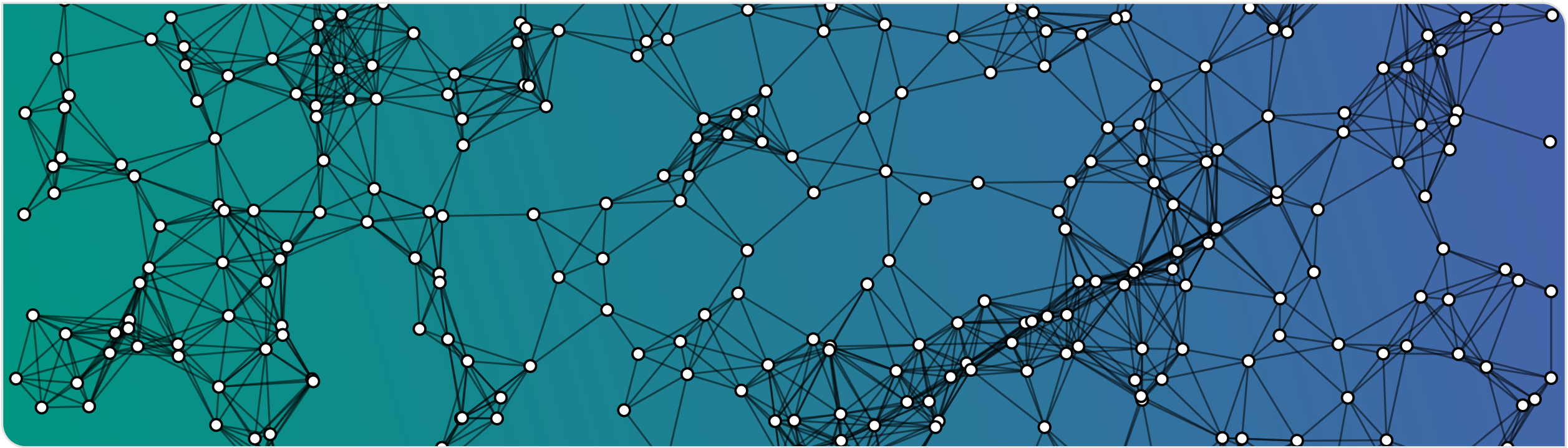
Karlsruher Institut für Technologie

Seminar Algorithmentechnik

Torsten Ueckerdt, Marcus Wilhelm, Max Katzmann, Thomas Bläsius, Michael Zündorf
Paul Jungeblut, Max Göttlicher, Wendy Yi, Jean-Pierre von der Heydt, Adrian Feilhauer



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- learn something about recent research in algorithms
- see some interesting proofs and proof techniques

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- understandable but formally correct proofs
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- spot mistakes in other's reports
- give constructive feedback

Learning Objective of the Course

	amount of work
Content ■ learn something about recent research in algorithms ■ see some interesting proofs and proof techniques	10h
Practice reading ■ reading mathy scientific texts ■ searching for additional literature/material	40h
Practice presenting ■ teaching proofs to others ■ making complicated things easy to understand ■ engaging and fun presentation ■ improving tool skills	30h
Practice writing ■ scientific writing ■ understandable but formally correct proofs ■ concise presentation	30h
Practice reviewing ■ spot mistakes in other's reports ■ give constructive feedback	10h
	120h≙4LP

Schedule

27.10.	Introduction
3.11.	Ipe tutorial
10.11.	Short presentations (5 min)
17.11.	
24.11.	Your Presentations (35+5 min)
1.12.	
8.12.	
15.12.	
...	
26.1.	First submission of written document
16.2.	Submission of reviews
15.3.	Final submission of written document

Course of Action

Today

- select a topic

Course of Action

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In two weeks (10.11.)

- short presentations (5 min)
  - advertise main presentation
  - motivate topic and intuitively explain highlights

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- select a topic

In two weeks (10.11.)

- short presentations (5 min)
  - advertise main presentation
  - motivate topic and intuitively explain highlights

Two weeks before your presentation (at last)

- you should have
  - read and understood your paper **in detail**
  - performed a literature review
  - thought about what to present and how to present it

Course of Action continued

One week before your presentation (or earlier)

- you should have
  - **finished** your slides for the presentation
  - send them to your advisor
- meet your advisor to discuss your slides

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First document submission deadline (26.1.)

- submit your document (at most 10 pages)
- receive two documents to review

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Review submission deadline (16.2.)

