Parallel and Distributed Computer Systems MSc

Vrije Universiteit Amsterdam - Faculteit der Exacte Wetenschappen - M Parallel and Distributed Computer Syst - 2013-2014

This master’s programme emphasizes experimental computer science, rather than theory, and typically requires design, implementation, testing, and performance analysis of software for advanced parallel and distributed systems. It contains a balance between classes and practical work: about one third of the first three semesters consists of practical projects. The final semester is a master's thesis, which will usually involve doing research in conjunction with one of the faculty members. In contrast to other master’s programmes, PDCS requires that students explicitly apply to be admitted. Up-to-date information can be found at the FEW-website.

Inhoudsopgave

Compulsory Optional Courses Theory Computer Science

Compulsory choice Theoretical Computer Science of 6 credits, at least one choice out of the courses below.

Note: Every programme, including the choice of optional courses, has to be discussed and agreed upon with the master coordinator or a personal mentor and approved by the Examination Board.

Vakken:

Naam	Periode	Credits	Code
Coding and Cryptography	Periode 1	6.0	X_405041
Concurrency and Multithreading	Periode 1	6.0	X_405064
Concurrency Theory	Periode 1	6.0	X_418103
Distributed Algorithms	Periode 2	6.0	X_400211
Logical Verification	Periode 5	6.0	X_400115
Protocol Validation	Periode 5	6.0	X_400117

Compulsory Optional Courses Programming

Compulsory choice Programming of 6 credits, at least one choice out of the courses below.

Note: Every programme, including the choice of optional courses, has to be discussed and agreed upon with the master coordinator or a personal mentor and approved by the Examination Board.

Vakken:

Naam	Periode	Credits	Code
Computer Networks Practical	Periode 5+6	6.0	X_405072
Operating Systems Practical	Periode 5+6	6.0	X_405071
Parallel Programming Practical	Periode 2+3	6.0	X_400162
PDCS Programming Project	Ac. Jaar (september)	12.0	X_405054

Optional Courses

Vakken:

Naam	Periode	Credits	Code
Advanced Logic	Periode 4	6.0	X_405048
Binary and Malware Analysis	Periode 1	6.0	X_405100

Computer Networking	Periode 4	6.0	X_418102
Concurrent Programming	Periode 3	6.0	X_418105
Evolutionary Computing	Periode 1	6.0	X_400111
Industrial Internship	Ac. Jaar (september)	6.0	X_405080
Internet programming	Periode 1	6.0	X_405082
Performance of Networked Systems	Periode 4	6.0	X_405105
Scientific Writing in English	Periode 2, Periode 6	3.0	X_400592
Selected Topics in Parallel and Distributed Computer Systems	Ac. Jaar (september)	3.0	X_400426
Selected Topics in PDCS	Ac. Jaar (september)	6.0	X_400379
Term Rewriting Systems		6.0	X_400121

Compulsory Courses

The courses Advanced Topics in Computer and Network Security and Advanced Topics in Distributed Systems and Research Proposal Writing and Master Project PDCS are part of the second year of the curriculum.

Compulsory alongside the below mentioned courses (78 credits), are
- optional courses Theoretical Computer Science 6 credits
- optional courses Programming 6 credits
- optional courses Computer Sciences 30 credits

Note: Every programme, including the choice of optional courses, has to be discussed and agreed upon with the master coordinator or a personal mentor and approved by the Examination Board.

Vakken:

Naam	**Periode**	**Credits**	**Code**
Advanced Topics in Computer and Network Security	Periode 2	6.0	X_405021
Advanced Topics in Distributed Systems	Periode 1	6.0	X_405022
Distributed Systems	Periode 2	6.0	X_400130
Large-Scale Computing Infrastructures	Periode 5	6.0	X_405106
Master Project	Ac. Jaar (september)	36.0	X_400461
Parallel Programming for High-performance Applications	Periode 1	6.0	X_400161
Research Proposal Writing	Periode 2	6.0	X_405023
Systems Security	Periode 4	6.0	X_405108

Advanced Logic

Vakcode	X_405048 (405048)

Periode	Periode 4
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	dr. R.D.A. Hendriks
Docent(en)	dr. R.D.A. Hendriks
Lesmethode(n)	Hoorcollege, Werkcollege
Niveau	500

Doel vak
The objective is to obtain a good understanding of modal logic and its use in computer science and artificial intelligence.

Inhoud vak
A thorough introduction to modal logics, and its applications in computer science and artificial intelligence. We will select some themes from the book Modal Logics for Open Minds, by Johan van Benthem: basic modal logic and possible world semantics, bisimulation and invariance, modal definability, decidability, ... In particular we treat the modal logics most relevant to computer science and AI: temporal, dynamic and epistemic logic.

Onderwijsvorm
Weekly 2 lectures and 1 exercise class, for the duration of 7 weeks.

Toetsvorm
A written exam and assignments that can make half a point bonus.

Literatuur
Johan van Benthem, Modal Logics for Open Minds, CSLI Publications 2010.

Aanbevolen voorkennis
The bachelor course Logica en Modelleren (previously Inleiding Logica), or an equivalent introduction to first-order logic.

