Enumerating minimal dominating sets in K_t-free graphs

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(TU Berlin)

IRIF
28/05/19

Joint work with **Marthe Bonamy** (Bordeaux), **Oscar Defrain** (Clermont-Ferrand), **Marc Heinrich** (Lyon), and **Michał Pilipczuk** (Warsaw)

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Problem: possibly many objects!

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Two perspectives about complexity

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- [Fredman and Khachiyan, 1996]:
  $O(s^{\log s})$-time for Minimal Dominating Set
  $s = \text{poly}\,|G| + |\mathcal{D}(G)|$

"Fast" output-sensitive algorithms

n: input size

- **output-polynomial:** poly$(n + s)$ to get all the solutions

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Note: output space is not counted.

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Minimal dominating sets

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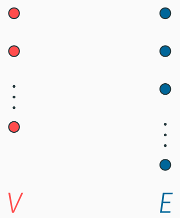

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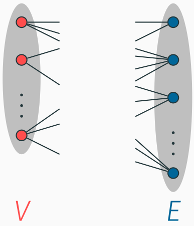

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+ all edges in V and in E

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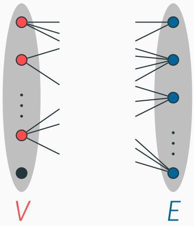

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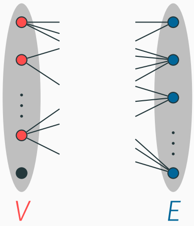

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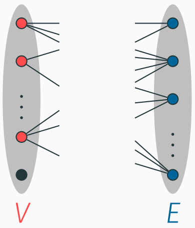

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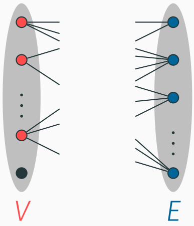

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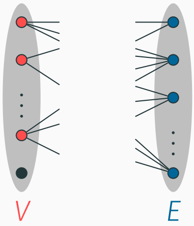

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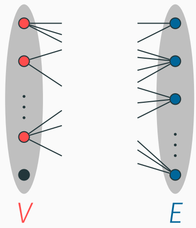

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Theorem (Bonamy, Defrain, Heinrich, Pilipczuk, R., 2019+)

There is an algorithm enumerating minimal dominating sets of K_t-free graphs in output-polynomial time, for every $t \in \mathbb{N}$.

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There is an algorithm enumerating minimal dominating sets of bicolored graphs (G, A) s.t. $G[A]$ is K_t-free in output-polynomial time, for every integer $t \geqslant 1$.

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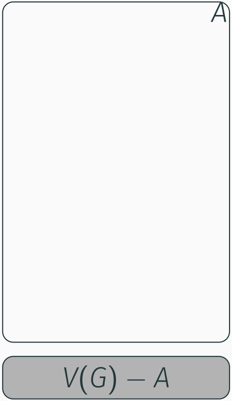
- $t = 1$: trivial
- $t > 1$: induction

Goal: enumeration of minimal DS in (G, A) s.t. $G[A]$ is K_t-free



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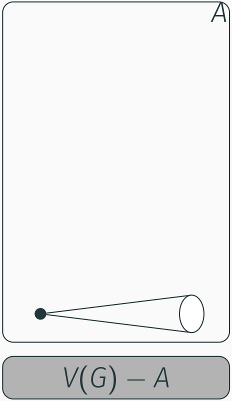

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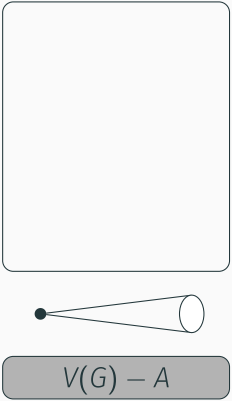

