NP-Completeness

LANDSCAPE OF OPTIMIZATION ALGORITHMS

Universiteit Utrecht

[Faculty of Science
Information and Computing Sciences]

NP-Hardness is not the end

- Almost every interesting real-life problem is NP-Complete.
  - Scheduling, planning, networks ...
- NP-Completeness is a starting point to think further not an excuse to call a problem impossible to solve.
- *There is more in life than complaining that problems are hard.*

NP-Hardness: you have to work harder for a good solution

Within the COSC master program

- Theoretically oriented:
  - Fixed parameter tractability,
  - Exact exponential-time algorithms,
  - Treewidth
  - Special graph classes / restricted instances, ...
- Experimentally oriented:
  - Integer Linear Programming based approaches:
    - Branch-and-bound
    - Decomposition approaches
  - Metaheuristics:
    - local search
    - evolutionary computing
  - Closer to real-life problems

A bit of myth busting

Within the algorithms part of the COSC program you will mainly see:

- Theory for network problems
- Experiments for scheduling problems

May give rise to a misunderstanding!

This is only because of the background of the researchers, **there is also theory for scheduling and experimental work for network problems**

Solution quality / Computation time	Optimum	Bound on quality	Good solution, no quality guarantee
Polynomial	Polynomial solution algorithms	Approximation algorithms	Construction heuristics
Super polynomial and/or no guarantee	Exact algorithms: • Tree search • Dynamic programming • Mixed Integer Linear Programming • ……	Hybrid algorithms • Column generation without complete branch-and-price	Meta heuristics: • Local search • Genetic algorithms

Very successful in experiments

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Solution quality Computation time	Optimum	Bound on quality	Good solution, no quality guarantee
Polynomial	Polynomial solution algorithms ***P***	Approximation algorithms	Construction heuristics ***NP-hard***
Super polynomial and/or no guarantee	Exact algorithms: • Tree search • Dynamic programming • Integer linear programming	Hybrid algorithms • Column generation without complete branch-and-price	• Local search • Genetic algorithms

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Solution quality / Computation time	Optimum	Bound on quality	Good solution, no quality guarantee
Polynomial	Polynomial solution algorithms	Algorithms and networks	Construction heuristics
Super polynomial and/or no guarantee	Algorithms and networks	Hybrid algorithms • Column generation without complete branch-and-price	Meta heuristics: • Local search • Genetic algorithms

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Solution quality / Computation time	Optimum	Bound on quality	Good solution, no quality guarantee
Polynomial	Polynomial solution	Approximation algorithms	Construction heuristics
Super polynomial and/or no guarantee	Scheduling and timetabling		• Genetic algorithms

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Solution quality / Computation time	Optimum	Bound on quality	Good solution, no quality guarantee
Polynomial	Network Science	Approximation algorithms	Construction heuristics
Super polynomial and/or no guarantee	Exact algorithms: • Tree search • Dynamic programming • Integer linear programming • ……	Hybrid algorithms • Column generation without complete branch-and-price	Meta heuristics: • Local search • Genetic algorithms

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Super polynomial and/or no guarantee	Exact algorithms: • Tree search • Dynamic programming • Integer linear programming • ……	Hybrid algorithms • Column generation without complete branch-and-price	Evolutionary computing

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