

## Deel 1 Algemeen

**Verantwoordelijke deca(a)n(en): Prof.dr. A. Blik**  
**Naam programmaleider masterprogramma: Prof.dr. A.P.J.M. Siebes**  
**Naam masterprogramma: Computing Science**  
**Engelse naam masterprogr: Computing Science**  
**Onderdeel van 'opleiding' (croholabel): Informatica - 66978**  
**Start per (maand en jaar): September 2010/ January 2011**  
**School/onderwijsinstituut: Graduate School of Natural Sciences**  
**Taal masterprogramma: Engels**  
**Vorm (voltijd/deeltijd): Voltijd**  
**Type programma (academisch / educatief / onderzoek): Onderzoek**  
**Titulatuur: Master of Science (MSc)**

### Algemeen

- 1 Wat is de reden om dit programma te starten?

(The application for internal certification concerns the joining of two existing master programs in the information and computing sciences into one master program of greater attractiveness and effectivity. This section gives the details.)

The information and computing sciences continue to develop rapidly, and their application impacts on every aspect of science and society. There is a strong need in science, industry and business for the advanced insights and skills of the field, to develop the complex information and software systems of the present and of the future. Information technology is recognized as one of the main drivers of innovation today. The experience with master education in ICT shows that in academic research and industrial R&D, as well as in many application areas, there continues to be a growing need for graduates with an academic background (MSc and PhD) in the advanced concepts, design methods and technologies of the discipline.

The design of information and software systems is not a matter of separate data-, algorithm-, software-, and interface considerations. As the insights in these separate areas have advanced, it has become widely understood that the design of information-driven systems in any domain requires considerations from multiple areas combined rather than separately. Also in research there is an increasing trend to combine domains that were traditionally studied separately, as a necessary development in understanding the principles of information-driven systems. Many students see this development in informatics and are attracted by the more integral concern, in which concepts and design, and thus theory and application requirements are combined in the surrounding of concrete IT challenges. In fact, it is also reflected in the development of the relevant chairs in computer science in the 'Departement Informatica'.

In view of these developments it is necessary to better tailor our master curricula to the needs of the informatics field and educate our students from this broader perspective, in the interest of their proper scientific training as well as their career possibilities in the field. The master education in this domain of computer science presently consists of two research masters: (1) Applied Computing Science, and (2) Software Technology. These separate programs will now be combined into one joint program called 'Computing Science' (CS). Already now students can choose courses from the individual programs in their individual study path. By integrating

the programs, we will be able to offer a far more flexible and attractive master program, which will give students the possibility to study across borders in the discipline.

From the perspective of the Faculty of Science, offering the combined programs as one joint program under a recognized representative name is an important step in optimizing its master offerings: it creates a timelier program, it gives more flexibility to the students, and it allows for greater efficiency from the perspective of the 'Department Informatica'.

## 2 Studentprofiel: beoogde doelgroep (lokaal, nationaal, internationaal)

Students with a BSc in informatics (computer science), or a BSc degree in a closely related program (information science, cognitive AI, mathematics, HBO Informatica, etc.) with a core in computer science (both theory and practice-oriented) at the UU BSc level either in their 'profielingsruimte' or in a minor, who want to specialize in computer science.

The program aims at students with a BSc in informatics or equivalent from the UU, from other universities in the Netherlands, as well as from international undergraduate programs in informatics/computer science of the specified level. In fact, the program is expected to have a much greater visibility and attractiveness to foreign students than the individual programs thus far, as the program conforms more to the scope as found internationally in Computer Science masters.

Graduates with a (Dutch) HBO bachelor degree in informatics continue to qualify for admission, provided their study program contains the right prerequisites in the formal aspects of informatics.

## 3 Omschrijving van algemene doelstelling en globale inhoud van het masterprogramma

The two-year master program in 'Computing Science' provides students with a strong foundation in the concepts, analysis techniques, and design methods underlying the development of modern information and software systems.

The program provides a modern and integrated mix of disciplinary knowledge, design and experimentation, and research in the combined areas of at least five chairs in computer science (Meyer, Siebes, Swierstra, van der Gaag, and van Leeuwen). The content of the program is based on the proven repertoires of the constituting master programmes, but now providing greater flexibility to students to combine courses in their individual study lines and greater efficiency for the department.