- submit your reviews, receive other's reviews

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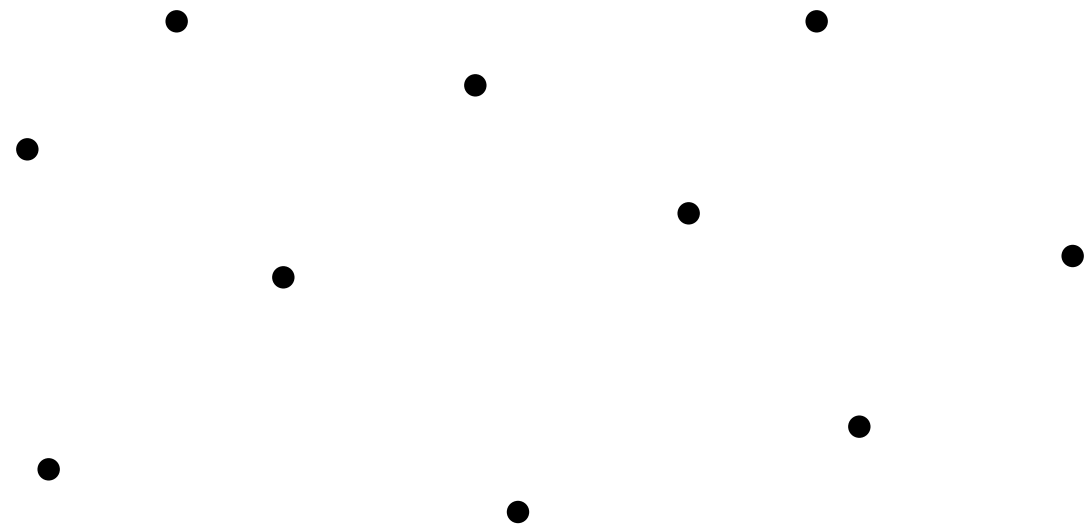
Grading

- Quality of main presentation
- Quality of *final* written document

Topic 1: How many triangulations are there?

Input: Points $P = \{p_1, \ldots, p_n\}$

Frage: How many triangulations does P have?



Chains, Koch Chains, and Point Sets with Many Triangulations

DANIEL RUTSCHMANN and MANUEL WETTSTEIN, Department of Computer Science, ETH Zurich, Switzerland

We introduce the abstract notion of a chain, which is a sequence of n points in the plane, ordered by x-coordinates, so that the edge between any two consecutive points is unavoidable as far as triangulations are concerned. A general theory of the structural properties of chains is developed, alongside a general understanding of their number of triangulations.

We also describe an intriguing new and concrete configuration, which we call the Koch chain due to its similarities to the Koch curve. A specific construction based on Koch chains is then shown to have $\Omega(9.08^n)$ triangulations. This is a significant improvement over the previous and long-standing lower bound of $\Omega(8.65^n)$ for the maximum number of triangulations of planar point sets.

Symposium on Computational Geometry (SoCG 2022)

Best Paper Award

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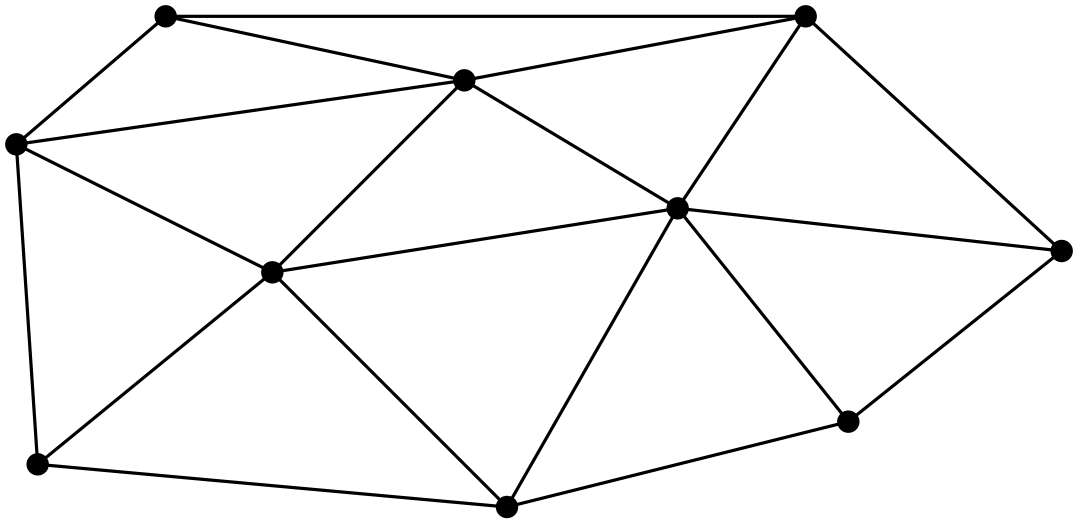

