finally, the panel found that students and staff are actively involved in safeguarding the quality of the courses and the programme.

In addition to these positive elements, the panel identified three issues that require attention: the programme could indicate more explicitly where students acquire research methodology skills in the curriculum and ensure that all students have acquired the necessary skills to start the master project; the admission and selection criteria for the double degree students need to be enforced by the programme in line with the Memorandum of Understanding with the collaborating universities; and the programme could check whether the mandatory courses can be distributed more adequately

across the curriculum in order to have students benefit even more from the wide range of interesting electives. It is to the credit of the programme management that these issues either were already on their agenda or have been added to their priority list during the site visit.

Conclusion
Master's programme Parallel and Distributed Computer Systems: the panel assesses Standard 2 as 'meets the standard.'

Standard 3: Student assessment
The programme has an adequate system of student assessment in place.

Findings

Assessment system
The panel noticed in the self-evaluation report that the assessment system of the master's programme PDCS is based on the provisions set by the Faculty of Science at the VU. The Faculty provides guidelines on how to set up valid tests and assessments. There is a clear link between the content of the course, the learning goals to be assessed and the chosen assessment method, which ranges from written exams to reports, presentations and practical assignments. Most courses use multiple assessment types in order to stimulate the active learning process of students. Written exams consist usually of open questions, although some exams also feature multiple-choice questions.

In 2014, the Faculty of Science established an examination policy for all degree programmes requiring each course to have two examiners and each course coordinator to keep documentation of the exam, including the answer model, assessment matrix and graded results. Because this examination policy was still being rolled out according to the self-evaluation report, the panel inquired about its status in several sessions: it seems that by now the principles of the policy are clear to all course coordinators/examiners and that this common understanding is reflected in the level of completeness of the individual course dossiers. However, keeping track of the course dossiers is difficult: archiving a complete hardcopy of each dossier with the education office proved to be too laborious, while maintaining a digital dossier is not sufficiently secure. The Faculty is now looking into other options to ensure that the course dossiers can be archived and thus retrieved easily for quality control and completeness. Based on the discussions, the panel thinks that making the course dossiers digitally available would be an efficient solution for both course coordinators/examiners and quality control bodies.

The panel gathered from the information materials and the discussions that master students are informed in class about fraud and plagiarism, but that there are only a limited number of fraud cases, which are handled according to strict procedures by the Examination Board.

Course and thesis assessments
The panel noticed that the assessment principles underlying the master's programme are sound and have been implemented in all courses. On site the panel looked into course files and their respective assessment forms and found these to be appropriate: the questions were valid and reliable. Students indicated during the visit that assessment is transparent: they know in advance what they need to study for the exam and how they will be assessed.

As part of its thesis review, the panel studied a sample of 19 master projects and their respective assessment forms. Every thesis is graded by the supervisor and a second assessor who are staff members of the Computer Science department and use a dedicated form with 20 criteria clustered around three components: research, thesis and presentation. Assessors give an appreciation on each criterion ranging from excellent to insufficient, as well as a grade per component. These grades are translated into a final grade according to a fixed weighting. While each criterion is briefly defined,

there is hardly any room on the evaluation form to provide qualitative feedback to motivate the appreciations on the criteria or the grades per component. According to the self-evaluation report, the two assessors attend the final presentation and determine grades for the three components independently, after which they need to come to a consensus on the final grading.

In a majority of cases the panel agreed to the final score and to the constituent sub-scores per component, and found that the criteria had been completed properly. However, the panel found that in a number of cases, it was not clear how the appreciation of a set of criteria had led to the grade on a component. Moreover, a few cases seemed to indicate that the final grade was the result of a weighted average of quite different scores per component, where a deserved threshold score on the thesis quality component was compensated by a much higher score on e.g. the presentation component. The panel therefore suggests to set a clear threshold of what the minimum requirements are for a thesis to pass, and to decide if compensation across components is possible/desirable. Similarly, the programme may want to consider what grade is allocated when assessors give excellent appreciations on (nearly) all criteria.

