CWI

PNA1

Algorithms, Combinatorics and Optimization

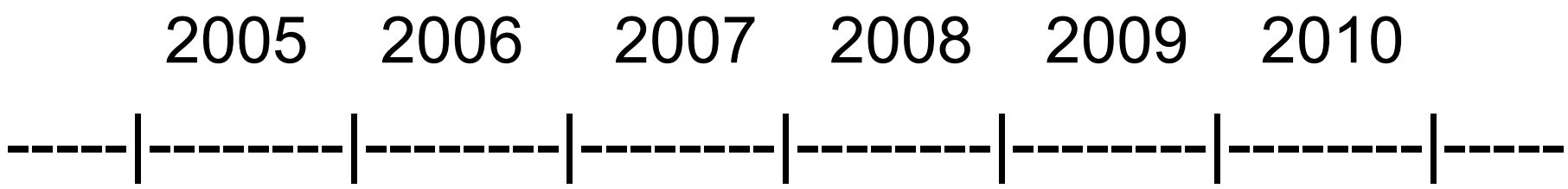
Current composition of the group

Senior researchers:	also professors at
Krzysztof Apt	U. Amsterdam
Bert Gerards	U. Maastricht
Monique Laurent	U. Tilburg
Guido Schaefer	VU Amsterdam
Lex Schrijver	U. Amsterdam