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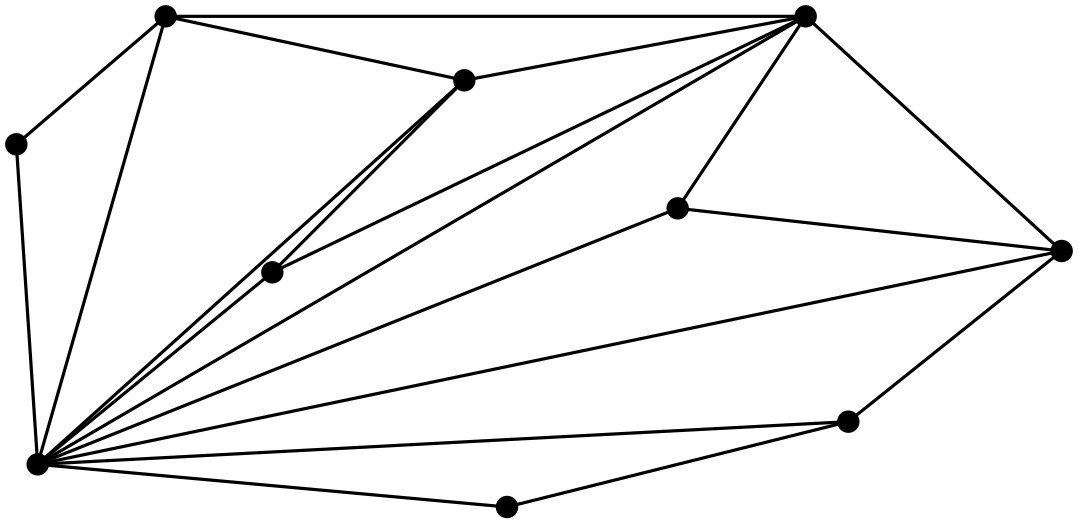

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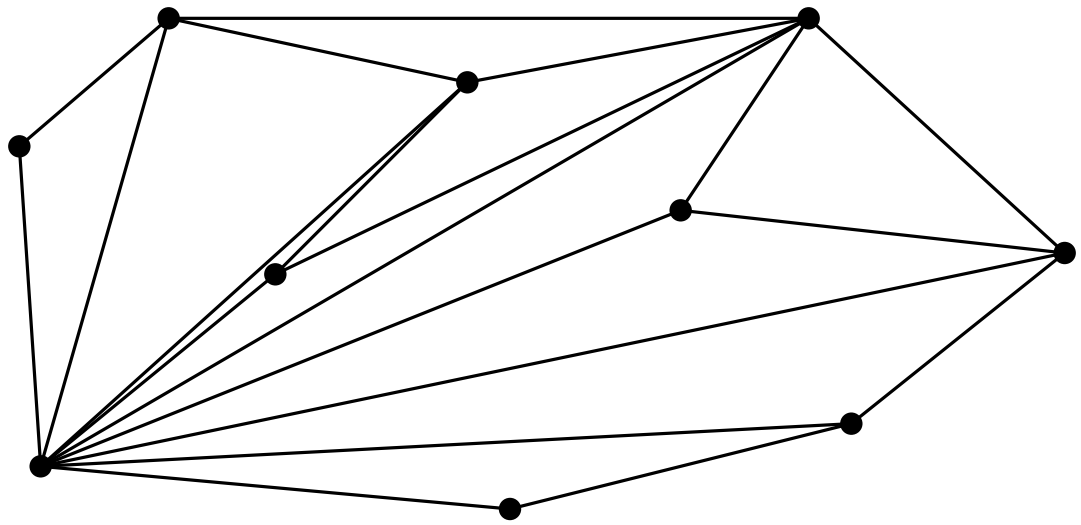

Theorem: There are sets of points with $\Omega(9.08^n)$ different triangulations.

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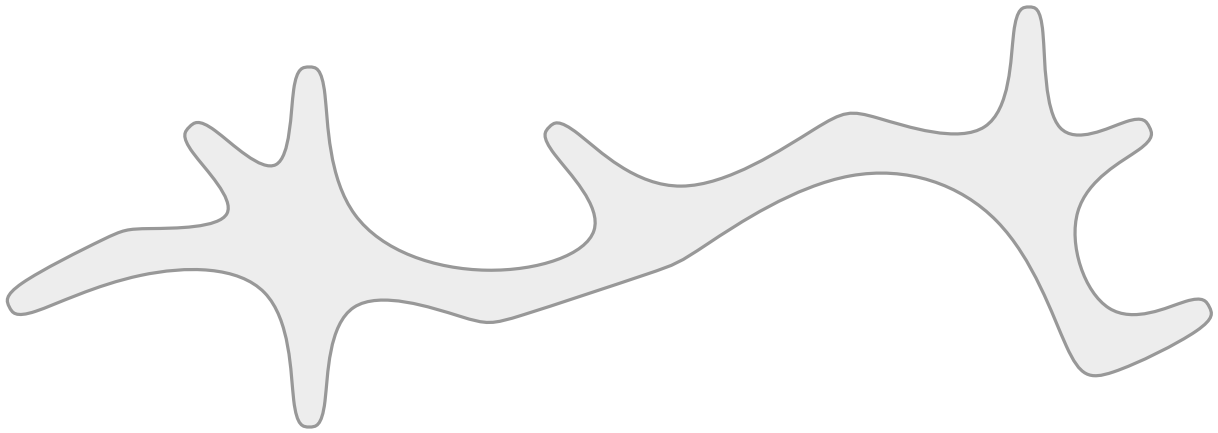
Topic 2: Tree Decomp. with Small Independence Number