Moreover, the panel noticed that only in a handful of cases, the evaluation form contained insightful feedback that explained the assessors' appreciation of the criteria or the grades. According to the panel additional feedback is all the more important for the accountability of the assessment towards external reviewers given that the thesis text, which is reviewed by an external body like the panel, only counts for one third of the grade. In this way, there is no feedback—apart from ticked appreciations per criterion—on the thesis work or the presentation that together account for two thirds of the final grade.

Students mentioned to the panel that in addition to formative feedback during the thesis trajectory, they also received oral feedback after the presentation. The management and staff admitted that the evaluation form does not invite qualitative feedback and indicated that they are looking into adapting the form. The panel welcomes these intentions and strongly encourages management and staff to make the thesis evaluation form more insightful and thus enhance its accountability both internally and externally.

Furthermore, the panel could not establish on the basis of the evaluation forms whether the assessors had come to an independent judgement before settling for a common final grade after the thesis presentation. The panel therefore suggests the programme management to reflect how the independent opinions can be reported on the evaluation form.

Examination Board
The quality of assessment and the end level of the master's programme PDCS are safeguarded by a subcommittee of the Examination Board at the faculty level. There is one subcommittee, which consists of three members, for all bachelor and master programmes. In order to safeguard the quality of assessment and implement the above-mentioned examination policy, the Examination Board has established an assessment committee which is composed of one member per subcommittee. Its tasks are to check through samples of courses and theses that examiners adhere to the provisions of the examination policy.

The panel gathered from the discussion with representatives of the Examination Board and assessment committee that the quality assurance of student assessment is organised properly and that the individual members have adequate experience to fulfil their various tasks. In view of its findings on the thesis evaluation form, the panel suggests that the assessment committee, when reviewing PDCS theses in the future, pays particular attention to the quality of the written feedback.

Considerations
The panel considers that student assessment is organised properly in the master's programme PDCS. The programme features a clear faculty-wide examination policy that is respected by the course coordinators and controlled by the assessment committee, but still requires a secure administrative

reporting system. According to the panel, this examination policy will provide a strong foundation for the quality and validity of the assessment when it has been fully implemented.

The policy and principles underlying course assessments are up to standard. The course assessments are valid, reliable and transparent. Moreover, the panel appreciates that the programme is taking fraud seriously.

Based on its own sample review, the panel considers that the grading process of the PDCS master project is up for improvement: the current evaluation format does not invite assessors to motivate their grades. In the few cases where the panel disagreed on the score, it was difficult to understand how the assessors had come to their grades. Moreover, given that the thesis text only accounts for one third of the final grade, the overall accountability of the assessment towards external bodies is limited. In this regard, the panel welcomes the intentions of the management to adjust the thesis evaluation form and suggests the management should look to the bachelor thesis evaluation form for inspiration. Moreover, the panel suggests to further increase the quality of the thesis assessment by asking assessors to report their individual opinions separately on the evaluation form.

According to the panel, the quality of the assessment is safeguarded properly by the faculty-wide Examination Board, its subcommittee for the computer science programmes and its assessment committee. The individual members have adequate expertise to deal with their respective tasks. The panel encourages the assessment committee to verify in its thesis review sample that the appreciations on the assessment criteria and the scores on the three components are motivated in an insightful way.

Conclusion
Master's programme Parallel and Distributed Computer Systems: the panel assesses Standard 3 as 'meets the standard.'

Standard 4: Achieved learning outcomes
The programme demonstrates that the intended learning outcomes are achieved.

Findings

Thesis quality
In order to establish whether students achieve the intended learning outcomes, the panel reviewed a sample of nineteen master projects that were accepted in the academic years 2016-2017, 2017-2018 and 2018-2019. The master project is an individual research project of 30 EC and meant as a final proof of competence involving an element of originality or creativity.

Prior to the site visit, the panel studied fifteen theses. It found that thirteen theses were undoubtedly of a quality that can be expected of a final project at master's level; two final projects, which were both on the lower end of the scoring continuum, were on the threshold of what the panel could accept as a pass. Given that the thesis sample contained master projects submitted until April 2019, the panel asked the programme for all other theses that had been approved in the meantime. Reviewing another four additional master projects, the panel noticed that the quality of these four theses was invariably good and fully in line with the often high grades.

