Pôle 2

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"Optimisation Combinatoire, Algorithmes"

Giard (HM) ; Bazgan, Mahjoub, Paschos (PU) ; Monnot (DR);
Escoffier, Ries (anciens)
Gourvès, Jeunet, Kim (CR) ; Cornaz, Furini, Gabrel, Giannakos,
Harutyunyan, Lampis, Murat, Sikora (MC)

2012 — 2017

Bilan : 5 chapitres + 153 articles + 120 proc. + 5 recueils

9 Conférences internationales

ISCO(12,14,16), APEX(12,13), ECCO(13), JGA(16), CIAC(15,17).

13 Editorial Board

Theoretical Computer Science, European Journal of Operational Research, Operational Research : An International Journal, Journal of Discrete Algorithms, Computers and Industrial Engineering, RAIRO - Operations Research, Foundations of Computing and Decision Sciences, Yugoslav Journal of Operations Research, Journal of Multicriteria Decision Making in Economics & Finance, Computers and Industrial Engineering, EURO Journal on Computational Optimization, Journal of Industrial Engineering, Journal of Project Management.

15 Thèses soutenues — 4 Post-docs effectués

Benamiche (Orange), Chopin, Taktak, Tourniaire, Bonnet, Jamain, Ould, Tlilane, Chatras (Reginov), Magnouche, Sali (Reginov), Chen (Decision Brain), Naghmouchi (Orange), Baujean (Orange), Mouaci (Orange).

Ferraioli, Boyaci, Sasaki, Stamoulis.

98 Séminaires : 15(2012), 17(13), 15(14), 19(15), 13(16), 19(17)

Orateurs venus de : G.-B.(7), Allemagne(5), Italie(5), Canada(4), E.-U.(4), Hongrie(3), Brésil(2), Japon(2), Grèce(2), Espagne(2), Suisse(2), Suède, Argentine, Norvège, Turquie, Autriche, Tunisie, Liban, Belgique, Chine, Tchéquie, Pologne, Portugal.

Applications : résoudre *efficacement*

Problèmes posés, par exemple, en

- Télécommunications (Mathis, AGaPe)
  Network Planning and Design, Survivability
- Services Web (Services, Multicritère)
  Service Composition Problem (←)
- Transports (Multicritère, Mathis)
  Traffic Control, Aircraft Routing, Train Timetabling
- Gestion de débris dans l'espace (Multicritère)
- Politique (Jeu)
  Voting

Efficacement...

[Lamé 1844] *"Le nombre des divisions à effectuer, pour trouver le plus grand commun diviseur entre deux entiers* A*, et* $B < A$*, est toujours moindre que cinq fois le nombre des chiffres de* B*."*

[Edmonds 1965] *"For practical purpose the difference between algebraic and exponentiel order is often more crucial than the difference between finite and non-finite."*

Edmonds' approach : Integer Polyhedra

Describe the convex hull of feasible solutions

$$\max\{c^\top x : Ax \leq a,\ x \text{ integer}\} = \max\{c^\top x : Bx \leq b\} \qquad (\forall c)$$

E.g.

$$\left\{\begin{array}{llll} x_1, & x_2, & x_3 & \geq 0 \\ x_1 & +x_2 & & \leq 1 \\ & x_2 & +x_3 & \leq 1 \\ x_1 & & +x_3 & \leq 1 \end{array}\right. = conv.hull\left\{\begin{pmatrix}0\\0\\0\end{pmatrix}\begin{pmatrix}1\\0\\0\end{pmatrix}\begin{pmatrix}0\\1\\0\end{pmatrix}\begin{pmatrix}0\\0\\1\end{pmatrix}\begin{pmatrix}1/2\\1/2\\1/2\end{pmatrix}\right\}$$

$$conv.hull\left\{\begin{pmatrix}0\\0\\0\end{pmatrix}\begin{pmatrix}1\\0\\0\end{pmatrix}\begin{pmatrix}0\\1\\0\end{pmatrix}\begin{pmatrix}0\\0\\1\end{pmatrix}\right\} = \left\{\begin{array}{llll} x_1, & x_2, & x_3 & \geq 0 \\ x_1 & +x_2 & +x_3 & \leq 1 \end{array}\right.$$

Dans un ensemble fini mais de taille exponentielle, *déterminer en temps* polynomial *un élément* optimum

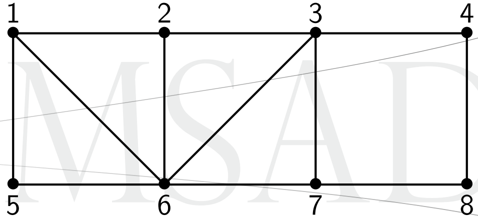
1. Relaxer l'ens. réalisable (Mathis)
   Cutting Plane Algorithms, min-max relations
2. Relaxer l'optimum (AGaPe)
   Approximation algorithms
3. Relaxer le temps (AGaPe)
   Fixed Parameter Tractable, Low-Exponential (Sub-Exponential)

