



Programme of Integrated course "Network design"

This course is composed of 2 Modules: 1) Network Flows, 2) Network Optimization

Programme of Module "Network Flows"

- Code: DT0059
- Type of course unit:
- Level of course unit:
- Semester: 2

Number of ects credits: (Master Degree in Computer Science) 6 (workload 150 hours)

Teachers: Fabrizio Rossi (fabrizio.rossi@univaq.it)

1	Course objectives	Ability to recognize and formulate network flow problems Knowledge of basic and advanced network flow algorithms Ability to design resolution approaches to solve non standard network flow problems
2	Course content and learning outcomes (dublin descriptors)	<p>Topics of the module include:</p> <ul style="list-style-type: none"> • Network Flows Problem: introduction and definitions • Maximum Flows and the path packing problem. Flows and cuts: Max-Flow/Min-Cut theorem. Augmenting path algorithms: Ford and Fulkerson algorithm, Edmonds and Karp algorithm. Generic Preflow-Push algorithm. Flows with lower bounds. • Maximum Flows: additional topics and applications. Flows in Unit Capacity Networks. Flows in Bipartite Networks. Network Connectivity. • Minimum Cuts. Global Minimum Cuts. Node Identification Algorithm. Random Contraction. Applications. • Minimum-Cost Flow Problems. Definition and applications. Optimality Conditions. The Ford-Bellman algorithm for the shortest path problem. Primal algorithms: Augmenting Circuit Algorithm for the Min Cost Flow Problem. • Network Simplex Algorithms. Applications of Min Cost Flows. <p>On successful completion of this module, the student should :</p> <ul style="list-style-type: none"> • Know and formulate network flow problems • Model decision problems as network flow problems Use base and advanced algorithms to solve network flow problems • Ability to identify network flow models scope • Ability to explain network flows models and algorithms • Ability to learn state-of-art algorithms for network flow problems
3	Course prerequisites	Basic knowledge of: Discrete Mathematics, Linear Programming, Algorithms and Data Structures, Computational complexity
4	Teaching methods and language	<p>Lectures</p> <p>Language: English</p> <p>Reference textbooks</p> <ul style="list-style-type: none"> • Cunningham, Pulleyblank, Schrijver , Combinatorial Optimization. • Ahuja, Magnanti, Orlin, Network Flows.
5	Assessment methods	Written text exam

Programme of Module "Network Optimization"

- Code: DT0060
- Type of course unit: Compulsory (Master Degree in Computer Science curriculum SEAS)
- Level of course unit: Postgraduate Degrees
- Semester: 2

Number of ects credits: (Master Degree in Computer Science) 6 (workload 150 hours)

Teachers: Fabrizio Rossi (fabrizio.rossi@univaq.it)

1	Course objectives	Ability to recognize and model network optimization problems as Integer Linear
---	--------------------------	--

		Programming problems. Knowledge of fundamental algorithmic techniques for solving large scale Integer Linear Programming problems. Knowledge of commercial and open source Integer Linear Programming solvers.
2	Course content and learning outcomes (dublin descriptors)	<p>Topics of the module include:</p> <ul style="list-style-type: none"> • Formulations of Integer and Binary Programs: The Assignment Problem; The Stable Set Problem; Set Covering, Packing and Partitioning; Minimum Spanning Tree; Traveling Salesperson Problem (TSP); Formulations of logical conditions. • Mixed Integer Formulations: Modeling Fixed Costs; Uncapacitated Facility Location; Uncapacitated Lot Sizing; Discrete Alternatives; Disjunctive Formulations. • Optimality, Relaxation and Bounds. Geometry of R^n: Linear and affine spaces; Polyhedra: dimension, representations, valid inequalities, faces, vertices and facets; Alternative (extended) formulations; Good and Ideal formulations. • LP based branch-and-bound algorithm: Preprocessing, Branching strategies, Node and variable selection strategies, Primal heuristics. • Cutting Planes algorithms. Valid inequalities. Automatic Reformulation: Gomory's Fractional Cutting Plane Algorithm. Strong valid inequalities: Cover inequalities, lifted cover inequalities; Clique inequalities; Subtour inequalities. Branch-and-cut algorithm. • Software tools for Mixed Integer Programming • Lagrangian Duality: Lagrangian relaxation; Lagrangian heuristics. • Network Problems: formulations and algorithms. Constrained Spanning Tree Problems; Constrained Shortest Path Problem; Multicommodity Flows; Symmetric and Asymmetric Traveling Salesman Problem; Vehicle Routing Problem Steiner Tree Problem; Network Design. Local Search Tabu search and Simulated Annealing MIP based heuristics • Heuristics for network problems: local search, tabu search, simulated annealing, MIP based heuristics. <p>On successful completion of this module, the student should :</p> <ul style="list-style-type: none"> • Know and define single objective network optimization problems • Use and design exact or heuristic algorithms to solve single objective network optimization problems <ul style="list-style-type: none"> • Ability to judge models and methods to tackle network optimization problems • Ability to explain the models, the algorithms and the computational complexity needed to solve network optimization problems • Ability to learn state-of-art algorithms for network optimization problems
3	Course prerequisites	Basic knowledge of: Discrete Mathematics, Linear Programming, Algorithms and Data Structures, Computational complexity. Knowledge of at least one programming language.
4	Teaching methods and language	<p>Lectures and software training</p> <p>Language: English</p> <p>Reference textbooks</p> <ul style="list-style-type: none"> • L.A. Wolsey, <i>Integer Programming</i>. Wiley. 1998.
5	Assessment methods	Written text exam and assignment