The panel was somewhat surprised by its findings, given that the master's programme PDCS has an outspoken scientific research oriented profile with high expectations regarding the career of its graduates. Moreover, the curriculum content is very much attuned to this profile and so is the position of the master project, which takes up a considerable study load and features intensive supervision. Notwithstanding its appreciation of several high quality theses, the panel was rather disappointed about the other, average, graduation projects. The panel found that in several cases the academic quality of the thesis and the scientific approach adopted by the students was certainly of an

acceptable level but not very strong. These master projects, according to the panel, did not live up to the very ambitious claims of the programme that each thesis should involve an element of originality or creativity and contribute to the solution or the analysis of a scientific problem.

The quality of the PDCS master projects was an important issue of discussion during the site visit. The programme director, the master project coordinator and the chair of the examination subcommittee provided an extensive and according to the panel convincing explanation about the quality of the two threshold level theses: both students were double degree students and only joined the master's programme at VU for one year. While other double degree students had entered the second year with optimal academic research skills, these two students had to catch up on these skills while writing their thesis project. As already mentioned with regard to intake (Standard 2), the panel thinks that programme management should enforce the provisions on admission stated in the Memorandum of Understanding with the respective partner universities in order to apply the same quality standards to all students graduating from the VU programme. Following the reaction of the management, the panel concluded that the threshold quality of two final projects is due to specific and exceptional situations in the past, which are not likely to happen again in view of the measures announced for admission of new students. With regard to the graduation projects that were of average scientific quality, the programme management and staff indicated that the contents of the research oriented seminars are being reviewed in order to make sure that all students are brought up to a level that allows for high quality final projects, in line with the high standing of the programme.

Alumni
In addition to verifying the quality of the final deliverables, the academic and/or labour market performance of master graduates is another way to establish whether students achieve the intended learning outcomes upon completion of the programme. Both the information materials and the discussions indicated that master graduates are effective in pursuing a career in either academia or industry. While most alumni find relevant employment on the labour market, several graduates do enter a PhD programme. In this regard the panel acknowledges with satisfaction that the programme is delivering on its double ambition, i.e. to prepare its students for entering a PhD trajectory and for taking up an IT-related position in industry.

Furthermore, the panel welcomes the efforts of the programme, in reply to the recommendation of the previous accreditation committee, to develop an alumni network and organise alumni events, together with the study association, in such a way that alumni become role models for current computer science students.

Finally, the panel was struck by the very positive feedback of both students and alumni with regard to the quality of the PDCS programme and its relevance for their academic and/or professional career. While the panel found the self-evaluation report to be rather factual, the PDCS student chapter and the discussions with students and alumni showed the panel that there is an enormous enthusiasm and commitment for this highly challenging top level master's programme.

Considerations
Based on its review of the master projects and the discussions on site, the panel considers that master's students who graduate from the PDCS programme are adequately prepared for a career in industry or academia.

The panel considers that the threshold quality of two final projects is due to specific and exceptional situations in the past, which are not likely to happen again in view of the measures announced for admission of new students. Furthermore, the panel would have expected more theses of excellent academic and scientific quality, given the explicit research-oriented profile of the programme and the position of the graduation project in the curriculum. The panel therefore welcomes the increased attention in the curriculum to academic research skills training.

Notwithstanding these reservations, the panel considers that the majority of final projects is of high quality and demonstrably prepares students very well for entering PhD trajectories and attractive positions in industry. Furthermore, the panel shares the enthusiasm of both students and graduates that this PDCS programme is a relevant and challenging stand-alone top master programme.

The panel welcomes the attention of the programme to its master graduates and considers that these alumni constitute a good basis for information, promotion and advice about the quality and relevance of the programme. Furthermore, the panel appreciates that some of the recently initiated events by the programme and the study association are set up in such a way that alumni become role models for current computer science students.

Conclusion
Master's programme Parallel and Distributed Computer Systems: the panel assesses Standard 4 as 'meets the standard.'

