### Program overview

**Year**  
2017/2018

**Organization**  
Electrical Engineering, Mathematics and Computer Science

**Education**  
Master Computer Science

<table>
<thead>
<tr>
<th>Code</th>
<th>Omschrijving</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS4010</td>
<td>Algorithms for Planning and Scheduling</td>
<td>5</td>
</tr>
<tr>
<td>CS4175</td>
<td>Seminar Algorithms: Automated Scheduling</td>
<td>5</td>
</tr>
<tr>
<td>IN4301</td>
<td>Advanced Algorithms</td>
<td>5</td>
</tr>
<tr>
<td>IN4335</td>
<td>Seminar Algorithms: Economics and Computation</td>
<td>5</td>
</tr>
</tbody>
</table>
The Algorithms group designs and evaluates algorithms to solve problems in complex systems where decentralization, uncertainty, conflicting interests, and time constraints are major issues. Think of real-time balancing of energy supply and demand in communities of producers and consumers, or of coordinating schedules for service providers at airports in order to ensure that planes are cleaned at the right time and provided with fuel and food services.

To design such algorithmic solutions we build upon fascinating fundamental scientific findings in computer science. In our group you learn how to design and use advanced algorithms using methods from planning and scheduling, algorithmic game theory, and sequential decision making under uncertainty. Also you will learn to implement these algorithms efficiently and to use the right methods to evaluate their performance.

Once you have obtained this algorithmic expertise, you can participate in our groups research projects on topics such as smart grids, transportation systems, surveillance or maintenance. Quite a number of these projects involve industrial partners such as Alliander, NedTrain and Thales. A good example of a recent master thesis is Frits de Nijs thesis Project Scheduling: The Impact of Instance Structure on Heuristic Performance, available at our website (http://www.alg.ewi.tudelft.nl). This website also contains information about possible master thesis projects.

To participate in a master thesis project you need to have completed at least our Advanced Algorithms course and two of our specialization courses.
<table>
<thead>
<tr>
<th><strong>CS4010</strong></th>
<th><strong>Algorithms for Planning and Scheduling</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Responsible Instructor</strong></td>
<td>Dr. M.T.J. Spaan</td>
</tr>
<tr>
<td><strong>Contact Hours / Week</strong></td>
<td>4/0/0/0</td>
</tr>
<tr>
<td><strong>Start Education</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>Exam Period</strong></td>
<td>none</td>
</tr>
<tr>
<td><strong>Course Language</strong></td>
<td>English</td>
</tr>
<tr>
<td><strong>Expected prior knowledge</strong></td>
<td>Basic knowledge of algorithms and optimization.</td>
</tr>
<tr>
<td><strong>Course Contents</strong></td>
<td>The course introduces algorithms for automated planning and scheduling (P&amp;S) from an Artificial Intelligence perspective. Main topics that will be considered are planning under uncertainty (partially observable Markov decision processes, POMDPs), resource-constrained project scheduling, multiagent planning and temporal planning. The course consists of a series of introductory lectures, both by the responsible instructor as well as by experts in particular topics. Furthermore, guest lectures by industry are envisioned to show how P&amp;S algorithms can be applied in practice. In parallel with the lectures, students collaborate in small groups on a distinct research project per group, for instance on P&amp;S problems in transport, logistics or smart energy grids. Purely algorithmic challenges will also be provided. The lectures and research projects provide a good opportunity to learn about topics suitable for Masters projects in the Algorithmics section.</td>
</tr>
<tr>
<td><strong>Study Goals</strong></td>
<td>After completing the Algorithms for Planning and Scheduling (P&amp;S) course, the student is able to: 1. Explain general techniques used in P&amp;S algorithms. 2. Explain several specific P&amp;S problem settings and corresponding algorithms. 3. Apply P&amp;S algorithms to problem domains, and can compare and evaluate them. 4. Design and implement an extension of a P&amp;S algorithm. 5. Communicate his/her findings effectively.</td>
</tr>
<tr>
<td><strong>Education Method</strong></td>
<td>Approximately 10 lectures combined with a research project (of 110 hours) in a small group. Three homework exercises (of 2 hours each) based on the lectures.</td>
</tr>
<tr>
<td><strong>Literature and Study Materials</strong></td>
<td>Mainly survey papers and book chapters.</td>
</tr>
<tr>
<td><strong>Assessment</strong></td>
<td>The assessment consists of the following items: 1. Homework exercises based on the lectures (20%) 2. Quality of work of the research project (30%) 3. A scientific report of the research project (including peer review of a report) (20%) 4. Performance during the project (15%) 5. Oral presentation of the research project (15%) Only items 2 and 3 can be examined a second time.</td>
</tr>
<tr>
<td><strong>Enrolment / Application</strong></td>
<td>Only a limited number of students can participate in this course. In order to be admitted, please submit a short motivation letter (max 200 words) via Brightspace. Attending the first lecture is compulsory.</td>
</tr>
<tr>
<td><strong>Remarks</strong></td>
<td>The 2017/2018 offering is the final offering as a seminar course.</td>
</tr>
<tr>
<td><strong>maximum aantal deelnemers</strong></td>
<td>30</td>
</tr>
</tbody>
</table>
**Seminar Algorithms: Automated Scheduling**