## 4 Karakterisering vervolgperspectieven nationaal en internationaal

Upon successful completion of the program, students obtain the MSc degree in Informatics of Utrecht University. It is the nationally and internationally recognized degree in Informatics which qualifies students for entering subsequent PhD programs in Computer Science as well as for beginning careers as software designers, specialists and/or consultants in IT companies and businesses. Experience with the old master programmes shows that UU graduates are in demand, and there is every reason to expect that this will only improve under the new combined program.

PS. The master programme 'Computing Science', which joins two existing master programmes into one with a timelier and more attractive focus, is firmly based on the well-

established educational and organizational framework of the 'Departement Informatica' and the UU Graduate School of Natural Sciences.

## **Deel 2      Informatie t.b.v. de beoordeling van de aanvraag**

### **Doelmatigheid**

- Wat is de minimumomvang van het programma qua instroom (welk aantal nieuwe studenten is jaarlijks nodig om het programma rendabel aan te bieden; indien mogelijk met cijfers onderbouwen)

The (minimum) expected size of the program is 50 students in each year of study. This is an increase of 20% over the old constituent programs which currently have an influx of 10-15 and 20-25 students respectively per year, with additional numbers of students from other master programmes taking courses from the programs as well.

- Wat is de maximumomvang van het programma

With the current research groups, an annual influx of up to 60-70 masterstudents can be accommodated. If the number of applicants exceeds this capacity, students will be deferred to other master programs in Informatics. In the extreme case that all master programmes in Informatics exceed their capacity, normal procedures of selection will be applied.

- Wat is de verwachte omvang van de jaarlijkse instroom (met onderbouwing)

The expected influx of the program is 50-60 students yearly, rising to 60-70 per year after two years. The new program will draw students on the combined profile, where we replace the profile of the old programs to reach a modernized program of greater attractiveness and with more and better options for the students. Further growth is expected after the new program becomes more widely known and especially international and HBO students will enter in larger numbers. We expect at least a 20-30% increase over the old programs together.

- Wat zijn de op de studenten en/of inhoud concurrerende programma's vanuit de UU (en is hier overleg mee geweest)

Within the Graduate School of Natural Sciences there currently are six master programmes in the central field of the information and computing sciences: Agent Technology, Applied Computing Science, Business Informatics, Content and Knowledge Engineering, Game and Media Technology, and Software Technology. The joining of Applied Computing Science and Software Technology into the new program 'Computing Science' creates no change in the relationships between these and other programs of the School. The focus of the joined master program remains unique among the programs.

(NB The master programme Content and Knowledge Engineering will be phased out in 2010-2011.)

- Wat zijn de op de studenten concurrerende programma's van andere universiteiten in en buiten Nederland en wat zijn de unique selling points van de opleiding in Utrecht?

The UU MSc programs in the information and computing sciences have a well-established position. Other universities likewise have their own spectrum of master programmes, with specializations that are different from those in Utrecht. Several universities have modified

their master offerings lately as well, just like Utrecht is doing now, to reflect the changes in the scientific and applied orientations of the ICT field.

In most MSc programme offerings in computer science there is a tendency towards master programmes that are broader, more generic and less topical (as seen e.g. at VU). Whereas the joining of the two master programmes here into one master programme 'Computing Science' is necessary for intrinsic scientific reasons, it is also necessary for maintaining the competitive position of Utrecht at the master level.

Utrecht's unique selling points are: the unique combination of high quality research expertise in algorithmic design, data analysis and decision support systems, and software technology in the supporting chairs, the flexibility that students have while focusing in their program line, and the proven record in master education in 'Informatica'. The UU master programmes in Informatica were all reviewed in the External Evaluation in 2007 and found to be in sound shape (cf. Onderwijsvisitatie Informatica, QANU September 2007).

## **2 Programma**

- Wat is de omvang van het programma in studiepunten

120 ECTS, i.e. 5 blocks of 15 ECTS each, followed by an MSc project (also including a colloquium requirement) of 45 ECTS.

- Wat is het competentieprofiel: bereidt het programma voor op een carrière in de wetenschap, of op beroepen op academisch niveau buiten het wetenschappelijk onderzoek?

Graduates of the program are educated and trained in the advanced concepts, algorithmic principles, and software design methods in computer science research, in the context of creating and understanding complex information and software systems. The competence profile is common to a large part of computer science. The orientation towards scientific research in combination with the high-level skills acquired in designing (components of) information-based systems is in high demand in the IT industry as well. Career perspectives include scientific (PhD-) research in computer science (Informatics, incl. ICT) as well as positions as software designer/specialist in IT companies (small and large) and in IT divisions of other companies or institutions. The profile is similar to that of the constituent programs.