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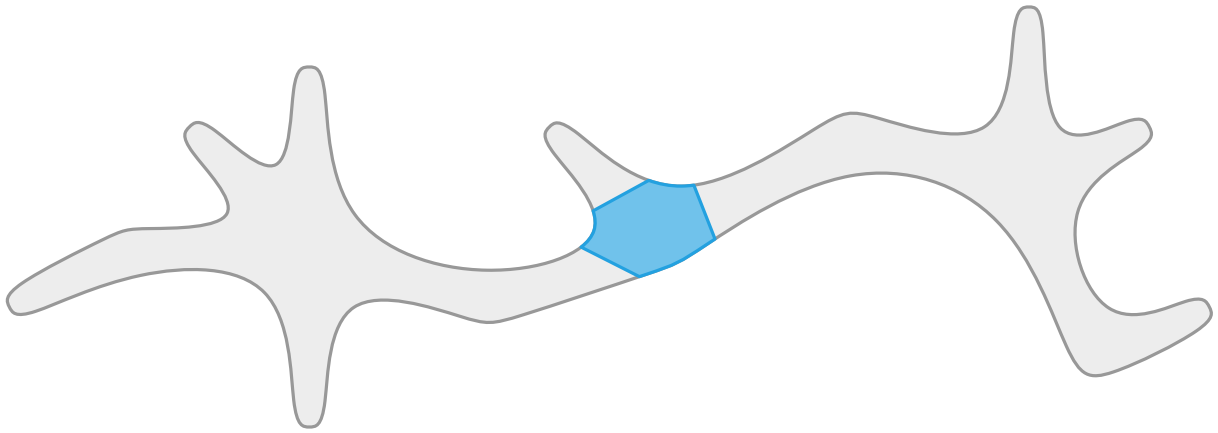

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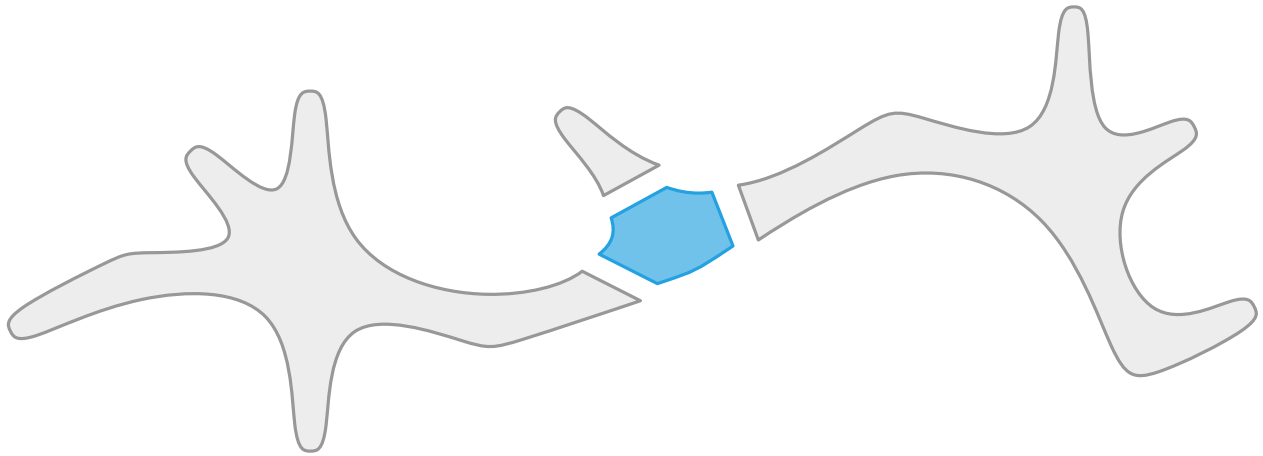

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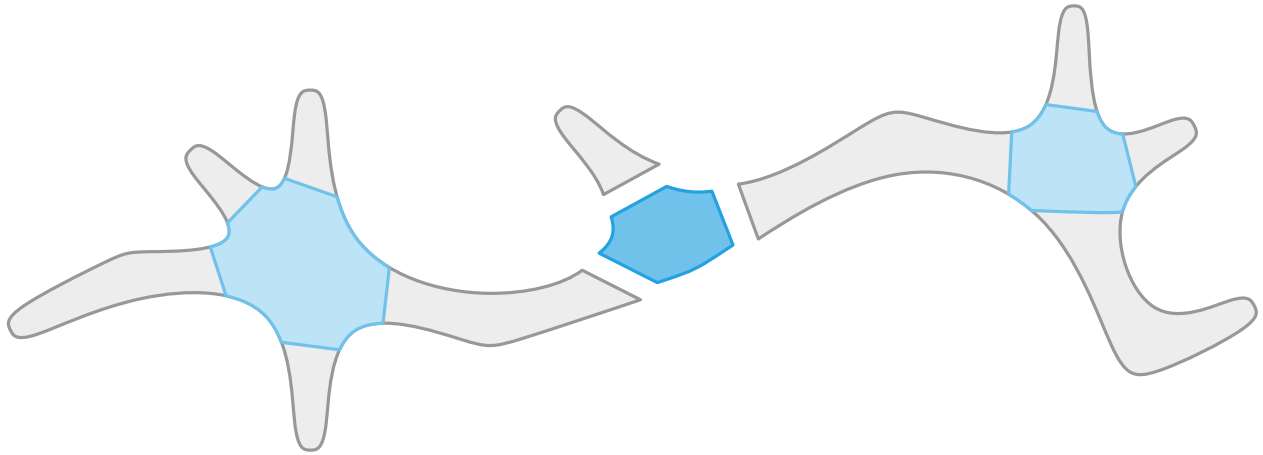