Part-time:		
	Jan Draisma	TU Eindhoven
	Frank Vallentin	TU Delft

Five postdocs & five PhD students

Guest researchers: Aharon Ben-Tal (Technion), Vincent Conitzer (Duke), Amy Greenwald (Brown)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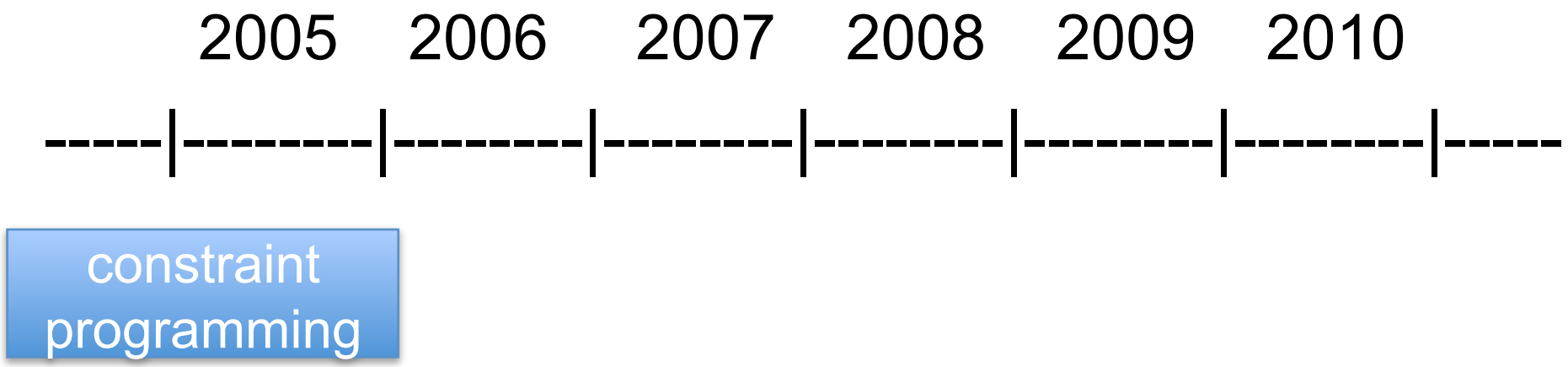
