Kursnamn på svenska: Modellering för kombinatorisk optimering
Swedish course title

Kursnamn på engelska: Modelling for Combinatorial Optimisation
English course title

Omfattning: 5 hp
Higher education credits

Undervisningsspråk: English
Language of instruction

Rekommenderade förkunskaper
Recommended prerequisites

A very basic background in discrete mathematics is required, but no algorithmics and no programming expertise are expected. Experience with a MatLab-style integrated development environment is a plus.

Kursens syfte och mål
General course objective/s and learning outcomes

OBJECTIVES

Optimisation in general, and discrete (or: combinatorial) optimisation in particular, is a service science, just like mathematics. Hard constrained discrete optimisation problems occur in many academic disciplines of science and technology, as well as in industry and society, and their efficient solving via effective modelling is of paramount importance there. Examples include vehicle routing, resource allocation in energy systems, the design of optimal chips in biology, the planning of minimal experiments, the scheduling of a wastewater treatment plant, and the verification of electronic circuits.

Since such problems occur in many guises in a wide range of disciplines, the ability to recognise them as such and the ability to use technologies able to model and solve them optimally (or near optimally) should be in the repertoire of many PhD students at the TekNat faculty.

Powerful tools for discrete optimisation are now accessible via a single user-friendly integrated development environment: with only relatively easy-to-acquire knowledge of declarative problem modelling principles and very basic programming skills, one can leave the algorithmic problem solving issues to the decades of cutting-edge research embedded in those tools, called solvers. This approach allows the solving of complex problems that are often mistakenly considered unsolvable, or where only small instances are solvable fast enough when inadequate methods are used.

LEARNING OUTCOMES

In order to pass, the student must be able to:
• define the concept of combinatorial (optimisation or satisfaction) problem;
• explain the concept of constraint, as used in a constraint-based modelling language;
• model a combinatorial problem in a constraint-based solving-technology-independent modelling language;
• compare (empirically) several models, say by introducing redundancy or by detecting and breaking symmetries;
• describe and compare solving technologies that can be used by the backends to a constraint-based modelling language, including constraint programming, local search, Boolean satisfiability (modulo theories), and mixed integer programming;
• choose suitable solving technologies for a combinatorial problem, and motivate this choice;
• present and discuss topics related to the course content, orally and in writing, with a skill appropriate for the level of education.

Kursinnehåll

Course contents

We teach, through examples, the use of a high-level declarative modelling language and its toolchain (see https://www.minizinc.org), interfaced with world-class solvers of several discrete optimisation technologies, such as mixed integer linear programming (MIP), local search (LS), constraint programming (CP), Boolean satisfiability (SAT and SMT), and hybrids.

We show that a single model of a problem can be run on multiple solvers, even of different technologies, without needing to learn their very diverse modelling languages and without needing to understand (deeply, if at all) how they work. For most scientists and engineers, the time to achieve a particular solution speed or quality is drastically reduced by such a model-once-solve-everywhere toolchain.

Undervisning (kursens uppläggning)

Instruction (course structure)

There are 12 lectures, 3 teacher-chosen assignments with submitted reports, and a student-chosen project with a presentation and a submitted report, the project being optional and ideally within the PhD student’s own research area.

Examination: assignment reports: 3 hp + project report: 2 hp

Assessment (form of examination)

Huvudansvarig institution: Department of Information Technology (IT)

Department with main responsibility

Kontaktperson: Prof. Pierre.Flener@it.uu.se

Contact person (name, e-mail address)

Kurs datum/period: Period 1 (late August to late October) in autumn

Course dates/period

Kurs datum/period: 2019

Antal platser: 20

Maximum number of participants

Anmälan om antagning till kursen ska skickas till Prof. Pierre.Flener@it.uu.se

Application for admission to the course is to be sent to

Submit application not later than extended to 29 August 2019
The ability to use technologies able to model and solve combinatorial (optimisation or satisfaction) problems optimally (or near optimally) should be in the repertoire of many PhD students at TekNat.