<table>
<thead>
<tr>
<th>Responsible Instructor</th>
<th>Dr. N. Yorke-Smith</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact Hours / Week</td>
<td>0/0/4/0, seminar</td>
</tr>
<tr>
<td>Education Period</td>
<td>3</td>
</tr>
<tr>
<td>Start Education</td>
<td>3</td>
</tr>
<tr>
<td>Course Language</td>
<td>English</td>
</tr>
</tbody>
</table>
| Expected prior knowledge | For this course you need to be able to read scientific papers/books (e.g. you have followed the bachelor seminar course), you need to be able to understand and analyse algorithms (e.g. you have followed a course on algorithm design), you need to be comfortable with probability, and you need to be able to use basic Artificial Intelligence search techniques (e.g. you have followed an introductory course on AI).

Also, it is preferred to have some knowledge of combinatorial optimization methods (e.g. from a course on Operations Research or Computer Science), and to have some knowledge and experience with reasoning about the computational complexity of problems (e.g. from a course on complexity theory).

**Course Contents**

Scheduling concerns the effective planning and management of time and resources. It has a crucial role in business, industry, government, and education. Scheduling lies at the intersection of Operations Research, Artificial Intelligence, and Computer Science.

In this course we will study real-life scheduling problems from an algorithmic perspective, paying attention also to the challenges of data and system development.

We go beyond classical scheduling problems studied in traditional Operations Research, such as the job shop scheduling problem [see WI4062TU], and focus on realistic problems with complex constraints and objectives.

In particular we discuss topics such as:
- meta-heuristic methods
- constraint-based methods
- project scheduling
- airline scheduling
- timetabling
- personnel scheduling
- design of scheduling systems

The course is a student seminar. Students therefore will have to participate in preparing and presenting lectures on the basis of a provided reading on the topics selected.

**Study Goals**

After completion of this course, the student has an overview of the state of the art in automated scheduling and its applications.

Students can identify scheduling applications from a variety of sectors, and evaluate the (dis)advantages of methods for solving scheduling problems in them. Students are able to find solutions to new applications in the literature and present the results on this in a scientific manner.

Further, the student is able to prepare and give an interactive lecture on the above topics based on provided and researched material, including:
- defining lecture goals
- making a lecture plan, and
- making exam questions.

**Education Method**

Student seminar; since we need to allocate topics, please register for this course on Brightspace before the course starts.

Expected workload in hours:
- preparing your lecture: 24
- creating & grading homework for your lecture: 8
- attending lectures: 12
- exam: 1
- studying chapters from the book: 24
- homework: 12
- preparing exam: 12
- writing paper: 24 + 8 (draft & final)

total: 125

**Literature and Study Materials**

Book: Automated Scheduling and Planning: From Theory to Practice, Uyar A.S., Ozcan E. and Urquhart N. (Eds.), Springer 2013
Slides
Articles

**Assessment**

The final grade will be based on:
- quality of preparation and lecture of the chapter studied
- report on a recent developments related to the chapter topic
- question answering during the seminar
- result of a final test on all topics

On Brightspace there are extensive guidelines regarding the evaluation of the lecture and its preparation.

**Elective**

Yes

**Tags**

Algorithmics
Artificial intelligence
Industry
Logics
Project
Small groups
Transport & Logistics
**Expected prior knowledge**
Basic courses in Algorithmics and Complexity Theory

**Course Contents**
Solving instances of intractable problems in reasonable time. Overview of approximation algorithms and approximation techniques. LP relaxations and semi-definite programming.

**Study Goals**
By the end of this course, students will have knowledge of and experience with some advanced algorithmic techniques: exact algorithms for NP-hard problems, approximation techniques, and linear programming relaxation techniques.

**Education Method**
Lectures, homework exercises, and programming assignments.

The expected workload is
- 30% lectures (including preparation for the exams)
- 40% homework exercises
- 30% programming assignments

**Literature and Study Materials**
Parts of the course are derived from the textbook
J. Kleinberg and E. Tardos,
Algorithmic Design,
Supplemental study material will be provided via Blackboard.