Doelgroep
mAI, mCS, mPDCS

Advanced Topics in Computer and Network Security

Vakcode	X_405021 (405021)
Periode	Periode 2
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	dr. B. Crispo
Docent(en)	dr. B. Crispo
Lesmethode(n)	Hoorcollege
Niveau	600

Doel vak

The goal of this course is for students to develop an in-depth understanding of classical and recent research in system and network security, and practice their presentation and argumentation skills. The class is restricted only to PDCS students so that individual guidance can be offered.

Inhoud vak
The course takes the form of seminars based on a selection of papers that either have had a strong impact on security today, or explore novel ideas that may be important in the future. Students are required to read all papers assigned during the semester and be able to competently discuss the material in class. Each student will be responsible for presenting one lecture -- that lecture will be based on the assigned paper for the week including as much relevant related work as necessary to distill the work presented in the paper. The speaker will have 25 minutes talk to present the papers she read. The presentation will be followed by 20 minutes of interactive discussion in the class. Before each lecture each student must submit to me at least two thought-provoking questions on the main paper for that week. These questions should critically evaluate the paper (eg, questioning the assumptions). At the end of the semester, each student must write a 4-pages long position paper about one of the topics that has been discussed in class. This can be about the topic the student has presented, or about any other topic that has been discussed in class.This is intended to be an interactive class, and as such, class participation will play a significant role in the grading criteria.
Students will be graded on the presentation and analysis of their assigned paper, their participation in discussions and questions.

Onderwijsvorm
Seminar, active participation

Toetsvorm
Presentations, participation at seminar, and a 4-page position paper. You will be graded with respect to your presentation, your position paper, and your active participation to the seminar. Each of these aspects will account for 1/3 of the final grade.
Important: you have to get at least 6 in all the 3 aspects to be able to pass the exam.

Literatuur
A selection of papers.

Vereiste voorkennis
The class is restricted only to mPDCS students so that individual guidance can be offered

Doelgroep
This course is only accessible for mPDCS students.

Advanced Topics in Distributed Systems

Vakcode	X_405022 (405022)
Periode	Periode 1
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen

Docent(en)	J. Urbani
Lesmethode(n)	Hoorcollege
Niveau	600

Doel vak
Discuss advanced topics relevant for traditional and modern distributed systems.

Inhoud vak
The course takes the form of a seminar that is based on a selection of papers that either have had a strong impact on distributed systems today, or explore novel ideas that may be important in the future. Subjects will cover important aspects of distributed systems such as communication, data consistency, replication, fault; tolerance, performance, scalability, etc. Also, modern distributed systems such as next- generation Web- based systems and wireless sensor networks will have their place. For this seminar we expect the students to actively participate by
means of presentations and discussions. Papers for discussions will be selected from the base set, with possibly 1 or 2 added where appropriate.

Onderwijsvorm
Seminar.

Toetsvorm
Presentations, participation at seminar, and a 4-page position paper.

Literatuur
A (selection of a) list of papers, yet to be decided.

Vereiste voorkennis
Distributed Systems (400130).

Doelgroep
mPDCS

Overige informatie
This course is only accessible for mPDCS students.
More information about this course is available at
http://www.cs.vu.nl/~gpierre/courses/atds/

Binary and Malware Analysis

Vakcode	X_405100 ()
Periode	Periode 1
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	dr. J.M. Slowinska
Docent(en)	prof. dr. ir. H.J. Bos, dr. J.M. Slowinska
Lesmethode(n)	Hoorcollege
Niveau	600

Doel vak
Deepening insights in static and dynamic analysis, applied to binaries and malware

Inhoud vak
Binaries in general, and malware in particular, are very hard to analyse. Unlike with source code, you have no idea what the binary does, or even what the data structures look like - let alone what they mean!. Security analysts, forensic experts, and reverse engineers often have to dig their way through such programs to figure out what the code is all about, and where the interesting pieces of information are.

How do they do this? What techniques and tools can they fall back on, and, conversely, what techniques do the malware authors use to prevent this?

This is a (tough) hands-on specialisation course for a small group of motivated students, who will learn essential analysis techniques and methods in both static and dynamic analysis. Not only will they pick apart real malware, they will also be working on a set of cool and very complicated challenges to find a secret burried deep inside a binary program.

For static analysis, we will look in depth at the generation of control flow graphs, and complications that may arise due to indirect calls and jumps (as well as deliberate obfuscation). For dynamic analysis, we will look at data and control flow tracking (dynamic information flow tracking)

Binary patching will be used to circumvent the binary's defenses. To do so, students need to know details about popular binary formats (ELF, PE, etc.), and work with all manner of state-of-art system tools to analyse the binaries (think IDA Pro, OllyDbg, taint analysis tools, etc.).

In addition, students will be exposed to programs that actively fight static and dynamic analysis.