GENERAL CONCLUSION

In the previous sections, the panel has come to the conclusion that the master's programme Parallel and Distributed Computer Systems at the Vrije Universiteit Amsterdam fulfils the quality requirements with regard to each of the four standards set by the NVAO's Assessment Framework for the higher Education Accreditation System of The Netherlands for limited programme assessments: intended learning outcomes, teaching-learning environment, student assessment, and achieved learning outcomes. Hence, the panel's overall assessment of the *master's programme Parallel and Distributed Computer Systems* as 'positive'.

APPENDICES

APPENDIX 1: DOMAIN-SPECIFIC FRAMEWORK OF REFERENCE

Bachelor's programme Computer Science
The bachelor's programme Computer Science uses the ACM Computer Science Curricula 2013 as domain-specific framework of reference. This curriculum framework is used by many programmes across the world and the Dutch computer science programmes have agreed to use it for bachelor's programmes, and as starting point for the master's programmes. This extensive document is available at: https://www.acm.org/binaries/content/assets/education/cs2013_web_final.pdf

The Association for Computing Machinery (ACM) is an internationally recognised institute that produces resources with the intention of helping computer science and similar fields advance scientifically as well as professionally. Besides giving detailed lists of subject matter to be covered in an undergraduate programme, it describes a computer science graduate in 11 characteristics.

At a broad level, the expected characteristics of computer science graduates include the following:
1. Technical understanding of computer science
2. Familiarity with common themes and principles
3. Appreciation of the interplay between theory and practice
4. System-level perspective
5. Problem solving skills
6. Project experience
7. Commitment to life-long learning
8. Commitment to professional responsibility
9. Communication and organizational skills
10. Awareness of the broad applicability of computing
11. Appreciation of domain-specific knowledge

For a more detailed coverage, please refer to chapter 3, page 23 on the above link.

Master's programme Parallel and Distributed Computer Systems
Not applicable.

APPENDIX 2: INTENDED LEARNING OUTCOMES

Bachelor's programme Computer Science

A graduate of the Bachelor programme in Computer Science:

1. Has thorough theoretical and practical knowledge of computer science which will enable the student to successfully complete a Master's programme in the field of computer science or to enter the labour market. This knowledge covers the areas of formal methods, logic and mathematics, programming, computer systems and software design;
2. Has become acquainted with research and development in the field of computer science at an academic level and with the associated scientific skills, and has practiced these skills and demonstrated aptitude in applying them;
3. Has gained experience in the practical skills that are relevant to the field of computer science, and is capable of applying them in specific and common professional situations. This includes using tools to model, assemble, deploy and evaluate computer-based systems;
4. Is aware of the role of computer science in society, including the related ethical issues, as well as the development of the field of computer science and the nature of this academic discipline, and is able to use this awareness when reflecting on his or her own activities and thought processes;
5. Is capable of taking a project-based approach, including participating in a multidisciplinary team, and can maintain an open attitude with regard to the exploratory development of complex systems;
6. Is able to communicate professionally and at an academic level, including the formulation of objectives, the selection of appropriate resources (technology), and the definition of projects and research plans;
7. Is familiar with empirical aspects of computer science, especially the evaluation of various types of systems, both in qualitative and quantitative terms;
8. Is capable of presenting results clearly and succinctly, both orally and in writing (i.e. reports for professional use or of an academic nature);
9. Possesses the requisite learning skills for completing a university Masters programme, and has demonstrated a clear analytical and problem-solving ability.