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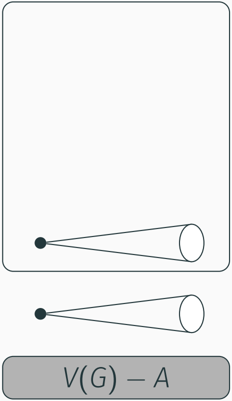

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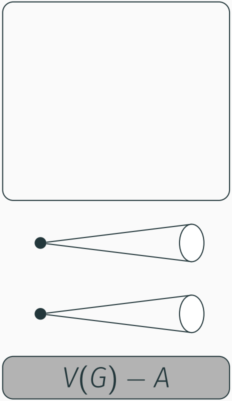

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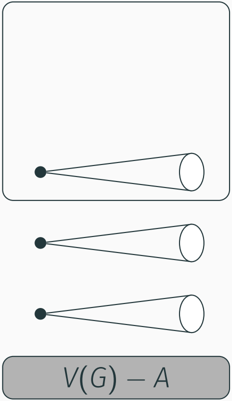

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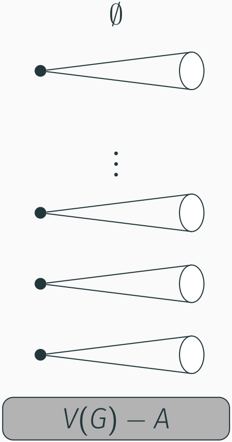

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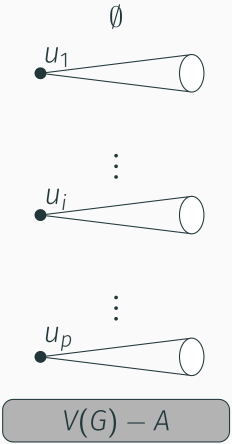

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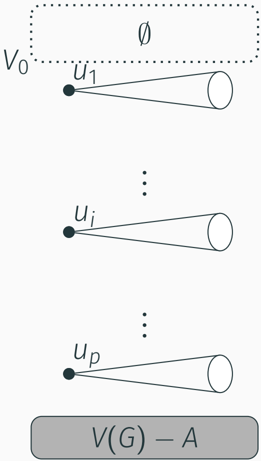

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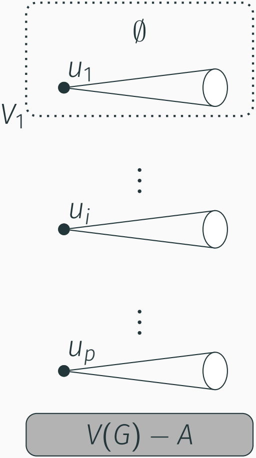

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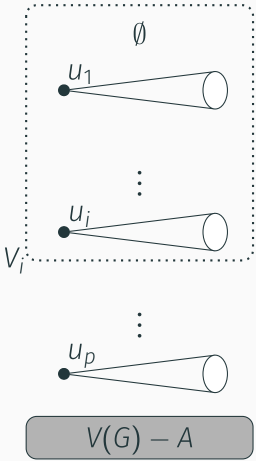

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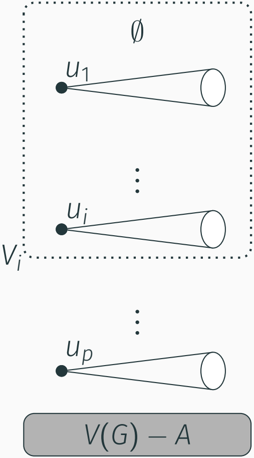

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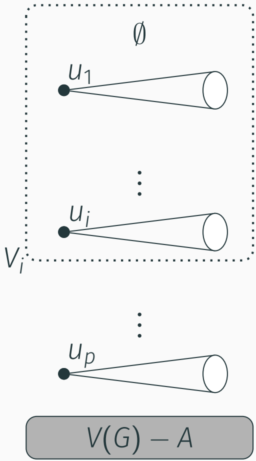