Onderwijsvorm
Hoorcollege and practical

Literatuur
Slides and online material

Doelgroep
mCS-HPDC, mCS-IWT, mPDCS

Coding and Cryptography

Vakcode	X_405041 (405041)
Periode	Periode 1
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	prof. dr. R.M.H. de Jeu
Examinator	prof. dr. R.M.H. de Jeu

Docent(en)	prof. dr. R.M.H. de Jeu
Lesmethode(n)	Hoorcollege
Niveau	500

Doel vak
To give an introduction the theory of error correcting codes and to cryptography.

Inhoud vak
This course provides a thorough introduction to the theory of error correcting codes, and to cryptography. It is aimed especially at students of Computer Science. For error correcting codes we shall include cyclic codes, BCH codes, Reed-Solomon codes and burst error correction. For cryptography we discuss some modern public key cryptography (e.g., RSA, ElGamal, DSA).

Onderwijsvorm
Lectures and exercise classes

Toetsvorm
Written exam and homework

Literatuur
We shall be working from "Coding theory and cryptography, the essentials" by Hankerson, Hoffman, Leonard, Lindner, Phelps, Rodger and Wall (second edition, revised and expanded).

Aanbevolen voorkennis
Some knowledge on linear algebra, on the integers modulo n, and on polynomials.

Doelgroep
mAI, mCS, mMath, mPDCS

Computer Networking

Vakcode	X_418102 ()
Periode	Periode 4
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	O.W. Schrofer
Lesmethode(n)	Hoorcollege
Niveau	400

Inhoud vak
http://studiegids.uva.nl/web/uva/sgs/nl/c/12057.html

Overige informatie
Course registration at the UVA is compulsory at least 4 weeks before the start of the semester via https://www.sis.uva.nl

Computer Networks Practical

Vakcode	X_405072 (405072)
Periode	Periode 5+6
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	dr. S. Voulgaris
Lesmethode(n)	Hoorcollege
Niveau	500

Doel vak
Put concepts of Computer Networks and Operating Systems into practice, in the context of smartphones.

Inhoud vak
This is a (tough) lab course, that involves low-level programming on Android smartphones. It requires very thorough understanding of operating systems and network concepts. It is done either individually or in groups of two.

Onderwijsvorm
Practical computer work

Toetsvorm
Practical computer work

Aanbevolen voorkennis
Computer Networks (X_400487)
Operating Systems (X_400011)
Good knowledge of Java!

Doelgroep
mCS-CSS, mCS-FCC, mCS-HPC, mCS-IWT, mPDCS

Concurrency and Multithreading

Vakcode	X_405064 (405064)
Periode	Periode 1
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	prof. dr. W.J. Fokkink
Examinator	prof. dr. W.J. Fokkink
Docent(en)	prof. dr. W.J. Fokkink
Lesmethode(n)	Hoorcollege, Werkcollege
Niveau	400

Doel vak
This course provides a comprehensive presentation of the foundations and programming principles for multicore machines.

Inhoud vak

Shared memory, mutual exclusion, synchronization operations, concurrent data structures, scheduling, transactional memory, multithreaded programming.

Onderwijsvorm
Lectures: 4 hours per week, exercise classes: 4 hours per week.

Toetsvorm
Written exam (which counts for 70% of the final mark) and one programming assignment (which counts for 30% of the final mark).

Literatuur
Maurice Herlihy, Nir Shavit, The Art of Multiprocessor Programming, Morgan Kaufmann, 2008.

Doelgroep
mAI-CIS, mAI-KTIIA, mAI-TAI, mCS-FMSV, mCS-HPDC, mCS-IWT, mCS-MM, mCS-SE, mCS-TAI, mPDCS

Overige informatie
The homepage of the course is at http://www.cs.vu.nl/~tcs/cm/

The lectures and written exam of the BSc and MSc variant of Concurrency and Multithreading coincide. The difference is that the BSc variant has a smaller programming assignment than the MSc variant.

The MSc variant of this course cannot be followed by students that included the BSc variant in their BSc program.

Concurrency Theory

Vakcode	X_418103 ()
Periode	Periode 1
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	O.W. Schrofer
Lesmethode(n)	Hoorcollege, Werkcollege, Computerpracticum
Niveau	600

Inhoud vak
http://studiegids.uva.nl/web/uva/sgs/nl/c/2090.html

Overige informatie
Course registration at the UVA is compulsory at least 4 weeks before the start of the semester via https://www.sis.uva.nl

Concurrent Programming

Vakcode	X_418105 ()
Periode	Periode 3
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen

Coördinator	O.W. Schrofer
Lesmethode(n)	Hoorcollege
Niveau	500

Inhoud vak
http://studiegids.uva.nl/web/uva/sgs/nl/c/9475.html

Overige informatie
Course registration at the UVA is compulsory at least 4 weeks before the start of the semester via https://www.sis.uva.nl

Distributed Algorithms

Vakcode	X_400211 (400211)
Periode	Periode 2
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	prof. dr. W.J. Fokkink
Docent(en)	prof. dr. W.J. Fokkink
Lesmethode(n)	Hoorcollege, Werkcollege
Niveau	500

Doel vak
To obtain a good understanding of concurrency concepts and a large range of distributed algorithms.