Master's programme Parallel and Distributed Computer Systems

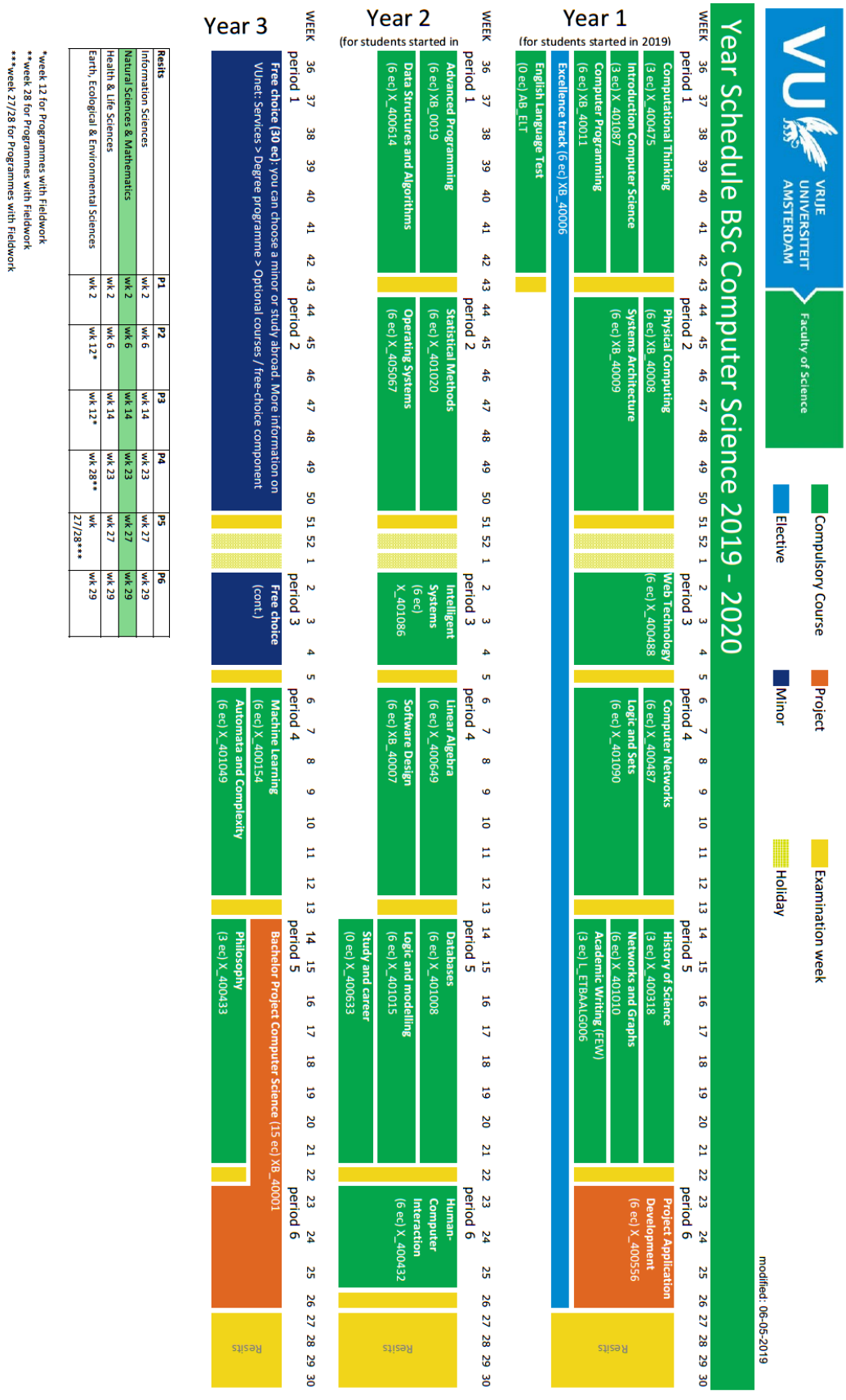
A graduate of the study programme will:

1. have solid scientific knowledge and understanding of Parallel and Distributed Computer Systems, including knowledge of computer systems, programming, operating systems, computer networks, data structures, the theoretical foundations of communication systems and security systems, all of which transcend Bachelor's level;
2. be capable of acquiring knowledge, understanding and skills in other sub-areas of computer science within a reasonable period;
3. have acquired practical skills in relevant areas of computer science at an academic level;
4. be aware of the applications of computer science in general and of Parallel and Distributed Computer Systems in particular, and be capable of applying their knowledge and skills to new and unfamiliar problems;
5. be capable of designing a research plan or project on the basis of a realistic problem description from the field of computer science;
6. be capable of conducting scientific research, both independently and as a member of a small team;
7. be capable of consulting international professional literature on relevant areas of computer science and of using the discussions and results found there;
8. be capable of formulating, analysing and evaluating scientific results, and of using them to draw relevant conclusions;
9. be capable of performing effectively in professional situations where scientific knowledge and skills in the field of computer science are required;