Explorer les généralisations

- Données incertaines (Services, Mathis)
  Robust Optimization [GMT14]
- Optimum sur plusieurs critères (Multicritère, Mathis)
  Pareto Set
- Critères en conflit (Jeux)
  Equilibrium, Preferences Aggregation

Fundamental problems : *Graphs*

E.g. Edges = $\{12, 15, 16, 23, 26, 34, 37, 48, 56, 67, 78\}$



- Vertex-Cover : $\{1, 6, 3, 8\}$ $\nu \leq \tau \leq 2\nu$
  - Matching : $\{15, 26, 37, 48\}$
- Shortest Path from $s = 1$ to $t = 8$: $(16, 67, 78)$

Vertex-Cover, Shortest Path

{sous-ens. de sommets touchant toutes les arêtes} min. weight

1. LP-duality ⇒ Graph Coloring (ϑ-Lovász [CM14], DSATUR [FGT17])
2. 2-approx. (maximal matching) (Hard for 7/6-approx.)
3. FPT $O(2^k kn)$ (k-edge-cover branching),
   kernel $O(k^2)$ (k-degree vertices),
   From $O(1.1740^n)$ To $O(1.0854^n)$ (in 13 papers) (G cubique)

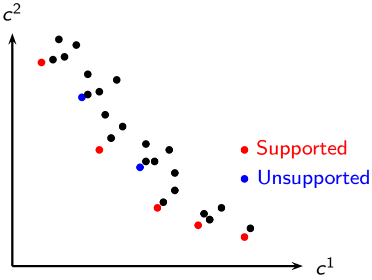
- *Stochastic version* 2-approx. (vertex weights, incidence)

{chemin de s à t} min. length

st-path with parallel edges e_i, f_i → 2^n "optimal" solutions

	e_i	f_i	E.g. $n=2$ ⇒ 4 paths	e_0, e_1	e_0, f_1	f_0, e_1	f_0, f_1
cost1 =	0	2^i		0	2	1	3
cost2 =	2^i	0		3	1	2	0

Multiobjective global minimum cut problem [AMMQ15]

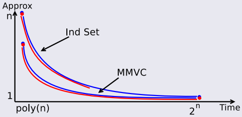


- For any constant number of objectives:
    - supported solutions = strongly poly. number
    - enumeration = strongly poly. time
- Open question: tractability of non-supported solutions?
    - Yes for two objectives.

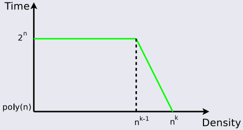
Trading Time for Approximation

- Algorithms for NP-hard problems
- Trade-off Time vs Approximation vs Generality

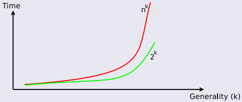
Time vs Approximation
Thm:[Bonnet, Lampis, Paschos STACS'16]
For any $r > 0$, r-approximation for Max Minimal VC runs in time $2^{O(n/r^2)}$.
Thm: This is optimal



Time vs Generality
Thm:[Fotakis, Lampis, Paschos STACS'16]
Max 3-SAT can be $(1 - \epsilon)$-approximated in time $2^{n^{1-\delta}}$ for instances of density $n^{2+\delta}$.
Thm: This is optimal

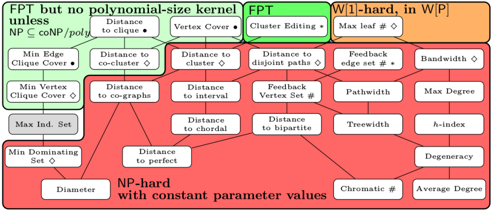


Time vs Generality vs Approximation
Thm:[Dell, Kim, Lampis, Mitsou Mömke, IPEC'15]
Max 3-SAT can be $(1 - \epsilon)$-approximated in 2^k time, where k is clique-width.
Thm: Needs n^k time to solve exactly



Structural Parameterization

- Take your favorite NP-hard graph problem.
- Take your favorite graph-parameter ρ.
  - Can you solve the problem in $f(\rho)n^{O(1)}$?
  - In $n^{f(\rho)}$?
- Hardness results implies hardness for "smaller" parameters.
- Positive results implies positive result for "bigger" parameters.



- Real-life input is not random: how to attack the problem.

[Bonnet, Sikora, DAM'16] [Dell, Kim, Lampis, Mitsou, Mömke, IPEC'15] [Bazgan, Nichterlein, Niedermeier, CIAC'15] [Lampis, Algorithmica'12]