Inhoud vak
Snapshots, graph traversal, termination detection, garbage collection, deadlock detection, routing, election, minimal spanning trees, anonymous networks, fault tolerance, failure detection, synchronization, consensus, mutual exclusion,self-stabilization, on-line scheduling.

Onderwijsvorm
4 hours per week HC
4 hours per week WC

Toetsvorm
Written examen (plus a take-home exercise sheet that can provide up to 0.5 bonus point).

Literatuur
W.J Fokkink. Distributed Algorithms: An Intuitive Approach. MIT Press, 2013.

Doelgroep
mAI, mCS, mPDCS

Overige informatie
The homepage of the course is at http://www.cs.vu.nl/~tcs/da/

Distributed Systems

Vakcode	X_400130 (400130)
Periode	Periode 2
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	dr. ing. T. Kielmann
Docent(en)	dr. ing. T. Kielmann
Lesmethode(n)	Hoorcollege
Niveau	400

Doel vak
After taking this course, you will be able to:

- understand to a large extent the intricacies related to designing and developing a distributed computer system.

- understand the tradeoffs between centralized, distributed, and fully decentralized solutions.

- be capable of successfully studying research papers on (advanced) distributed systems.

Inhoud vak
It is difficult to imagine a standalone modern computer system: every such system is one way or the other connected through a communication network with other computer systems. A collection of networked computer systems is generally referred to as a distributed (computer) system. As with any computer system, we expect a distributed system to simply work, and often even behave as if it were a single computer system. In other words, we would generally like to see all the issues related to the fact that data, processes, and control are actually distributed across a network hidden behind well-defined and properly implemented interfaces. Unfortunately, life is not that easy.

As it turns out, distributed systems time and again exhibit emergent behavior that is difficult to understand by simply looking at individual components. In fact, many aspects of a distributed system cannot even be confined to a few components, as is easily seen by just considering security.

In this course, we pay attention to the pillars on which modern distributed systems are built. Unfortunately, these pillars cannot be viewed independently from each other: each one is equally important for understanding why a distributed system behaves the way it does, and depends on the way that other pillars have been constructed. In this sense, pillars form principles, in turn offering a view that one can take when studying distributed systems. We will consider the following principles:

- architectures
- processes
- communication
- naming
- coordination
- consistency and replication
- fault tolerance

- security

These principles will be discussed in the context of a few simplifying concepts that have been used to master the complexity of developing distributed systems: objects, files, documents, and events.

Onderwijsvorm
The course is taught as a series of lectures.

Toetsvorm
There is a written exam.

Literatuur
Andrew S. Tanenbaum, Maarten van Steen, "Distributed Systems, Principles and Paradigms", 2nd edition, Prentice-Hall (2007).

Vereiste voorkennis
Students should have taken a standard course on computer networks. Experience with (distributed) programming will be helpful.

Doelgroep
mCS, mPDCS, mAI, mIS

Evolutionary Computing

Vakcode	X_400111 (400111)
Periode	Periode 1
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	prof. dr. A.E. Eiben
Docent(en)	prof. dr. A.E. Eiben
Lesmethode(n)	Hoorcollege
Niveau	400

Doel vak
To learn about computational methods based on Darwinian principles of evolution. To illustrate the usage of such methods as problem solvers and as simulation, respectively modelling tools.To gain hands-on experience in performing experiments.

Inhoud vak
The course is treating various algorithms based on the Darwinian evolution theory. Driven by natural selection (survival of the fittest), an evolution process is being emulated and solutions for a given problem are being "bred". During this course all "dialects" within evolutionary computing are treated (genetic algorithms, evolutiestrategieën, evolutionary programming, genetic programming, and classifier systems). Applications in optimisation, constraint handling and machine learning are discussed. Specific subjects handled include: various genetic structures (representations), selection techniques, sexual and asexual genetic operators, (self-)adaptivity. If time permits, subjects in Artificial Life and Evolutionary Robotics will be handled. Hands-on-experience is gained by a compulsory programming assignment.

Onderwijsvorm
Oral lectures and compulsory pogramming assignment.

Toetsvorm
Written exam and pogramming assignment (weighted average).

Literatuur
Eiben, A.E., Smith, J.E., Introduction to Evolutionary Computing.
Springer, 2003 ISBN 3-540-40184-9.
Slides available from http://www.cs.vu.nl/~gusz/ecbook/ecbook.html .

Doelgroep
mBA, mAI, mCS, mPDCS

Industrial Internship

Vakcode	X_405080 ()
Periode	Ac. Jaar (september)
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	dr. ing. T. Kielmann
Niveau	500

Doel vak
Deepening insights by applying study contents in an industrial setting

Inhoud vak
Individual project work by which the student applies the study contents in an industrial setting. Before the start of the internship, the student has to get approval for the internship project by a VU Computer Science lecturer. The project has to focus on research or development aspects, by which the student can apply and validate the study contents within the specific constraints of an industrial setting. At the end of the internship, the student submits a written report to the lecturer, in which the work, the lessons learned, and the insights from applying study contents in an industrial setting are described.

Onderwijsvorm
individual project work in an industrial setting

Toetsvorm
written report

Aanbevolen voorkennis
The student should have completed at least 48 credits of his or her Master programme such that there are sufficient study contents to be applied in an industrial setting.