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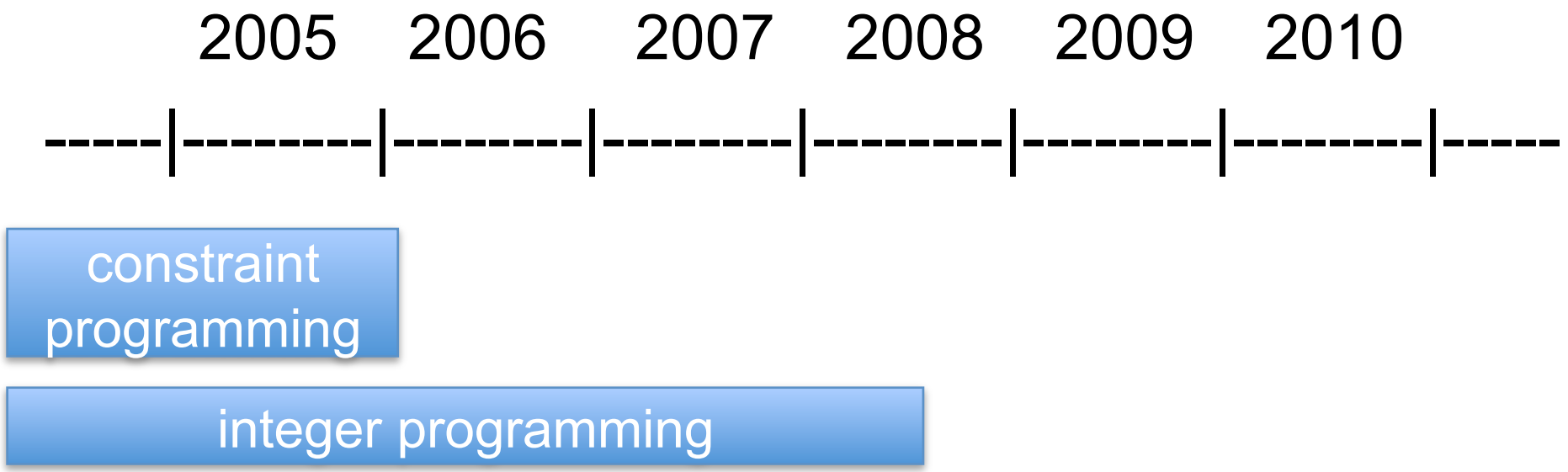
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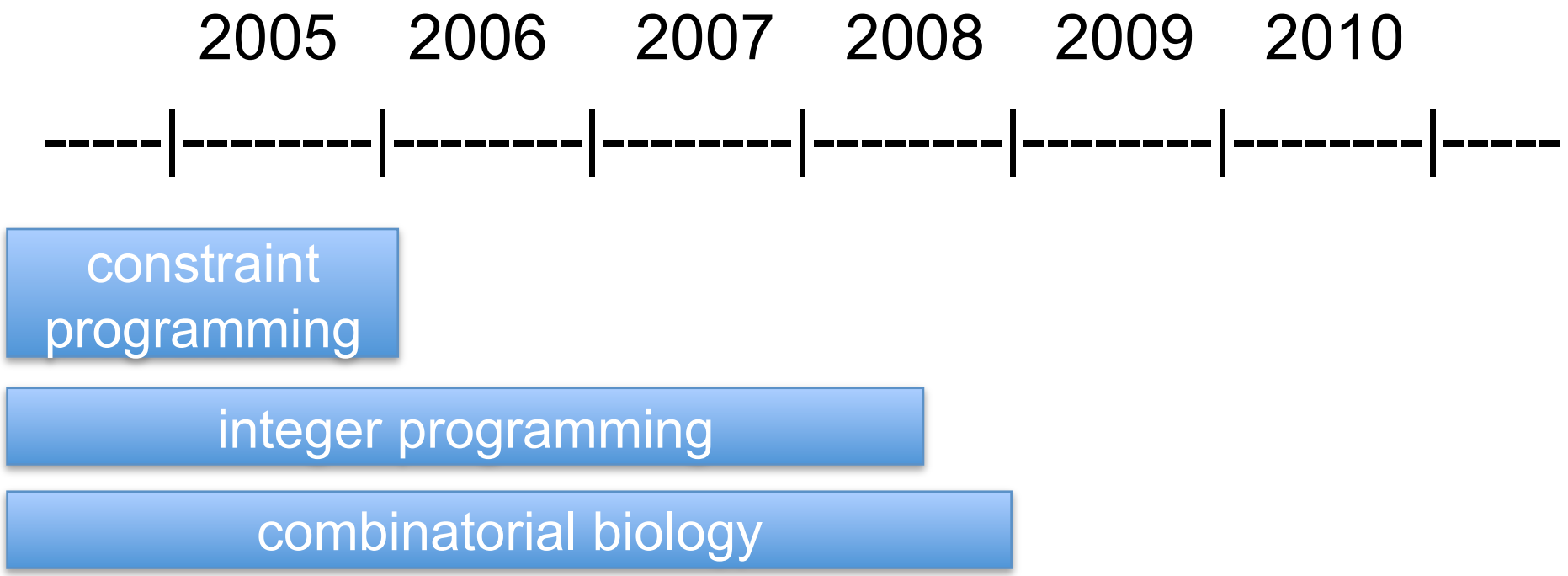