- Op welke wijze wordt dit competentieprofiel in het programma gerealiseerd (globale aanduiding van inhoud&vorm van beroepsvoorbereidende onderdelen)

The master programma combines four large domains of research which constitute main pillars of computer science: languages and formal methods, algorithms and complexity, data analysis and logic, and decision making under uncertainty. These domains are the core areas for the understanding and the design of modern information and software systems, although even more aspects can come into play in an integrated approach.

The structure of the new combined master programme follows the standard MSc curriculum structure shown in Table 1 below. The program is based on a core set of courses in any one of the joint key domains of the chairs in the program and a set of optional courses which fit the particular core research direction and the interest of the student. A student is also required to participate in the regular software or algorithmics colloquium series of the program, an important element for creating and maintaining the student community in the program. (This

is a 'best practice' in one of the existing programs and it will be extended to a requirement in the joint program.) The first period has a provision for 'homologatie', especially for the benefit of HBO students with HBO-bachelor degrees that do not fully meet the entrance requirements.

Table 1. Overview of the curriculum

	year 1				year 2			
	semester 1		semester 2		semester 1		semester 2	
	period 1	period 2	period 3	period 4	period 5	period 6	period 7	period 8
timeslot 1	course	course	course	course	course	MSc project and -thesis		
timeslot 2	course	course	experimentation project + seminars					

In more detail, the MSc programme 'Computing Science' provides the following generic curriculum of courses and activities:

- Period 1: Programming language concepts, software engineering, probabilistic reasoning, intelligent agents, advanced data mining
- Period 2: Advanced functional programming, algorithms and networks, evolutionary computing, multimedia retrieval
- Period 3: Compiler construction, model checking, scheduling and time-tabling, decision theory, learning from data, experimentation project
- Period 4: Generic programming, software architecture, algorithmic mechanism design, simulation, experimentation project, research seminar
- Period 5: Automatic program analysis, queries and retrieval, experimentation project, research seminar
- Period 6-8: MSc project and –thesis.

together with the software and algorithmics colloquia series. (The actual rostering in periods 1-5 may differ slightly, depending on the yearly scheduling constraints.)

The program realizes the competence profile by means of study lines ('studieadviespaden') directed to research areas of the collective chairs of the program. A study line consists, as a rule, of (a) a core of 5 required courses, (b) a motivated choice of 5 further master courses (including seminars, up to two experimentation projects, and courses from other cores or even other master programmes if this is motivated by the chosen core), and (c) a MSc thesis project in the second master year (internal in the department or external in another research institute or a company) and prepared for by the chosen core.

As in our current proven practice, a student must define his/her preferred study line at the start of his master study, with required approval by the program coordinator. A study line may include a theoretical or applied focus, depending on a student's preference and perspectives. Later modifications in a chosen study line always require renewed approval of the program coordinator, again following current 'best practice' of the existing programs.

A study line allows the student to combine and integrate one or two (or several) domains of research expertise according to his/her interests and motivations. The following study lines are anticipated, with their cores of required courses. (The study lines will also be part of the information for prospective students.)

- Software design
  - Core: programming language concepts, software engineering, advanced functional programming, compiler construction, software architecture
- Formal methods and program analysis
  - Core: programming language concepts, advanced functional programming, model checking, generic programming, automatic program analysis
- Algorithm design and complexity
  - Core: intelligent agents, algorithms and networks, scheduling and time-tabling, algorithmic mechanism design, simulation
- Advanced planning and decision making
  - Core: probabilistic reasoning, algorithms and networks, evolutionary computing, decision theory, scheduling and time-tabling, simulation
- Engineering Bayes (design of decision processes with uncertainty)
  - Core: programming language concepts, probabilistic reasoning, advanced functional programming, decision theory, software architecture
- Big data (data analysis, data mining, pattern discovery and information retrieval).
  - Core: advanced data mining, multimedia retrieval, learning from data, queries and retrieval.

The additional courses in a study line are determined based on relevance to the chosen core direction and the combination of different subareas, following the philosophy of the new program. (This includes the possibility of including other courses, including courses from other master programmes such as e.g. Technical Artificial Intelligence, if this is motivated by the chosen core.) The study lines above are not meant to be limiting for the student but indicate the most representative lines.

- *In het geval van een programma dat vooral voorbereidt op een carrière in de wetenschap:*

>welke graduate school is betrokken bij het programma

Graduate School of Natural Sciences.