Doelgroep
mCS, mPDCS

Overige informatie
Various lecturers

Internet programming

Vakcode	X_405082 ()
Periode	Periode 1
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	dr. S. Voulgaris
Examinator	dr. S. Voulgaris
Docent(en)	dr. S. Voulgaris
Lesmethode(n)	Hoorcollege
Niveau	500

Doel vak
Guide the student through the design and development of Network and Web applications.

Inhoud vak
The course discusses the principles for understanding, designing, and developing Internet applications. This includes programming the network (sockets, threads, RPC, RMI), programming the web interface (servlets, PHP, Javascript, AJAX), and setting up secure communication channels. Throughout the course, as well as in the context of the lab assignments, attention is paid to practical issues of applying these concepts.

Onderwijsvorm
Lectures combined with lab assignments

Toetsvorm
Final exam plus lab assignments

Literatuur
Course slides

Vereiste voorkennis
Knowledge of C, Java

Aanbevolen voorkennis
Good knowledge of both C and Java

Doelgroep
mAI, mCS, mPDCS

Large-Scale Computing Infrastructures

Vakcode	X_405106 ()
Periode	Periode 5
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	dr. ing. T. Kielmann

Docent(en)	dr. ing. T. Kielmann
Lesmethode(n)	Hoorcollege
Niveau	500

Doel vak
Students explore the field of large-scale computing infrastructures. They study its technological frontiers from scientific publications and get hands-on experience via programming assignments.

Inhoud vak
Cloud infrastructures like Amazon's EC2 or Microsoft's Azure provide seemingly limitless compute and storage capacity. The technology underlying these systems strongly relies on decades of work on high-performance computing platforms, such as cluster computing, computing grids, and supercomputers. We study aspects of computing in large scale, such as resource management and scheduling, remote data access, energy efficiency, failure resilience, performance of large systems, as well as suitable software architecture and programming models such as Map/Reduce.

Onderwijsvorm
Introductory lectures, followed by a seminar part and practical programming assignments. In the seminar part, students explore the technological frontiers of large-scale computing, published in top-quality scientific venues of the field. Students present their findings and write position papers about topics presented by other students in the class. With the practical programming assignments, students get hands-on experience with large-scale computing infrastructures.

Toetsvorm
Both parts contribute 50% each to the grade:

- seminar presentation and position paper

- programming assignments

Literatuur
Various scientific articles as available online

Aanbevolen voorkennis
Students should have basic knowledge about distributed systems and parallel application programming.
Students must be able to program in Java and Python (or be able to get the needed skills on the fly).

Doelgroep
mPDCS, mCS

Logical Verification

Vakcode	X_400115 (400115)
Periode	Periode 5
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen

Coördinator	dr. F. van Raamsdonk
Docent(en)	dr. F. van Raamsdonk
Lesmethode(n)	Hoorcollege, Practicum
Niveau	500

Doel vak
Introduction to the proof assistant Coq and its foundations

Inhoud vak
A proof-assistant is used to check the correctness of a specification of a program or the proof of a theorem. The course is concerned with the proof-assistant Coq which is based on typed lambda calculus. In the practical work, we learn to use Coq. One of the exercises is concerned with the correctness proof of the specification of a sorting algorithm, from which a functional program is extracted. In the course, we focus on the Curry-Howard-De Bruijn isomorphism between proofs on the one hand and lambda-terms (which can be seen as functional programs) on the other hand. This is the basis of proof-assistants like Coq. We study various typed lambda calculi and the corresponding logics.

Onderwijsvorm
2 hours theory class, 2 hours practical work

Toetsvorm
Written exam and obligatory Coq exercises

Literatuur
Course notes

Vereiste voorkennis
An introduction course in logic.

Doelgroep
mCS, mAI, mMath

Overige informatie
The course is taught once every two years, the next opportunity will be in study year 2014-2015

Master Project

Vakcode	X_400461 (400461)
Periode	Ac. Jaar (september)
Credits	36.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	dr. ing. T. Kielmann
Niveau	600

Doel vak
With the Master project, the student is to demonstrate the ability to integrate knowledge, insights, and skills gained so far in the Master programme, and to apply them to a new or otherwise unknown subject.

Inhoud vak
The student is offered a research question that needs to be answered following a systematic approach. This approach includes steps such as exploring relevant literature, and will, in general, consist of setting up and carrying out experiments by means of simulations, emulations, or actual systems software. The results and findings will be described in a thesis conforming to the academic standards in the field. An oral presentation of the project results concludes the project.

Toetsvorm
The grade will be determined based on the quality of the performed project work, a written thesis, and an oral presentation.

Aanbevolen voorkennis
The student must have completed (almost) the complete study program before starting the Master Project.

Doelgroep
mPDCS

Overige informatie
Various lecturers

Operating Systems Practical

Vakcode	X_405071 (405071)
Periode	Periode 5+6
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	ir. M.P.H. Huntjens
Docent(en)	ir. M.P.H. Huntjens
Lesmethode(n)	Hoorcollege
Niveau	500

Doel vak
Gain practical experience with the contents of the Operating Systems course.