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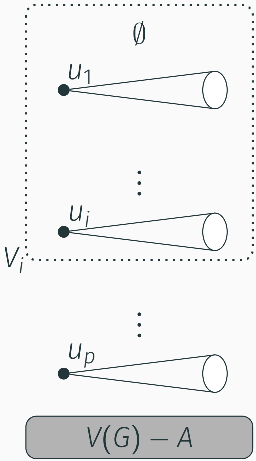

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   extend each minimal DS of V_i
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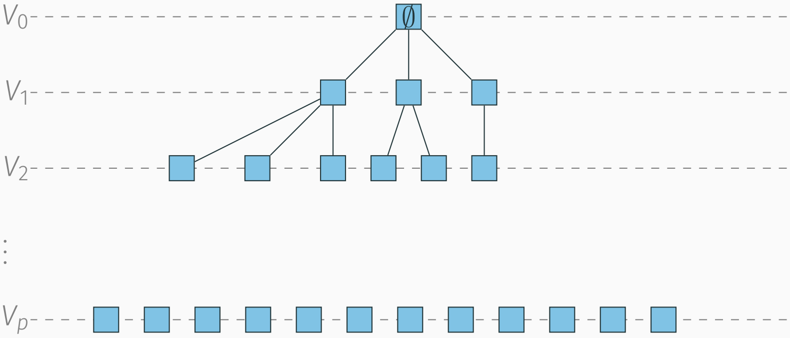
Growing partial minimal dominating sets



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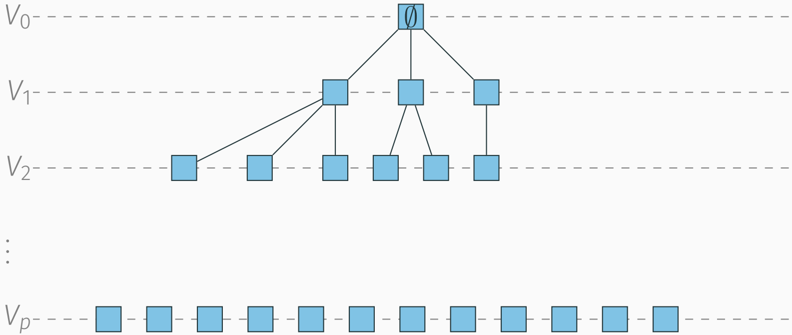

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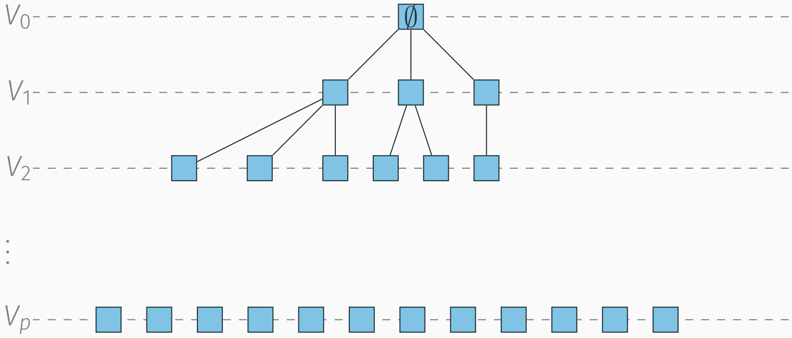

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Goal: extend a minimal DS D of V_i to a minimal DS of V_{i+1}

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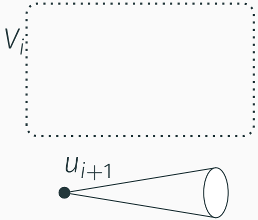

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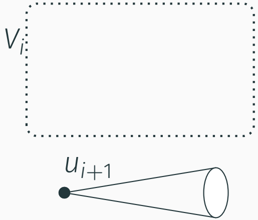

