200634 - MDX - Discrete Network Models

Coordinating unit: 200 - FME - School of Mathematics and Statistics
Teaching unit: 715 - EIO - Department of Statistics and Operations Research
Academic year: 2017
Degree: MASTER’S DEGREE IN STATISTICS AND OPERATIONS RESEARCH (Syllabus 2013). (Teaching unit Optional)
ECTS credits: 5 Teaching languages: Spanish

Teaching staff
Coordinator: ELENA FERNÁNDEZ AREIZAGA
Others: Segon quadrimestre:
    ELENA FERNÁNDEZ AREIZAGA - A
    JESSICA RODRÍGUEZ PEREIRA - A

Opening hours
Timetable: By appointment.

Prior skills
The course does not follow a traditional text, since, to a large extent, it is based on proposals of problems made by the students themselves. The type of models that are studied can be found in:


Requirements
It is highly recommended to have followed the course Integer and Combinatorial Optimization, of which the current course is the best complement.

Basic knowledge on modeling techniques in Operations Research and Integer Programming is required.
Basic knowledge on some programming language is required.

Degree competences to which the subject contributes
Specific:
7. CE-2. Ability to master the proper terminology in a field that is necessary to apply statistical or operations research models and methods to solve real problems.
8. CE-3. Ability to formulate, analyze and validate models applicable to practical problems. Ability to select the method and / or statistical or operations research technique more appropriate to apply this model to the situation or problem.
9. CE-5. Ability to formulate and solve real problems of decision-making in different application areas being able to choose the statistical method and the optimization algorithm more suitable in every occasion.
Translate to English
10. CE-6. Ability to use appropriate software to perform the necessary calculations in solving a problem.
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11. CE-7. Ability to understand statistical and operations research papers of an advanced level. Know the research procedures for both the production of new knowledge and its transmission.
12. CE-8. Ability to discuss the validity, scope and relevance of these solutions and be able to present and defend their conclusions.
13. CE-9. Ability to implement statistical and operations research algorithms.

Transversal:

2. ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding how companies are organised and the principles that govern their activity, and being able to understand employment regulations and the relationships between planning, industrial and commercial strategies, quality and profit.
3. SUSTAINABILITY AND SOCIAL COMMITMENT: Being aware of and understanding the complexity of the economic and social phenomena typical of a welfare society, and being able to relate social welfare to globalisation and sustainability and to use technique, technology, economics and sustainability in a balanced and compatible manner.
4. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.
5. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.
6. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

Teaching methodology

The course is based on class attendance and on active participation in class. Teaching methodology is mainly oriented to problem solving and case studies, using different models and solution techniques. This methodology requires the study of specific course material and its application to different discrete network models in various contexts as, for instance, telecommunications, logistics, transportation and service or hub location. Occasionally it will be needed to introduce some theoretical aspect to make it possible to address in an efficient way some of the studied models. Throughout the course case studies will be introduced, which will be used to illustrate practical and professional applications of the topics in the syllabus.

Each student will intensify its study on a specific problem of a discrete network model with a potential application. For this problem she will propose modeling and solution alternatives. These models and techniques will have to be implemented with appropriate computational tools, and computationally tested.

The different topics in the syllabus will not necessarily be presented in a sequential fashion, and will appropriately alternate in the study of specific models.

If the profile and background of students makes it suitable the course will be taught in English.

Learning objectives of the subject

This course studies discrete models stated as network design problems. The main objective are the potential applications of these models, including logistics and telecommunications among others. The course is offered as an specialization in the field of Operations Research. In particular, it is considered as a highly suitable complement of the course Integer and Combinatorial Optimization oriented to theoretical aspects and solution techniques, whereas the focus on the current course are models and their applications, as well as practical implementation aspects.

The main objective of this course is, therefore, to highlight the versatility of discrete network models and to introduce the
student to the main models their applications and possible algorithmic alternatives. A more specific objective of this course is to know alternative formulation possibilities for these problems in terms of the criteria and the characteristics to be considered in each case, and to be able to assess the corresponding advantages and downsides.