Inhoud vak
This practical is divided into two separate exercises, each adding functionality to a different part of the MINIX 3 operating system. Both exercises are required to pass the class. The first exercise adds kernel functionality (process profiling), the second one adds file system functionality (defragmentation). Together, these courses cover a significant part of the content of the Operating Systems course.

Onderwijsvorm
Practical computer work

Toetsvorm
Practical computer work.

Doelgroep
mCS, mPDCS

Overige informatie
Students who have not taken the "bedrijfssystemen" or "operating systems" course at the VU are strongly advised to follow the Operating Systems course or study the
internals of MINIX 3 in detail before the start of the course. All information about the course is available online at http://www.cs.vu.nl/~bs/ .

Parallel Programming for High-performance Applications

Vakcode	X_400161 (400161)
Periode	Periode 1
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	prof. dr. ir. H.E. Bal
Docent(en)	prof. dr. ir. H.E. Bal
Lesmethode(n)	Hoorcollege
Niveau	400

Inhoud vak
TThis lecture discusses how programs can be written that run in parallel on a large number of processors, with the goal of reducing execution time. The class has a brief introduction into parallel computing systems (architectures). The focus of the class, however, is on programming methods, languages, and applications. Both traditional techniques (like message passing) and more advanced techniques (like parallel object-oriented languages) will be discussed. Several parallel applications are discussed, including N-body simulations and search algorithms. About 4-5 lectures are devoted to an important new development: programming many-core machines such as Graphical Processing Units (GPUs). The class fits well with existing research projects within the department of Computing Systems. It is a good basis for M.Sc. projects in the area of parallel programming, which use the parallel computing systems of the department.

Onderwijsvorm
Class with separate practicum (6 ECTS).

Toetsvorm
Written exam.

Literatuur
To be announced.

Vereiste voorkennis
Knowledge about the first part of the class Parallel Programming is recommended (introduction into parallel programming, MPI, and Java).

Doelgroep
mAI, mBIO, mCS, mPDCS

Parallel Programming Practical

Vakcode	X_400162 (400162)
Periode	Periode 2+3
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	prof. dr. ir. H.E. Bal
Docent(en)	prof. dr. ir. H.E. Bal
Lesmethode(n)	Hoorcollege
Niveau	500

Inhoud vak
With this practicum, several parallel programs have to be written, using different programming environments, including Java, MPI, and CUDA/OpenCL (for GPUs). The programs must be tested on a parallel machine of the faculty (see http://www.cs.vu.nl/das4) and the performance (speedups) of the programs must be measured, analyzed, and, whenever necessary, optimized. A brief report must be written that explains the approach and discusses the measurements.

Onderwijsvorm
Practical computer work.

Toetsvorm
Practical computer work.

Aanbevolen voorkennis
Parallel Programming Course.

Doelgroep
mAI, mCS, mPDCS

PDCS Programming Project

Vakcode	X_405054 (405054)
Periode	Ac. Jaar (september)
Credits	12.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	dr. ing. T. Kielmann
Niveau	600

Doel vak
Let the student get hands-on experience with developing systems-level software in the context of ongoing research projects

Inhoud vak
PDCS programming projects can be taken instead of other practical courses. They are often related to existing research programs in

computer systems. There is no set course description as each project is negotiated individually with the professor supervising and grading it. The assignment aims to offer students challenging projects that are often research-oriented by nature. Students are strongly advised to talk to staff members individually to see whether they have a project that matches the student's interest, as well as the capacity to supervise such a project.

Onderwijsvorm
Individual programming project

Doelgroep
mPDCS

Overige informatie
Various lecturers

Performance of Networked Systems

Vakcode	X_405105 ()
Periode	Periode 4
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	prof. dr. R.D. van der Mei
Docent(en)	dr. ing. T. Kielmann, prof. dr. R.D. van der Mei
Lesmethode(n)	Hoorcollege
Niveau	400

Doel vak
The student will acquire basic knowledge of:

• performance aspects of software and hardware systems,
• performance aspects of networked systems and services,
• performance engineering principles and methods,
• quantitative models for predicting and optimizing the performance of networked systems,
• quantitative models planning capacity of networked systems.

The student will gain experience in engineering and planning performance of networked systems, and will learn how to tackle practical performance problems arising in the ICT industry.

Inhoud vak
Over the past few decades the use of information and communication technology (ICT) has been experiencing tremendous growth, which is not likely to slow down in the near future. As a consequence, our information and communication systems are expected to process huge amounts of (digital) information, which puts a tremendous burden on our ICT infrastructure. At the same time, our modern society has become largely dependent on the well-functioning of our ICT systems; large-scale system failures and perceivable Quality of Service (QoS) degradation may completely disrupt our daily lives and have huge impact on our economy. Motivated by this, the course will focus on the following performance related issues of networked systems:

- How can we design and engineer networked systems for performance?
- How can we plan capacity in networked systems?
- How can we predict and optimize the performance of networked systems?