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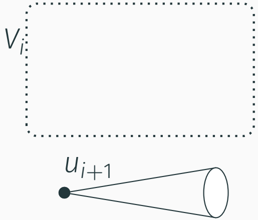

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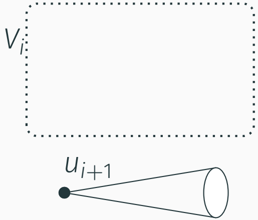

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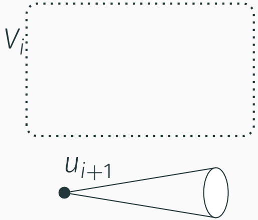
candidate extension: minimal X s.t. $D \cup X$ dominates V_{i+1}

Goal: extend a minimal DS D of V_i to a minimal DS of V_{i+1}



Observation:

- possibly D dominates V_{i+1}
- if not then $D \cup \{u_{i+1}\}$ does.

extension is always possible

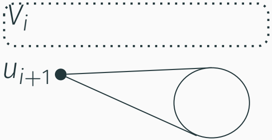
candidate extension: minimal X s.t. $D \cup X$ dominates V_{i+1}

Lemma: $|$candidate extensions of $D| \leqslant |$minimal DS of $(G, A)|$
(so we can try them all even if only few *work*)

Which are the candidate extensions of D?

D: minimal DS of V_i

Candidate ext.: minimal X s.t. $D \cup X$ dominates V_{i+1}



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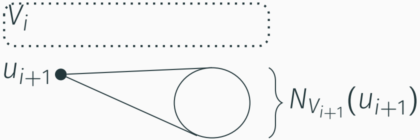

K_{t-1}-free!

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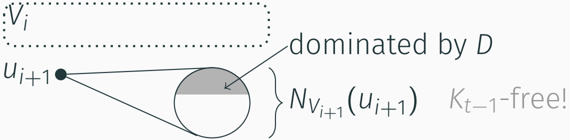

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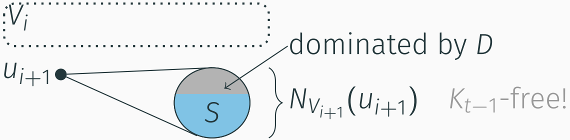

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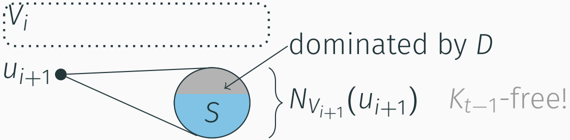

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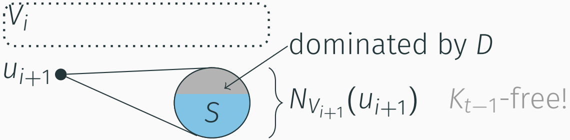

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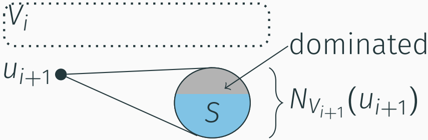

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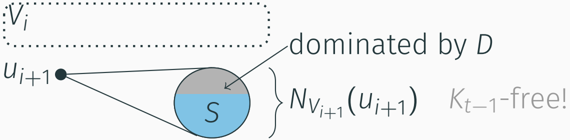

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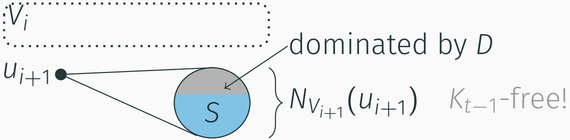