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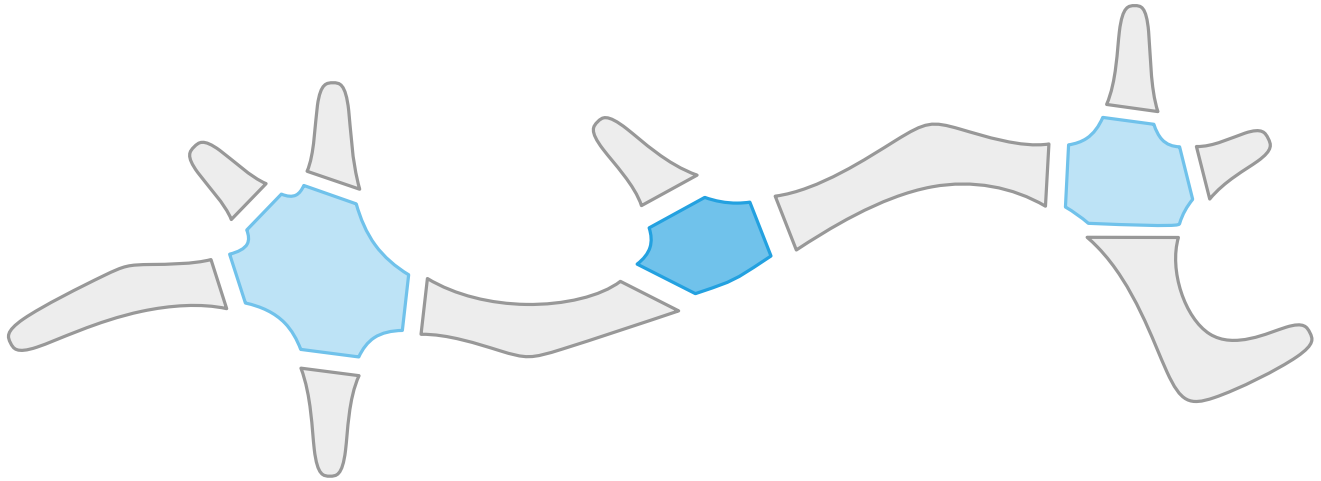

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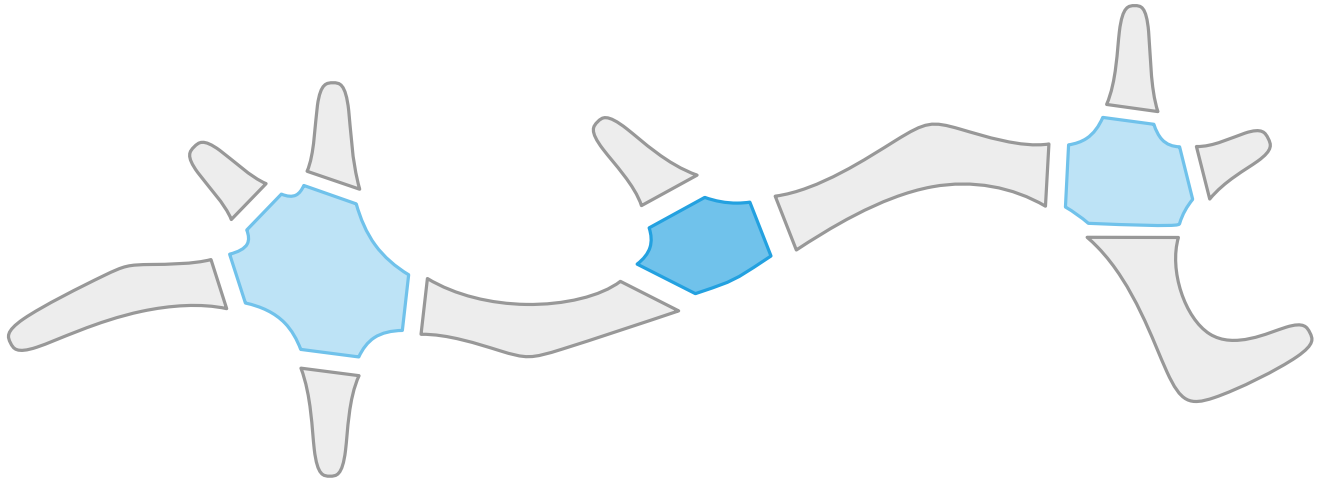