In addition to basic theory of performance models and engineering for networked systems, the application of the theory to solve practical problems will play a central role.

Onderwijsvorm
Classroom lectures and practical homework assignments.

Toetsvorm
The assessment will be based on both homework assignments and a written exam.

Literatuur
A textbook, supplemented with a number of subject-matter research papers.

Textbook:
D.A. Menasce, V.A.F. Almeida and L.W. Dowdy
Performance by Design - Computer Capacity Planning by Example
Prentice Hall PTR, Upper Saddle River, NJ 07458
ISBN 0-13-090673-5

Doelgroep
mBA, mCS, mPDCS, mEct

Protocol Validation

Vakcode	X_400117 (400117)
Periode	Periode 5
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Lesmethode(n)	Hoorcollege, Practicum, Werkcollege
Niveau	500

Doel vak
Learning to use formal techniques for specification and validation of communication protocols.

Inhoud vak
This course is concerned with the specification and validation of protocols, using formal methods. The course is based on a specification language based on process algebra combined with abstract data types, called mCRL. This language and its toolset can be used for the specification of parallel, communicating processes with data. Model checking is a method for expressing properties of concurrent finite-state systems, which can be checked automatically. Interesting properties of a specification are: "something bad will never happen" (safety), and "something good will eventually happen" (liveness). In the lab we will teach the use of a tool for automated verification of the required properties of a specification.

Onderwijsvorm
4 hours per week HC
4 hours per week WC/PR (mixed)

During the practicum the mCRL tool and the CADP model checker will be used for the validation of protocols discussed during lectures.

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Toetsvorm
Written exam, together with a practical homework assignment. The overall mark of the course is (H+2W)/3, where H is the mark for the homework assignment, and W is the mark for the written exam.

Literatuur
Wan Fokkink, Modelling Distributed Systems, Springer 2007.

Aanbevolen voorkennis
Logica en Modelleren

Doelgroep
mAI-CIS, mAI-KTIIA, mAI-TAI, mCS-FMSV, mCS-HPDC, mCS-IWT, mCS-MM, mCS-SE, mCS-TAI, mPDCS

Overige informatie
The homepage of the course is at http://www.cs.vu.nl/~tcs/pv/ This course is taught every other year. It will be given in the Spring of 2014.

Research Proposal Writing

Vakcode	X_405023 (405023)
Periode	Periode 2
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	prof. dr. A.S. Tanenbaum
Docent(en)	prof. dr. ir. H.E. Bal
Lesmethode(n)	Hoorcollege
Niveau	600

Doel vak
The aim of this course is to learn to read papers at a research level, organize the material for the framework of a seminar talk, and practice presentation skills for such talk. At the end of this course, the student will be able to acquire the prerequisites for reading and understanding a paper by researching the literature on his own, understand the logic of a paper, and be able to critically evaluate a paper. He or she will be able to extract and condense the material for a talk of a fixed length, and give a captivating and interesting talk to fellow students.

Inhoud vak

This course has the single main aim to teach students the first steps of writing a research proposal. Students are asked to evaluate a number of existing proposals that were submitted by staff members in recent years. In addition, each student will also have to write his or her own proposal, which is then evaluated by fellow students following a procedure very similar to what happens in real life. This class may only be attended by PDCS students.

Doelgroep
mPDCS

Scientific Writing in English

Vakcode	X_400592 (400592)
Periode	Periode 2, Periode 6
Credits	3.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	M. van den Hoorn
Lesmethode(n)	Hoorcollege, Werkcollege
Niveau	400

Doel vak
The aim of this course is to provide the writing student with the essential linguistic means for producing English academic texts which are effective, idiomatically and stylistically appropriate and grammatically correct.

Inhoud vak
The initial focus in the course lies on the form of scientific texts in the Exact Sciences:
• Abstract (or summary)
• Introduction
• Methods
• Results
• Discussion

General course outline
Introducing the topics
- Academic and technical writing in English
- The characteristics of different kinds of scientific texts
- How scientific writing is judged and assessed
- Where do you find your information and how do you present it?
- How to avoid committing plagiarism
Who am I writing for? What do I want to say?
- Your readership
- Key parts of an academic article: title, abstract, introduction, methods, results and discussion
Writing the actual article
- Paragraph and sentence construction: how do I link paragraphs together?
- Writing simple and complex sentences. Active and passive sentences.
- Argumentation : how do I put an argument? How do I frame my own opinion?
Should I use “I” or “we”?

Writing correct English
- Use of apostrophes and colons
- Word order, verb tenses, time and tense
- Avoiding mistakes typically made by Dutch writers
- Common spelling mistakes

You will be making considerable use of peer assessment: examining fellow students' written work and giving them feedback. This method provides useful insights into how a text might be improved. The process of providing someone else with feedback on their text is something that you will find very instructive.

Onderwijsvorm
The course is focused on self-tuition. The plenary sessions concentrate on the process of writing and the product of writing. Homework is part of the course. With each topic, participants work through a phased series of exercises that usually conclude with the requirement to write a short piece of text. The instructor will append extensive written remarks to this text.