>zijn er afspraken gemaakt met onderzoekscholen en/of graduate school voor de overstap van studenten naar een PhD traject

Graduates qualify for PhD studies in the areas of the supporting chairs and in a broad range of other subareas of computer science. At virtually all universities and research institutes (also in our Faculty of Science), PhD positions are often bound to externally funded research projects. The larger number of chairs in the joined program can be expected to give more continuous opportunities for PhD positions.

*In het geval van een programma dat vooral voorbereidt op academische beroepen buiten het wetenschappelijk onderzoek:*

- >welke beroepen/beroepsvelden, nationaal, internationaal

Graduates qualify for professional careers in the Software and IT industry and in companies and (profit or non-profit) organizations which require complex information and software systems for their operations. Graduates from the old constituent programs are in demand and find jobs in a great variety of industries and companies.

- >zijn er afspraken met beroepsorganisaties en zo ja, welke

There are many contacts with industry, and the professional requirements (varying with time and without great uniformity) of qualified academically trained employees are quite well understood. The change towards an integrated master programme with greater choice options is one of the direct consequences of this. The organization of national research schools (IPN – Informatica Platform Nederland) represents computer science in many national contexts towards industry. The master program links to two of the schools which are well-represented in the department (IPA – Institute for Programming Research and Algorithmics, and SIKS – School for Information and Knowledge Systems).

- Welke leerstoelen participeren in het programma, in welke verhouding en wat is de inzet

The master programme joins the expertise of the constituent programs. The following chairs therefore participate in the master programme: prof.dr A. Siebes (Algorithmic Data Analysis), prof.dr S.D. Swierstra (Software Technology), prof.dr.ir L.C. van der Gaag (Decision Support Systems), and prof.dr J. van Leeuwen (Algorithmic Systems). The chairs of professors Siebes and van der Gaag also contribute to the master programme Technical Artificial Intelligence (the new name of the program Agent Technology). The joint chairs cooperate closely.

- Welke onderdelen van het programma kunnen aan andere instellingen in Nederland of in het buitenland worden gevolgd of uitgevoerd

All parts of the master programme can, in principle, be taken at other academic Computer Science departments, in the Netherlands or abroad, subject to approval by the program coordinator (who supervises the study lines) and the Committee for the Master Exams.

### 3 Diploma-eisen

(The answers to the questions below are essentially identical to those for the constituent programs but included here for completeness.)

- Wat zijn de eisen die aan een student worden gesteld qua
  - theoretische verdieping/cursorisch onderwijs (omvang in studiepunten)

The cursory part of the program consists of 60 ECTS in the first master year and 15 ECTS in the second. Study lines consists of 30-40 ECTS in foundational master level courses, and the further ECTS in motivated optional courses, seminars and up to 15 ECTS in experimentation projects.

- zelfstandige onderzoekopdracht (omvang in studiepunten)

The MSc thesis project is carried out in blocks 2, 3 and 4 of the second master year and has a size of 45 ECTS.

- externe stage (omvang in studiepunten)

The MSc thesis project can be carried out in a project (‘research stage’) externally, again of 45 ECTS in size.

- Op welke wijze wordt getoetst of een student aan de diploma-eisen voldoet

Every part of the program is assessed separately, by our usual standard. The primary means of assessment in the cursory part consists of classroom participation and (written) examinations. Seminars are assessed based on the quality of the presentations, written summaries and participations, and experimentation projects on the novelty and quality of the study and the reporting. MSc thesis projects are assessed based on individual quality, development and performance during the project, the quality of the results and of the resulting MSc thesis and the quality of the final presentation. A more detailed description of the assessment is given in the 'Docentenhandleiding Informatica Versie 5.1' which also gives uniform guidelines for grading (master-) projects.

#### **4 Ingangseisen** (*Indien selectieve toelating, zie ook punt 5*).

Wat moet de student minimaal aan kennis en kunde in huis hebben om met een voor het programma normale inspanning in 1 of 2 jaar (afhankelijk van programmaduur) de eindtermen van het masterprogramma te halen. Het is niet de bedoeling om cursussen te noemen, maar juist om in te gaan op de benodigde competenties.

(The answers to the questions below are essentially identical to those for the current programs but included here for completeness.)