small separators $\Rightarrow$ efficient algorithms
small *treewidth*

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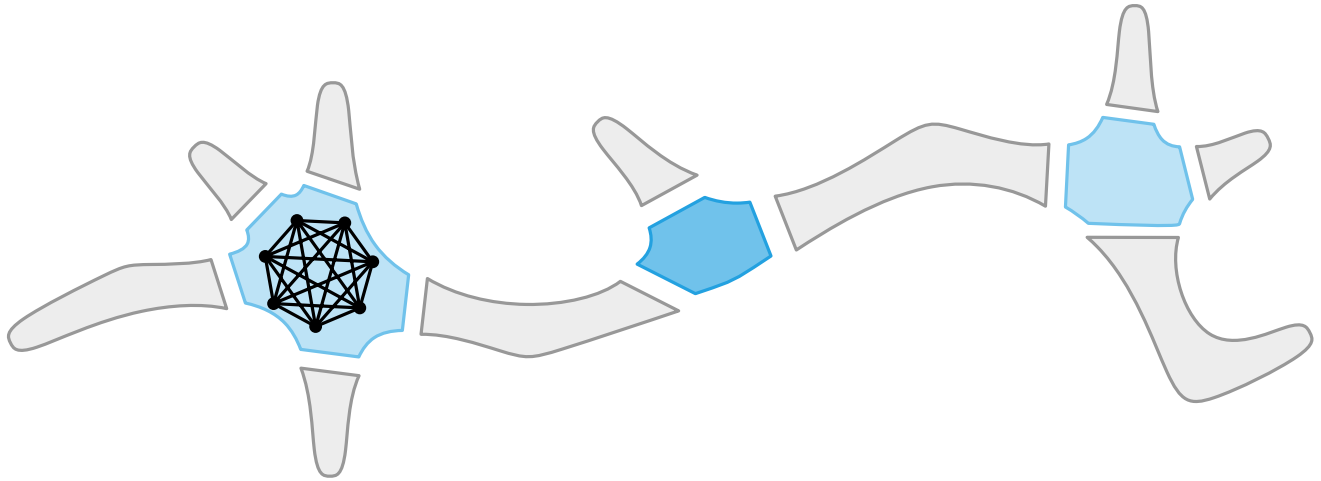

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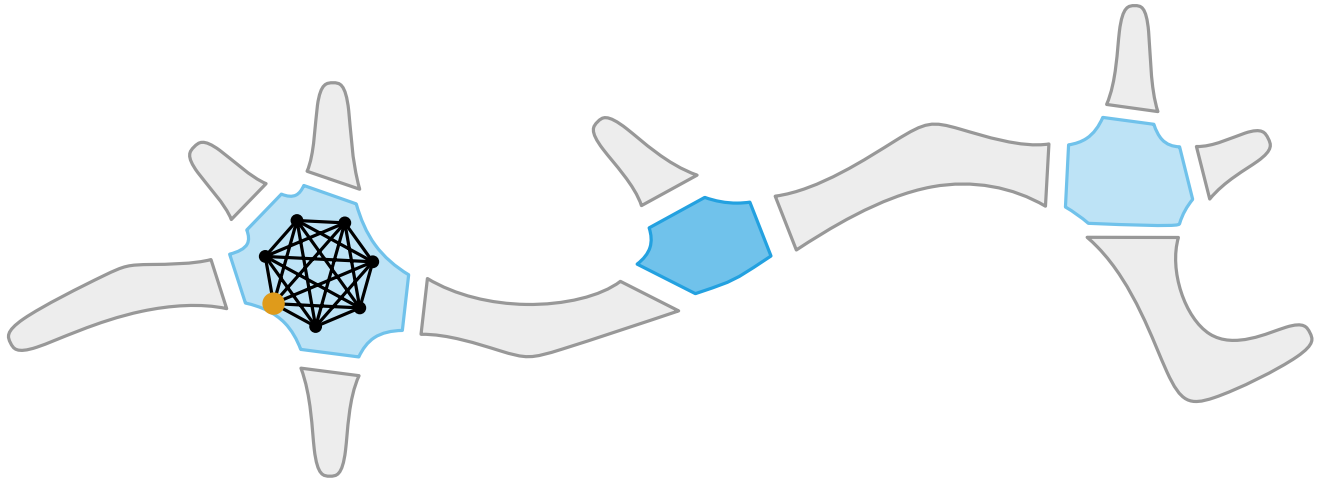