Toetsvorm
There will be no examination. However, students will receive their credits only when they have participated in all classes (presence is obligatory) and also when they have handed in the assignments satisfactorily. Students will receive a 'pass' when they have finished the course.

Literatuur
For this course you need the book Effective Scientific Writing: an advanced learner's guide to better English (A. Bolt & W. Bruins, ISBN 978 90 8659 6171). This book can be obtained at the VU bookstore, which is located in the VU main building. The costs are € 27,95 per book. For questions contact the Taalcentrum-VU at 020 - 598 9804.

Vereiste voorkennis
Bachelor Exact Sciences

Doelgroep
Optional for mAI, mCS, mIS, mBIO, mPDCS, mCh, mDDS, mPhys.

Selected Topics in Parallel and Distributed Computer Systems

Vakcode	X_400426 (400426)
Periode	Ac. Jaar (september)
Credits	3.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	dr. ing. T. Kielmann
Niveau	500

Doel vak
The goal of this course is to treat special topics, in the field of parallel and distributed computer systems, that are otherwise not included in the regular curriculum, to individual students as part of further preparation for their master's degree.

Inhoud vak
The actual content of the course is to be decided after consultation of one the PDCS staff members, who will act as project supervisor.

Onderwijsvorm
Individual study under guidance of the supervisor.

Toetsvorm
To be decided by the supervisor.

Literatuur
To be decided by the supervisor.

Vereiste voorkennis
None specific.

Doelgroep
mPDCS

Overige informatie
Two versions of this course exist. X_400426 has a volume of 3EC. X_400379 has a volume of 6EC.

Selected Topics in PDCS

Vakcode	X_400379 (400379)
Periode	Ac. Jaar (september)
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	dr. ing. T. Kielmann
Niveau	500

Doel vak
The goal of this course is to treat special topics, in the field of parallel and distributed computer systems, that are otherwise not included in the regular curriculum, to individual students as part of further preparation for their master's degree.

Inhoud vak
The actual content of the course is to be decided after consultation of one the PDCS staff members, who will act as project supervisor.

Onderwijsvorm
Individual study under guidance of the supervisor.

Toetsvorm
To be decided by the supervisor.

Literatuur
To be decided by the supervisor.

Vereiste voorkennis
none specific

Doelgroep
mPDCS

Overige informatie
Two versions of this course exist. X_400426 has a volume of 3EC. X_
400379 has a volume of 6EC.

Systems Security

Vakcode	X_405108 ()
Periode	Periode 4
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	prof. dr. ir. H.J. Bos
Docent(en)	prof. dr. ir. H.J. Bos
Lesmethode(n)	Hoorcollege, Werkcollege
Niveau	500

Doel vak
Introductory (but very tough) course on security with a scope that includes systems
work. At the end of the course students will deeply understand the basic notion of memory corruption attacks (buffer overflows, format strings, etc), SQL injection, cross-site scripting attacks, and other vectors used by computer hackers. The course is very(!) hands-on.

Inhoud vak
The course covers a wide spectrum of security issues. We explicitly aim wider than cryptography, as we want to show students how hackers penetrate systems. Much of the course will be hands-on: in lab assignments, student will carry out and investigate attacks in a controlled environment. This involves programming at the both the highest and lowest levels (say SQL and assembly). However, we will plan to discuss cryptography and trust infrastructures.

Onderwijsvorm
Lectures and (very challenging) practical assignments.

Toetsvorm
Written exam (30%) and practical assignments (70%).

Literatuur
No set book. All material will be made available during the course.

Aanbevolen voorkennis
No formal requirements, except a keen interest and a lot of time. Programming experience
in C very strongly recommended. Knowledge of assembly and computer architecture helps too.

Doelgroep
mCS, mPDCS.

Term Rewriting Systems

Vakcode	X_400121 (400121)
Credits	6.0
Voertaal	Engels
Faculteit	Faculteit der Exacte Wetenschappen
Coördinator	dr. R.C. de Vrijer
Docent(en)	drs. J. Endrullis
Lesmethode(n)	Hoorcollege, Werkcollege
Niveau	600

Doel vak
Learning the fundamental notions of term rewriting and getting acquainted with some more advanced topics in the field

Inhoud vak
The course description is; available on
http://studiegids.uva.nl/web/uva/sgs/nl/c/14304.html

Onderwijsvorm
Lectures and practice sessions

Toetsvorm
Written examination

Literatuur
Course notes will be provided

Vereiste voorkennis
Compulsory: Inleiding logica.
Advised: Inleiding theoretische informatica.

Doelgroep
mCS, mAI, mMath

Overige informatie
The course is taught once every two years, the next opportunity will be in study year 2014-2015

Term rewriting systems (TRSs) provide for a natural formalism for specifying rules of computation and investigating their properties. TRSs are of basic importance for functional programming and for the implementation of abstract data types. Applications can also be found in theorem proving, proof checking and logic programming. Some topics that will be covered in the course are:
- abstract reduction systems
- critical pairs and Knuth-Bendix completion
- orthogonality and reduction strategies
- termination (rpo's, monotone algebras)
- combinatory logic
- decidability issues
- infinitary rewriting