**Assessment**
The final mark depends on the marks obtained for
- (a) homework exercises (6 in total),
- (b) programming assignments (3 in total) and
- (c) the exam (3 parts).

The course contains 3 parts: Part 1, Part 2 and Part 3.

There are 2 homework exercises per part. These exercises are evaluated on a scale from 0 to 10 and the final mark for the homework exercises (HE) is the average of these results. Homework exercises have to be completed individually.

There is a programming assignment to be completed at the end of each part. Each assignment is graded on a scale from 0 to 10. The final mark for the programming assignment (PA) is a weighted average of the mark obtained for the three assignments with weights of 20%, 40% and 40%, respectively. Programming exercises can be completed by 2 students working together.

The final exam consists of three parts. Each part will be examined after the four lectures about that part have been delivered and will be graded on a scale from 1 to 10. The final mark for the exam (EX) is the average of the marks for the parts. At the (partial) exams and their resits are closed book.

The final mark for the course is determined as follows:
- if each of the HE, PA and EX marks is above 5, the final mark is the average of these three marks.
- if at least one of HE, PA or EX is less than or equal to 5, the final mark is the minimum of the results obtained for HE, PA or EX.
For this course you need to be able to read scientific papers/books (e.g. you have followed the bachelor seminar course), and you need to be able to understand and analyse algorithms (e.g. followed a course on algorithm design).

Also, it is preferred to have some knowledge and experience with reasoning about the computational complexity of problems (e.g. from a course on complexity theory).

In this course we study developments on the border of computer science and economics.

In particular we discuss topics such as:
* game theory
* auctions
* mechanism design
* matching
* human computation/crowd sourcing

The course is a student seminar. Students therefore will have to participate in preparing and presenting lectures on the basis of a recent book on the topics selected.

After completion of this course, the student
- can give an overview of the state of the art and main challenges in selected topics on the border of computer science and economics,
- can name applications and give definitions and (dis)advantages of a number of formal models and methods for these applications,
- can use and analyse some of these models, and the properties of related algorithms.

Furthermore, the student is able to prepare and give an interactive lecture on these topics based on the provided chapters, including:
- defining lecture goals
- making a lecture plan,
- designing exercises for practicing, and
- making exam questions.

Also the student is able to find solutions to new applications in the literature, and communicate these results to fellow students both verbally and in writing.

This course is a student seminar and uses review by peers. This means that your contributions are seen by fellow students (for feedback). By participating in this course you agree with the instructors sharing your contributions with other students in the course.

A selection of chapters from the following book will be made available:

The end grade will be based on:
1. Quality of preparation and lecture of the chapter studied (including submitted questions)
2. An extension of the chapter based on related literature
3. Quality of answers to the homework given during the seminar
4. Result of a final test on all chapters

On Brightspace you can find further guidelines regarding the lecture and the chapter extension.

Only for item 4 a resit can be requested.

Course year 2017/2018 is the last time this seminar is offered in this form. If you are interested in these topics, we refer you to CS4210-A and CS4210-B. You may then indicate your interest, and in particular in CS4210-B there is the possibility to choose topics related to this course (IN4335).
<table>
<thead>
<tr>
<th>Name</th>
<th>Unit</th>
<th>Department</th>
<th>Telephone</th>
<th>Room</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof.dr.ir. K.I. Aardal</td>
<td>Elektrotechn., Wisk. &amp; Inform.</td>
<td>Optimization</td>
<td>+31 15 27 85093</td>
<td>28.2.W600</td>
</tr>
<tr>
<td>Dr. M.T.J. Spaan</td>
<td>Elektrotechn., Wisk. &amp; Inform.</td>
<td>Algoritmiek</td>
<td>+31 15 27 81102</td>
<td>28.3.E060</td>
</tr>
<tr>
<td>Dr. M.M. de Weerdt</td>
<td>Elektrotechn., Wisk. &amp; Inform.</td>
<td>Algoritmiek</td>
<td>+31 15 27 84516</td>
<td>28.3.E100</td>
</tr>
<tr>
<td>Prof.dr. C. Witteveen</td>
<td>Elektrotechn., Wisk. &amp; Inform.</td>
<td>Algoritmiek</td>
<td>+31 15 27 82521</td>
<td>28.3.E080</td>
</tr>
<tr>
<td>Dr. N. Yorke-Smith</td>
<td>Elektrotechn., Wisk. &amp; Inform.</td>
<td>Algoritmiek</td>
<td>+31 15 27 82521</td>
<td>28.3.E180</td>
</tr>
</tbody>
</table>