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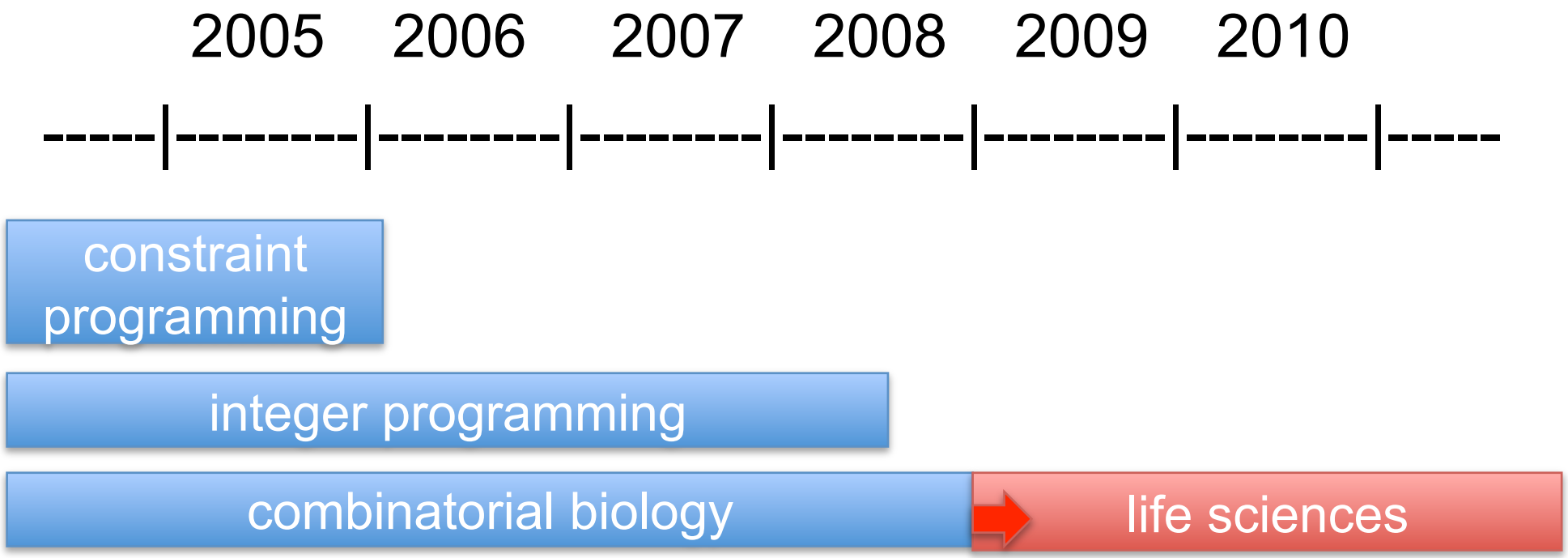
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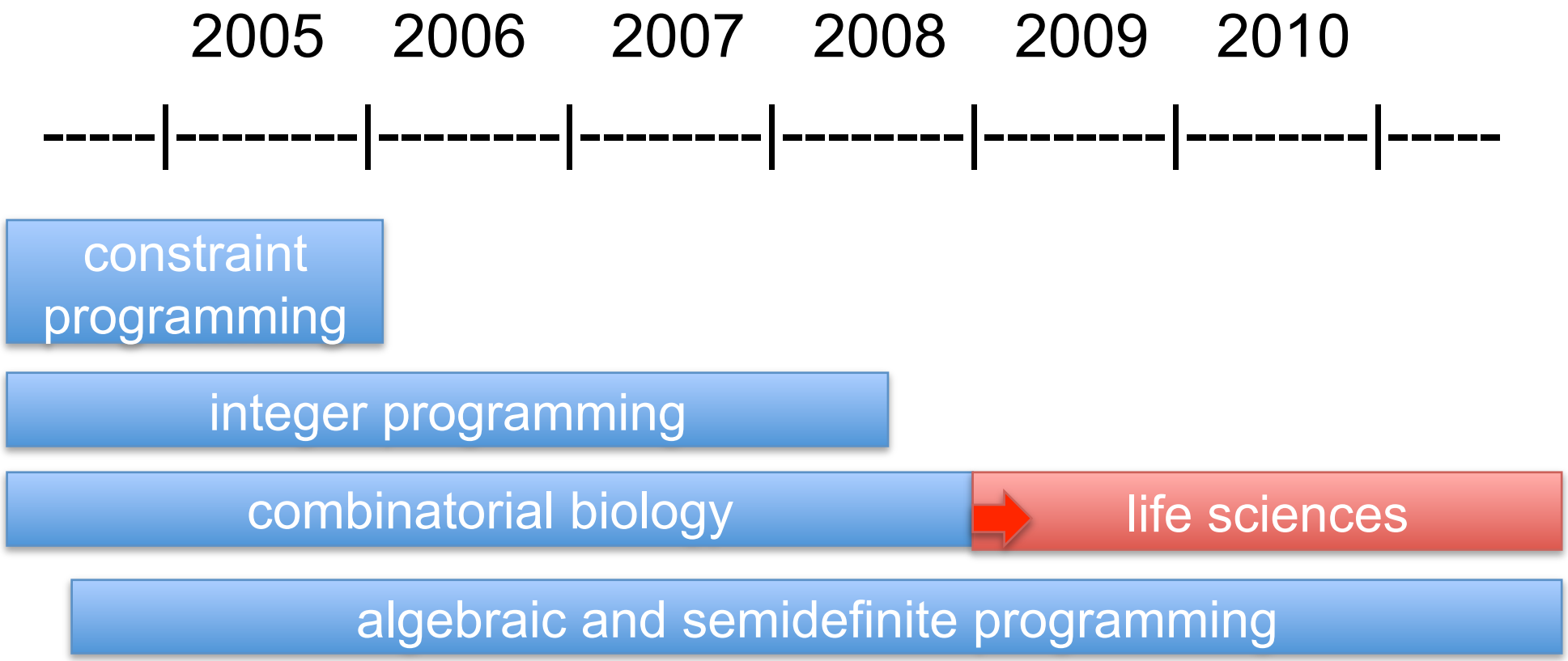
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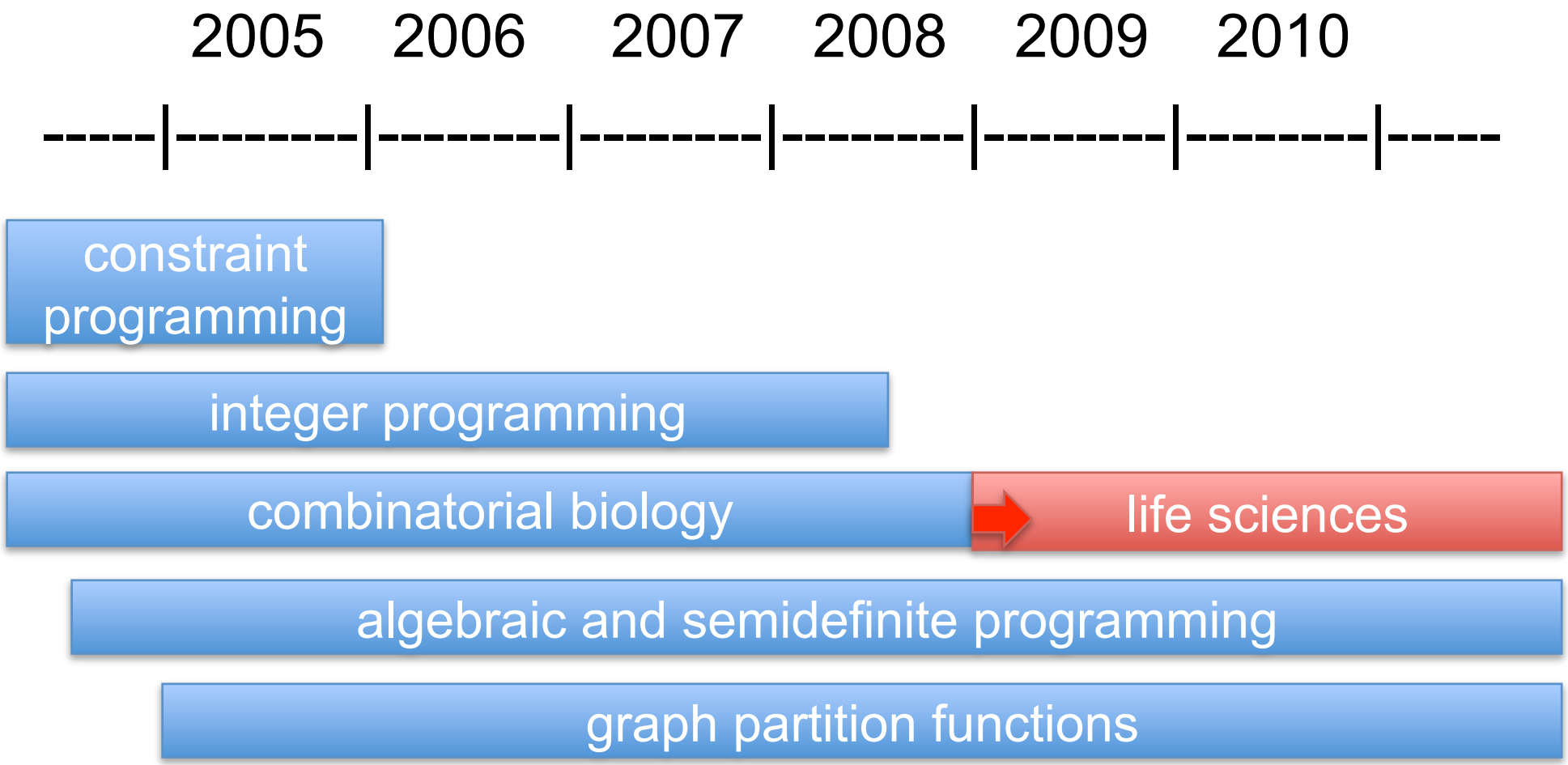