From the perspective of discrete optimization, the objective of this course is to know the alternative algorithmic approaches, to assess their associated technical difficulties and to be able of using available software to implement a solution method appropriate in each case.

### Study load

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Hours large group: 30h</th>
<th>24.00%</th>
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<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>0h</td>
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<tr>
<td></td>
<td>Hours small group:</td>
<td>15h</td>
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<td>Guided activities:</td>
<td>0h</td>
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<tr>
<td></td>
<td>Self study:</td>
<td>80h</td>
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### Content

<table>
<thead>
<tr>
<th>Section</th>
<th>Learning time</th>
<th>Theory classes:</th>
<th>Laboratory classes:</th>
<th>Self study:</th>
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<tbody>
<tr>
<td><strong>Introduction to discrete network models and their applications.</strong></td>
<td>5h</td>
<td>5h</td>
<td></td>
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<tr>
<td><strong>Description:</strong></td>
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<tr>
<td>Presentation of the main families of discrete models in networks and their applications.</td>
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<tr>
<td><strong>Basic concepts in discrete network models.</strong></td>
<td>12h</td>
<td>5h</td>
<td>3h</td>
<td>4h</td>
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<tr>
<td><strong>Description:</strong></td>
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<td>Robustness: alternative criteria for reliability in networks.</td>
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<tr>
<td><strong>Types of demand in network optimization.</strong></td>
<td>12h</td>
<td>5h</td>
<td>3h</td>
<td>4h</td>
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<tr>
<td><strong>Description:</strong></td>
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<td>Single commodity vs multiple commodities.</td>
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<td>Demand among users vs demand user/server.</td>
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<tr>
<td><strong>Modeling alternatives for discrete network models.</strong></td>
<td>12h</td>
<td>5h</td>
<td>3h</td>
<td>4h</td>
</tr>
<tr>
<td><strong>Description:</strong></td>
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<td>Compact vs extended formulations.</td>
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<td>Models with two, three and four index variables.</td>
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<td>Reinforcement of formulations: valid inequalities.</td>
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### Applications of discrete network models.

**Learning time:** 12h  
Theory classes: 5h  
Laboratory classes: 3h  
Self study: 4h

**Description:**  
Telecommunications: network design problems.  
Location: Network location. Hub location problems.  

### Solution methods.

**Learning time:** 12h  
Theory classes: 5h  
Laboratory classes: 3h  
Self study: 4h

**Description:**  
Heuristic methods.  
Decomposition methods (Lagrangean relaxation, column generation, etc)  
Branch-and-cut-methods: separation of valid inequalities.

### Development of the practical assignment

**Learning time:** 60h  
Self study: 60h

**Description:**  
Development of the practical assignment: Problem proposal; presentation in class of the selected problem, its potential applications and modeling alternatives de modelización. Presentación en clase del método de solución elegido. Implementación del modelo y método de solución propuestos. Realización de experiencia computacional y análisis de resultados. Elaboración y entrega en plazo indicado de informe detallado en el que se detallen todos los apartados anteriores.
1. (40%) Individual project by each student. For each student the project will focus on his intensification problem. The project will consist of: (i) Study of modeling alternatives for the problem addressed and justified proposal of a specific model; (ii) design and implementation of a solution algorithm for the problem; (iii) presentation and analysis of obtained results.

2. (25%) Presentation and discussion in class of the problem proposed by the student. Presentation and discussion of the model addressed and its modeling and solution alternatives. Presentation of the computational experiments carried out and of the obtained results.

3. (25%) Active participation in class: Presentation of the issued exercises. Participation in the discussion of the projects and exercises presented by the other students, …

4. (10%) Fulfillment of 3-4 exercises throughout the course. The exercises will be briefly discussed in class but they should be done autonomously as a personal assignment outside the class. A due date for delivering each of them will be set.

**Bibliography**

**Basic:**


**Complementary:**


**Others resources:**

**Computer material**

**CPLEX**

Software for modeling and solving linear-integer programming models