10. have developed a critical scientific attitude and an awareness of the social aspects of information technology;
11. be capable of communicating at a professional level and of giving clear oral and written presentations of their own work or other's work;
12. be thoroughly prepared for an academic programme at PhD level and/or other post-graduate programmes as a professional computer scientist.

APPENDIX 3: OVERVIEW OF THE CURRICULUM

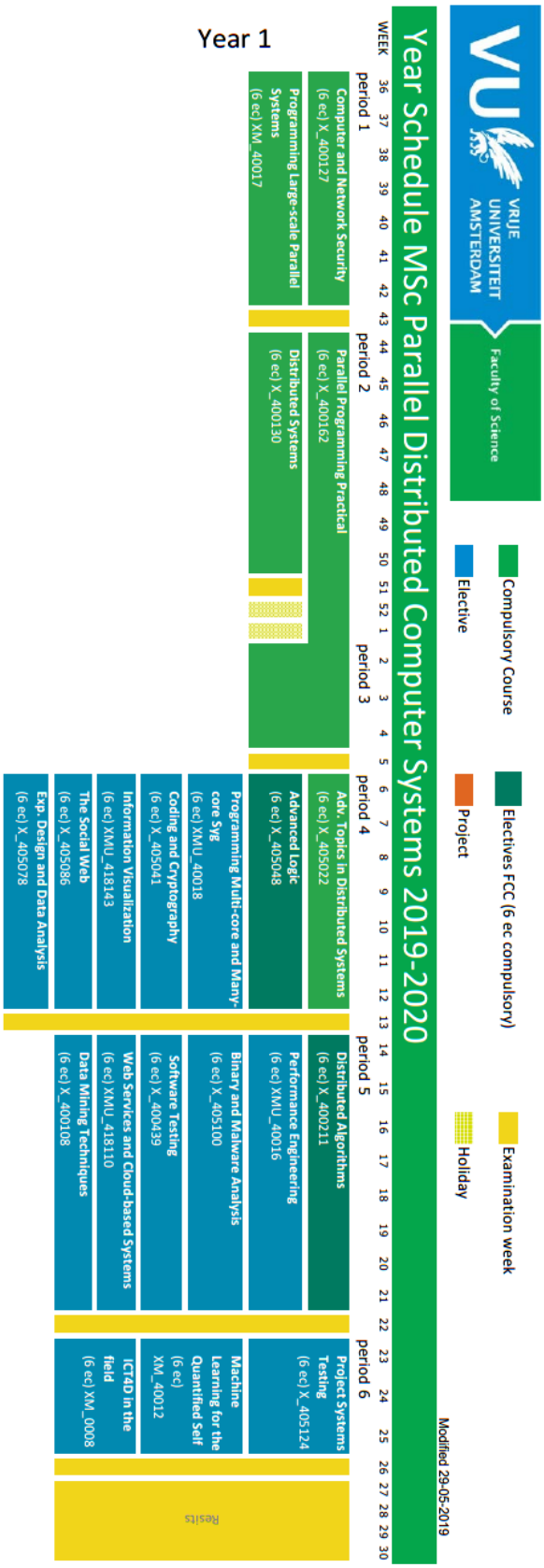
Bachelor's programme Computer Science



Rests	P1	P2	P3	P4	P5	P6
Information Sciences	wk 2	wk 6	wk 14	wk 23	wk 27	wk 29
Natural Sciences & Mathematics	wk 2	wk 6	wk 14	wk 23	wk 27	wk 29
Health & Life Sciences	wk 2	wk 6	wk 14	wk 23	wk 27	wk 29
Earth, Ecological & Environmental Sciences	wk 2	wk 12*	wk 12*	wk 28**	wk 27/28***	wk 29