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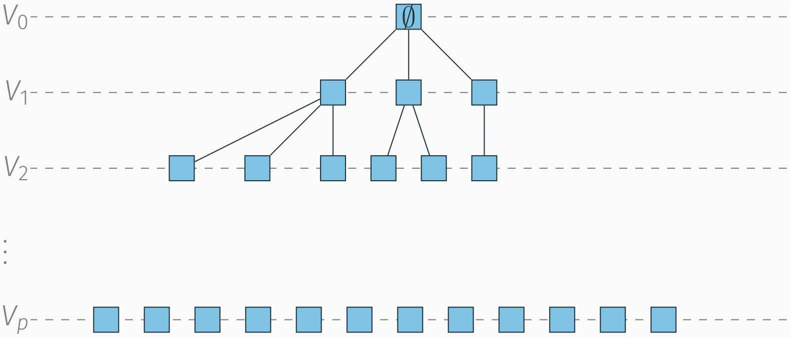
In both cases: subproblem (G, A') where A' is K_{t-1}-free

The algorithm



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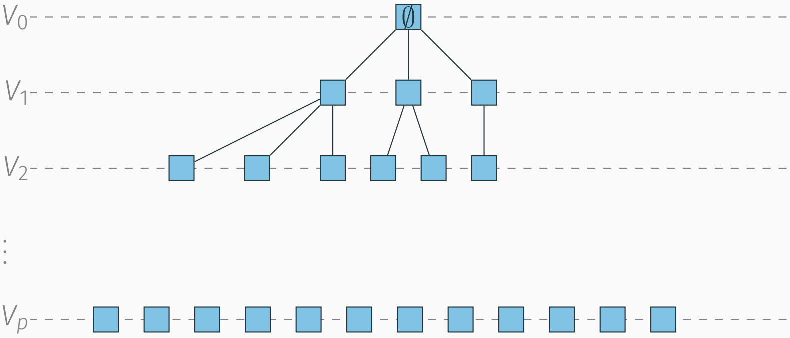

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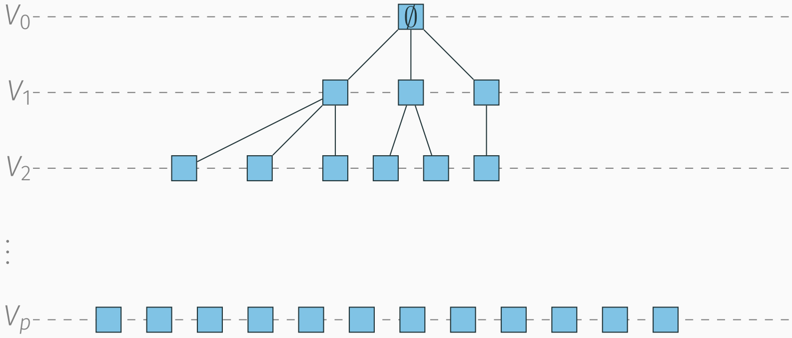

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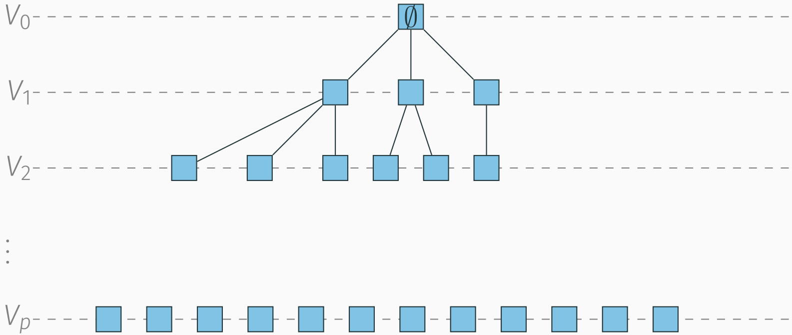

For each D minimal DS of V_i:

- compute all candidate extensions;
- only keep the $X \cup D$'s that are minimal and children of D.

Theorem (Bonamy, Defrain, Heinrich, Pilipczuk, R., 2019+)

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Deciding if a vertex set X can be extended into a minimal dominating set is NP-complete in bipartite graphs.

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Extensions

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$\exists$ *output-polynomial time and polynomial space algo. for:*

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The end

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Thank you!