idea: consider size max. independent set

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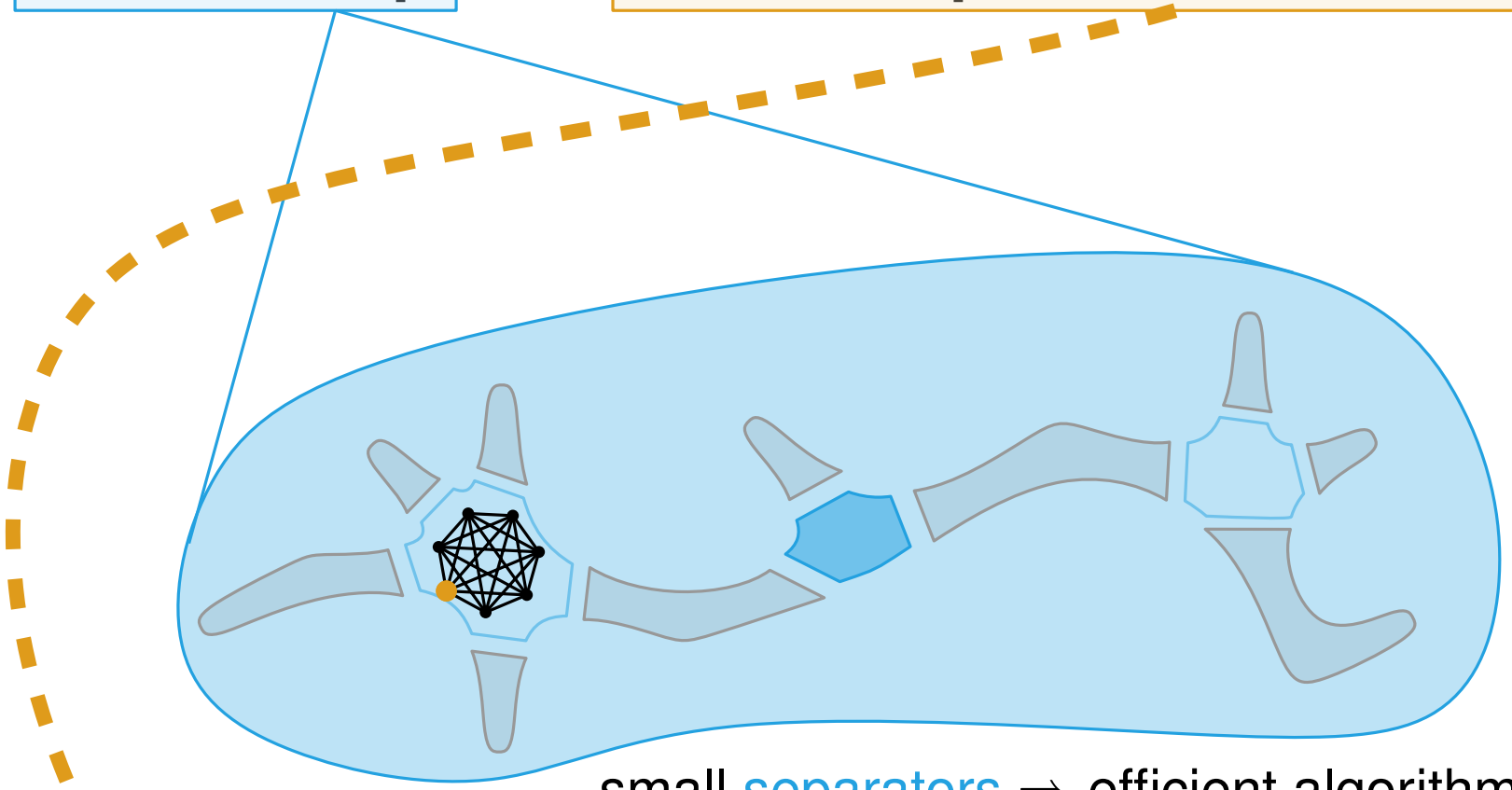

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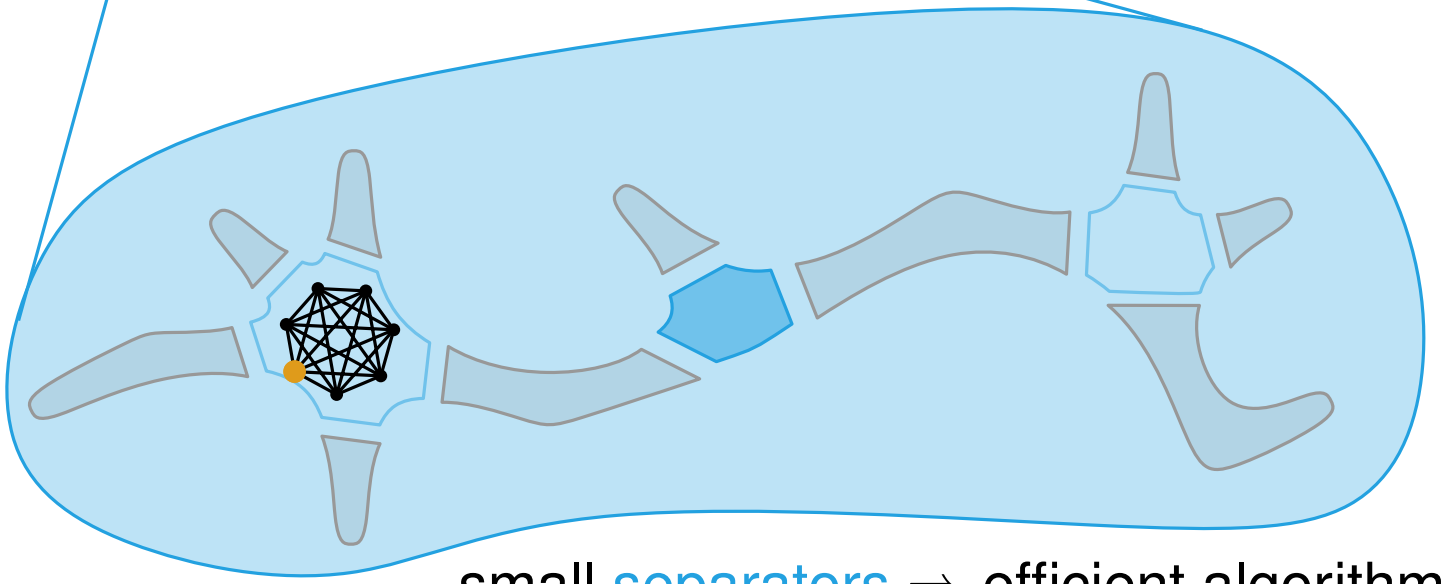
approximation algorithm