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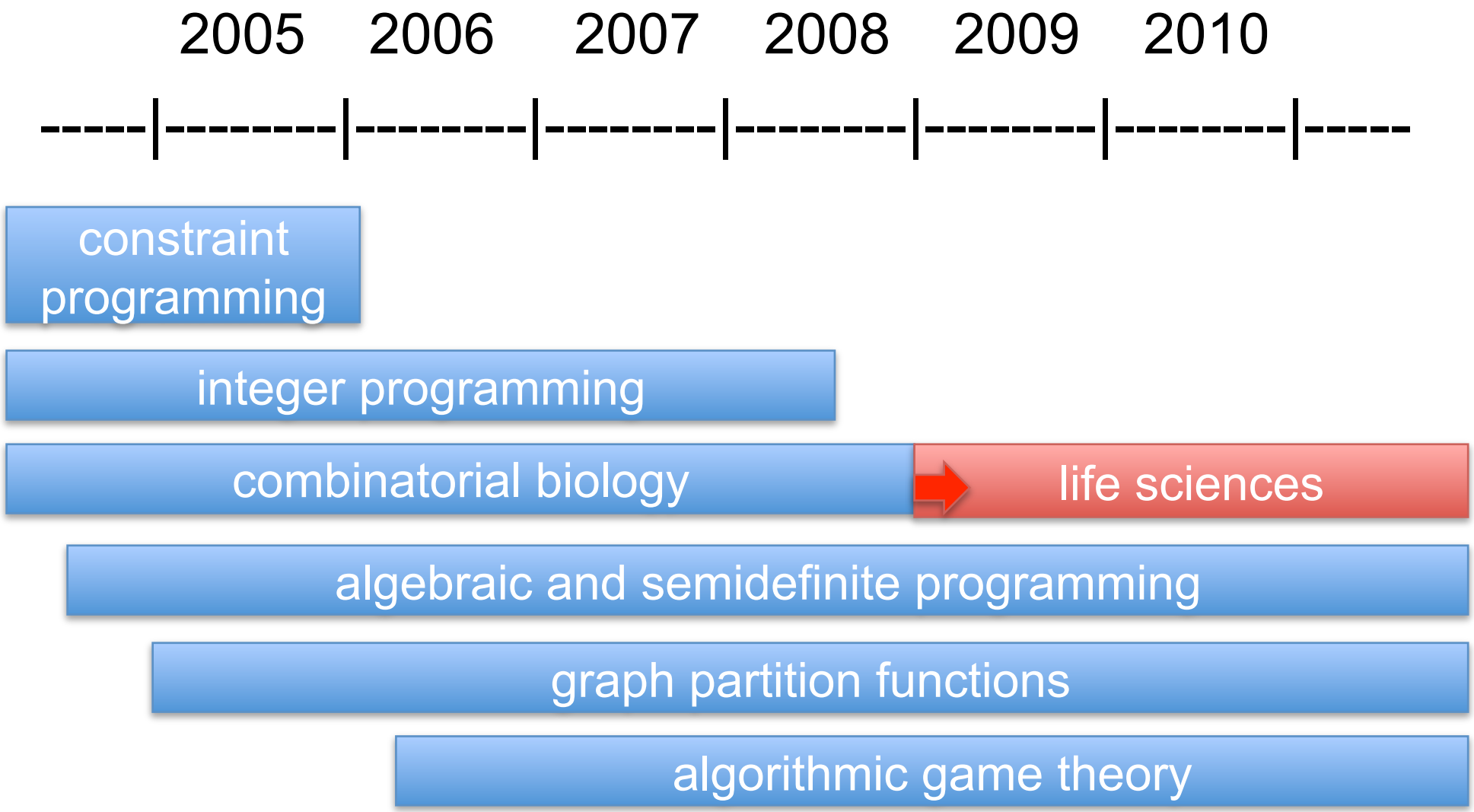
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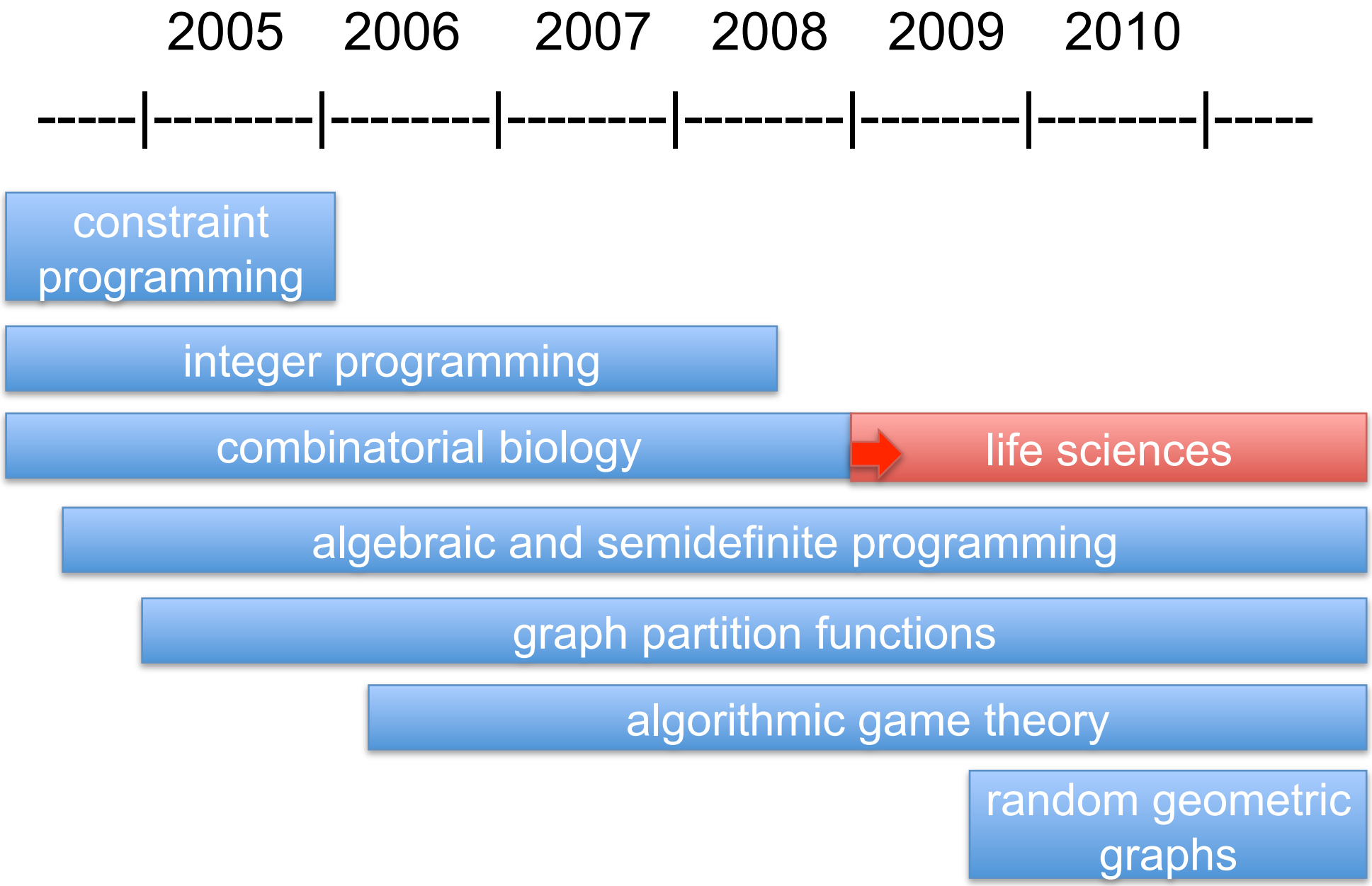
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