- kennis en vaardigheden die nodig zijn om met een voor het programma normale inspanning de eindtermen van het masterprogramma te halen

The entrance requirement conforms to the level and contents of the UU major in Informatics. For foreign/ HBO students also: an adequate ability to speak, communicate and write in the English language (ToEFL level as required by the Graduate School). More concretely, students qualifying for entrance must:

- have a reasonable experience in the use of several programming languages (amongst which functional and object-oriented languages)
  - have adequate knowledge of the workings of computer systems, networks and operating systems
  - have a basic knowledge of algorithms and data structures, their design and analysis
  - have a basic knowledge of modern software construction
  - have a basic knowledge of computer science and logic
  - be able to reason formally, and
  - be able to communicate facts and findings verbally and in writing, including using information and communication technology and audio-visual means.
- bachelorprogramma (binnen en buiten de UU) dat waarschijnlijk aan deze eis voldoet

The UU BSc degree in Informatics is a standard ('doorstroom'), but the BSc degrees in Informatics (Computer Science) at many regular universities in the Netherlands and abroad are nowadays equivalent to it to the extent that is needed for entry in the master programme 'Computing Science'. Suitable standards must be achieved in basic backgrounds, as in the UU major, in the domains of programming (Java, C#, Haskell, software engineering) and algorithmic and formal methods (datastructures, discrete mathematical methods, complexity theory). *Other* BSc programmes that likely satisfy the entrance requirements include:

- a BSc in Mathematics (with a minor in informatics) or Artificial Intelligence,
- a HBO-bachelor in the 'HBO-opleiding Informatica',

- a HBO-bachelor in Informatics/Information Technology other than the 'HBO-opleiding Informatica',

in all cases depending on the particular program followed.

- procedure voor studenten die niet geheel aan de toelatingseisen voldoen

Small deficiencies (less than 15 ECTS) are facilitated in the 'homologatie' in the first period of the program. If the entrance requirements are not fully met by a student and the deficiency is larger, but motivation and other indicators are convincing, the Admissions Committee may allow a student to prepare for entrance by means of an individual pre-master program of at most three (bachelor-level) courses which must be passed before qualifying for entrance in the master programme. With HBO's whose bachelor program(s) in informatics do not meet the entrance requirements fully as a rule, a standard pre-master package can be agreed which students can embed in their individual study program in the HBO if they wish to qualify for entrance beforehand. A well-functioning arrangement of this type exists e.g. with the HU.

## 5 Toelatingsprocedure en selectieve toelating

- Hoe is de toelatingsprocedure georganiseerd

The admissions procedure follows the standard procedure in the Graduate School of Natural Sciences. The concrete admission decisions for the master program are taken by the graduate admissions committee, after consultation with the program leader. No changes wrt the current practice are needed or foreseen.

- Indien het een programma betreft met een beperkte instroom en selectieve toelating (kwalitatieve selectie van in principe gekwalificeerde kandidaten):
  - wat zijn de selectiecriteria

Not applicable.

- hoe is de selectieprocedure georganiseerd

Not applicable. (If selection is needed due to overload, the selection process will follow normal procedures.)

## 6 Inschrijving en startmomenten

- Op welke momenten kan een student het programma starten in het academische jaar

Students are expected to enter the program in September (start of the first period) or in February (start of the third period). The majority is expected to enter in September, in accordance with the normal periodicity in the completion of BSc programs.

## 7 Verplichting programmaleiding

- Beschrijving van de activiteiten gericht op
  - de begeleiding van studenten bij hun studie

The program coordinator supervises all individual programs. Before entering the MSc program, every student must seek approval of his/her preferred program with the program coordinator, following any one of the main options or alternative. Subsequently, every MSc

student is under supervision by the program coordinator and a tutor from any of the chairs underlying the program. In the last part of their MSc studies, the supervision is carried out by the MSc thesis supervisor.

- o de voorbereiding van studenten op een latere beroepsuitoefening

The options for further (PhD-) study or careers in industry or business are part of the advising by the MSc thesis supervisor, who most closely works with (a group of) particular students. The preparation for a research career (PhD position) normally requires anticipation on the part of the student and (thus) of the tutor resp. the supervisor, as the qualification for a PhD (AiO) position at UU or elsewhere may require an orientation on specific research themes.

- o de specifieke begeleiding van internationale studenten

Foreign students need assistance when entering the master programme and, more generally, the university where they will spend the next two years of their academic training. The Graduate School of Natural Sciences resp. the student union organizes a yearly introduction week around September 1<sup>st</sup> which introduces all (new) master students to the faculty, the departments where they will study, the campus, the city, and their fellow students in the program. In all practical matters of the program, the policy of the existing and new programs is to let new students become part of the chair groups as quickly as possible e.g. as participants of the regular software and algorithmics colloquium meetings of the groups.

June 2nd, 2010.