*week 12 for Programmes with Fieldwork
**week 28 for Programmes with Fieldwork
***week 27/28 for Programmes with Fieldwork

Master's programme Parallel and Distributed Computer Systems



Resits	P1	P2	P3	P4	P5	P6
Information Sciences	wk 2	wk 6	wk 14	wk 23	wk 27	wk 29
Natural Sciences & Mathematics	wk 2	wk 6	wk 14	wk 23	wk 27	wk 29
Health & Life Sciences	wk 2	wk 6	wk 14	wk 23	wk 27	wk 29
Earth, Ecological & Environmental	wk 2	wk 12*	wk 12*	wk 28**	wk 27/28**	wk 29

*week 12 for Programmes with Fieldwork
**week 28 for Programmes with Fieldwork
***week 27/28 for Programmes with Fieldwork

APPENDIX 4: PROGRAMME OF THE SITE VISIT

6 November 2019

09.00 Arrival panel
09.15 Internal panel meeting
11.15 Session with programme management
12.00 Lunch
12.50 Guided tour
13.30 Session with bachelor students
14.30 Session with lecturers bachelor programme
15.30 Session with students master programmes PDCS & CS
16.45 Session with lecturers master programmes PDCS & CS
17.45 Open consultation hour (no appointments)
18.00 Additional session with programme director PDCS
18.45 Internal panel meeting
19.00 End of day 1

7 November 2019

09.00 Session with alumni and professional advisory board
10.00 Session with Examination Board
11.15 Session with programme management
12.00 Lunch & Internal panel meeting
14.00 Plenary feedback
15.00 Development dialogue VU & UvA
16.30 End of site visit

APPENDIX 5: THESES AND DOCUMENTS STUDIED BY THE PANEL

Bachelor programme Computer Science, Self-evaluation report for retaining accreditation, Faculty of Science, Vrije Universiteit Amsterdam.

Master programme Parallel and Distributed Computer Systems, Self-evaluation report for retaining accreditation, Vrije Universiteit Amsterdam.

Prior to the site visit, the panel studied 15 theses of the bachelor's programme Computer Science and 19 theses of the master's programme Parallel and Distributed Computer Systems. Information on the selected theses is available from QANU upon request.

The following materials were made available either as appendices to the self-evaluation reports through the QANU portal or as background information during the site visit:

- Internationalisation policy
- Teaching and Examination Regulation 2019-2020
- Rules and Guidelines for Examination
- Examination Policy of the Faculty of Science
- Annual Report Examination Board 2018-2019
- Minutes Examination Board subcommittee
- Quality Assurance policy

- Curriculum advice for bachelor curriculum
- Overview of the bachelor's curriculum 2019-2020
- Study guide bachelor's programme 2019-2020
- Data tables student intake, drop-out, throughput, success rate
- Overview of international students bachelor's programme
- Overview of staff bachelor's programme
- Assessment plan bachelor's programme
- Pre-assessment form bachelor project
- Assessment form bachelor project
- List of graduates bachelor's programme
- Annual report Programme Committee 2018-2019
- Annual report bachelor's programme 2017-2018
- Course materials and assessment dossiers on:
    - Computer programming
    - Logic & Sets
    - Physical Computing
    - Software Design
    - Philosophy
    - Data Structures & Algorithms

- Overview of the master's curriculum 2019-2019
- Study guide master's programme 2019-2020
- Overview of staff master's programme
- Data tables student intake, drop-out, throughput, success rate
- Overview of international students master's programme
- Assessment plan master's programme
- Pre-assessment form master thesis
- Assessment form master thesis
- List of graduates master's programme
- Overview of recent theses leading to publication
- Partnership Agreement VU – Amrita University

- Partnership Agreement VU – Bucharest University
- Annual report Programme Committee 2018-2019
- Annual report master's programme 2017-2018
- Course materials and assessment dossiers on:
    - Research proposal writing
    - Logical verification
    - Computer & network security
    - Advanced operating systems
    - Service oriented design
    - Advanced logic