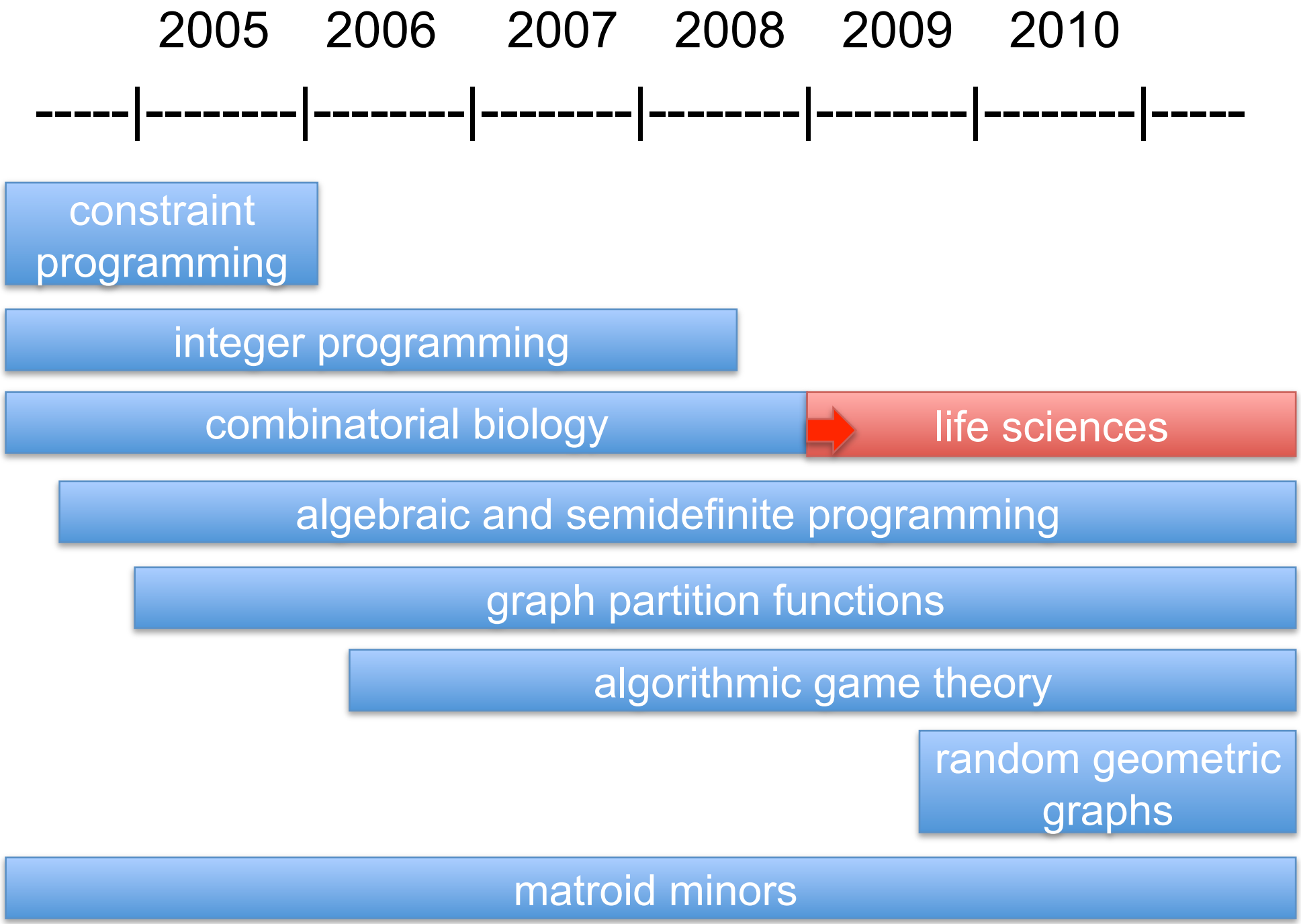
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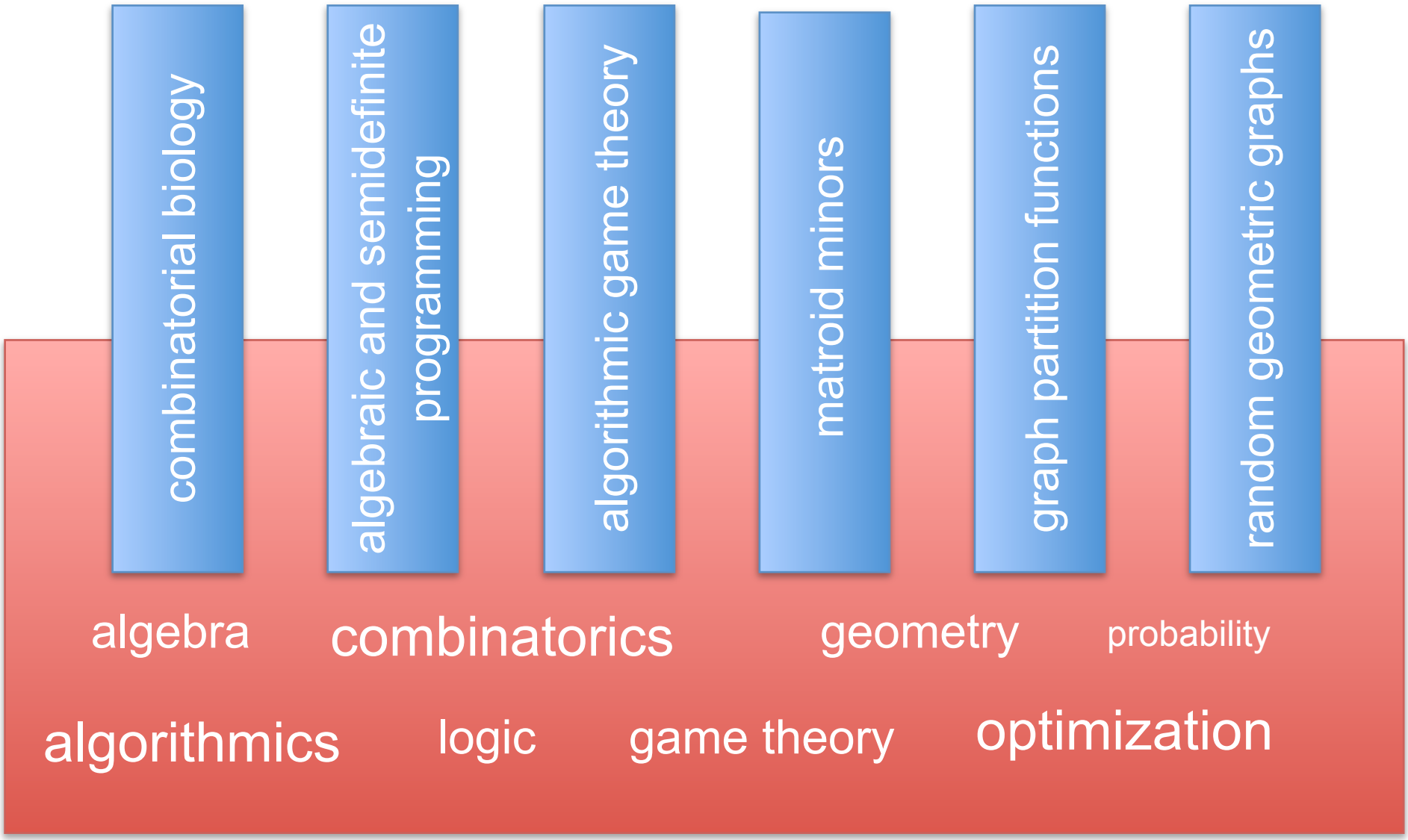
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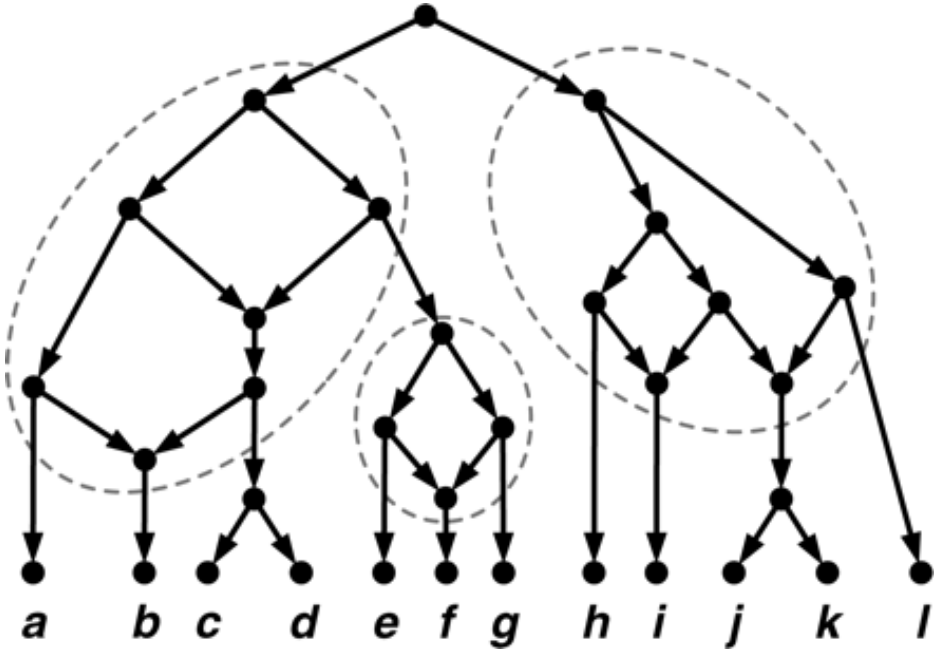
Combinatorial biology

Phylogenetic networks

- *Efficient algorithms for 2-level networks*
- *Optimal worst-case approximations*

2-level network



Metabolic networks

→ Joint project with MAS3 / MAC4

→ MAC4 [Life Sciences] since 2009

Algebraic and semidefinite programming

New area, combining tools from:

- real algebraic geometry & moment theory
- invariant theory (exploit symmetry)
- harmonic analysis
- semidefinite programming

Algebraic and semidefinite programming

Highlight results

Better bounds for:

- Codes
- Graph coloring
- Crossing numbers
- Kissing numbers

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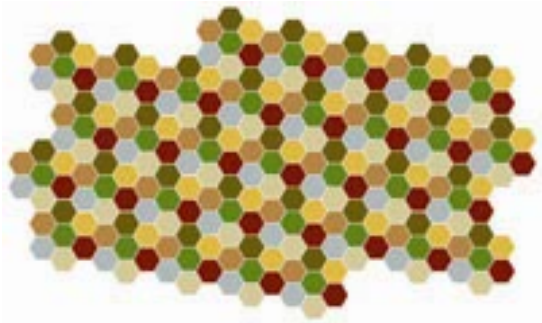
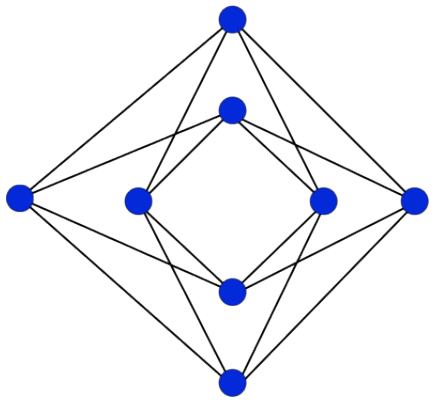




Algebraic and semidefinite programming

Future directions

- Higher order SDP relaxations

- Mixing numeric and symbolic algorithms

- Linking classical and quantum computing: Grothendieck inequalities, noncommutative polynomials,…

➡ Joint project with PNA6
[Algorithms and Complexity]

Graph partition functions

in the spin model

$$f(G) = \sum_{\substack{\varphi: V(G) \to [k] \\ \text{vertex coloring}}} \prod_{uv \in E(G)} A_{\varphi(u),\varphi(v)}$$

Highlight results

- Characterization in terms of “reflection positivity”
- Recent extension to the edge model

Algorithmic game theory

Mechanism design

- Socially optimal mechanisms

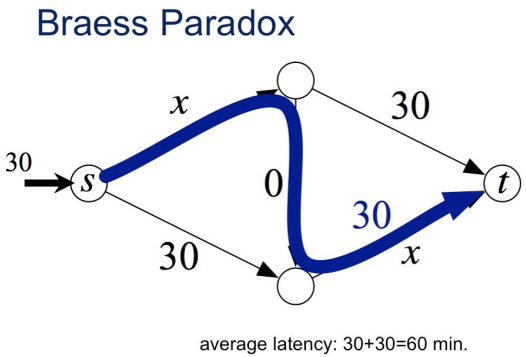
  VCG is optimum for `public project'

Equilibria in strategic games

- Computation of Nash equilibria

  2 players: better approximations

  3-players repeated games: hard



- Price of anarchy in network routing

  A centralized route guidance does not help to reduce the inefficiency of equilibria in network routing

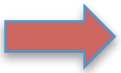
Algorithmic game theory

Reasoning in strategic games

- Interactive epistemology

Future directions

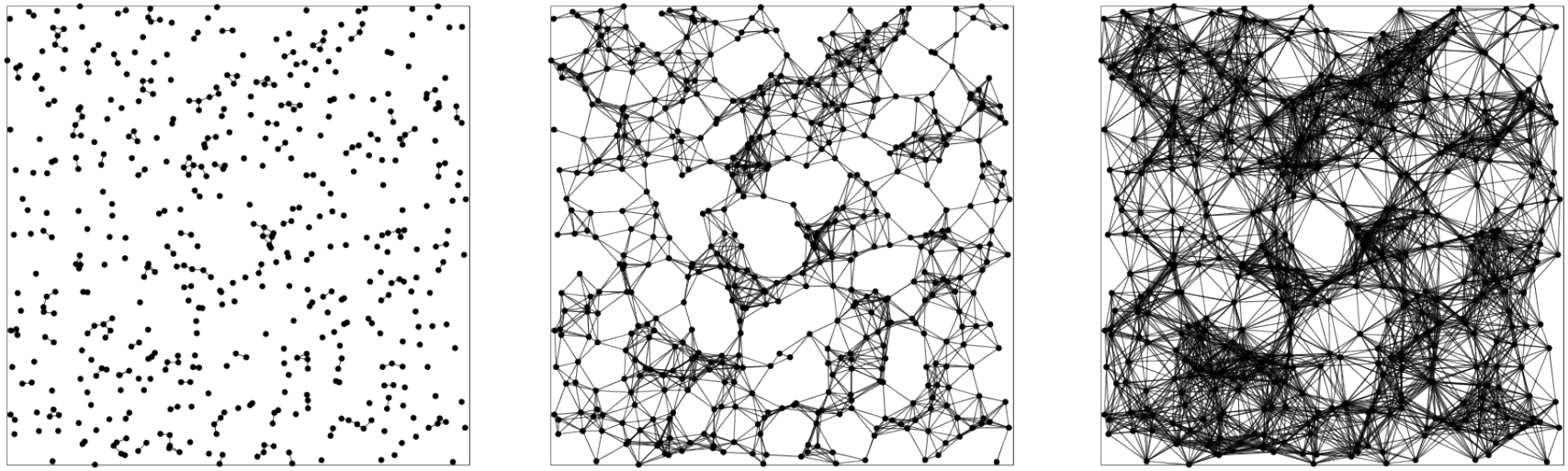
- Altruistic player behavior
- Smoothed analysis and robustness
- Social networks



Joint projects with

SEN1 [Software Analysis and Transformation]
SEN3 [Foundations of Software Engineering]
SEN4 [Multi-Agent and Adaptive Computation]

Random geometric graphs



Highlight result

Phase transition behavior for Hamiltonian circuit
and for coloring number

NWO Veni

Cooperation with PNA2

[Probability and Stochastic Networks]

Matroid minors

Is any minor closed matroid property characterized by finitely many forbidden obstructions ?

Can it be tested in polynomial time ?

Highlight result: Yes, for binary matroids

Challenges:

- Extension to any finite field
- Rota's conjecture:

The class of matroids representable over any given finite field is characterized by finitely many forbidden minors

Societal relevance

- "The New Dutch Timetable: The O.R. Revolution" [INFORMS Edelman Award 2008]

- Scheduling internships for medical students

  → Spin-off SAFIRO

- Optimizing bidding strategies for Google AdWords (planned, with WatchWord)

- Health care logistics (ambulance planning), planned cooperation with PNA2 [Probability and Stochastic Networks]

Outreach

- DisWis: Educational project about discrete mathematics for high school students [Sigma Prize 2008]

- Internships for high school students at CWI

- Popularization lectures

- Participation in the organization of the International Mathematical Olympiad, Amsterdam 2011

Outreach

Knowledge dissemination: organization of

- 15 international workshops and conferences
- 10 doctoral schools [Oberwolfach, IPAM, HIM]

Incubator for talent:

- SIAG/Optimization Prize for Vallentin
- Vidi grant for Vallentin
- Veni grant for Mueller
- Rubicon grant for Oliveira
- Tucker Prize finalist: Gijswijt
- Philips Prize for van Leeuwen
- ICALP Best Student paper award for Wojtczak
- Microsoft Research Beyond Search Award for Immorlica and Markakis (with SEN4)

Academic reputation

- Academia Europaea — Apt, Schrijver
- Honorary professorship Waterloo — Gerards
- Royal Dutch Academy of Sciences and two German academies; Spinoza and Von Neumann Awards; honorary doctorates Waterloo & Budapest — Schrijver
- Editorships in leading scientific journals
  (SIAM, MOR, MP, Combinatorica, JCTB, TOCL, TPLP, J Logic & Computation, EPTCS,...)
- Program & Scientific committees
  (MOS, EATCS, MFO, ESF Games, 5ECM, IPAM, TARK, NWO, DIAMANT, LNMB,...)

Q-P-R-V

Quality: awards, academies, honorary degrees, invited lectures (ICM), editorships, grants, publications in top journals (J.AMS, J.EMS, FOCM, GAFA, JCTB, SIOPT, MP)

Productivity: 107 journal & 73 conference articles, 2 books, 2 edited books, 15 book chapters, 10 PhD's

Relevance: for mathematics, computer science, physics, economics, and society

Viability: new areas (algorithmic game theory, algebraic optimization, graph limits); recent staff rejuvenation; worldwide collaboration

SWOT

S: Strong group with national and international visibility, and a broad expertise

WT: - General focus on short term research
- Limited NWO financing PhD/postdocs
- Difficulty to recruit talented staff (in NL)

O: - Increased focus worldwide on applying fundamental mathematics to combinatorics, algorithms and optimization
- Momentum in algorithmic game theory, with high potential for challenging applications