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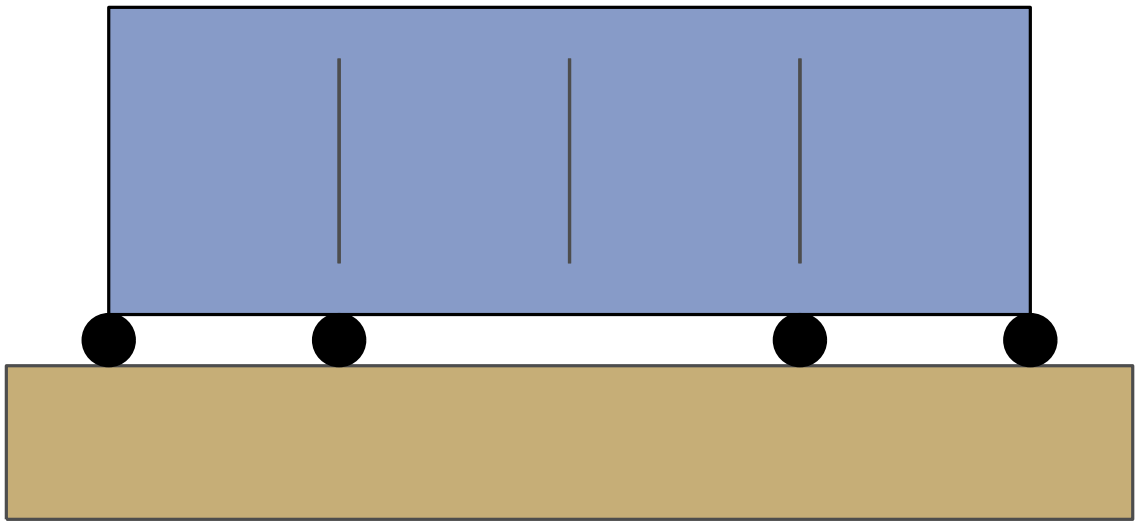

- Imagine a train driving on tracks

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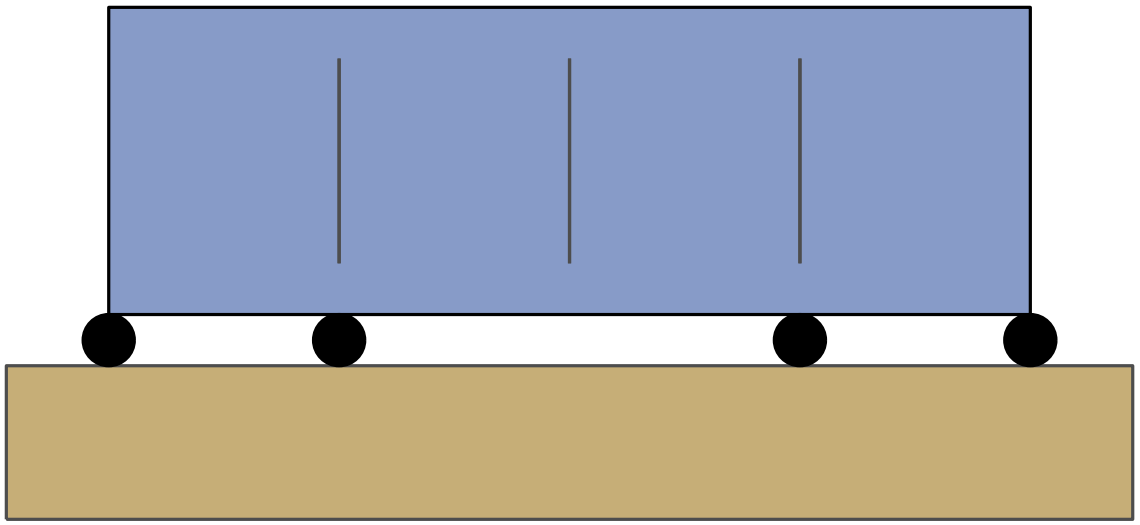

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- This is very wasteful. We can get by with much less rail

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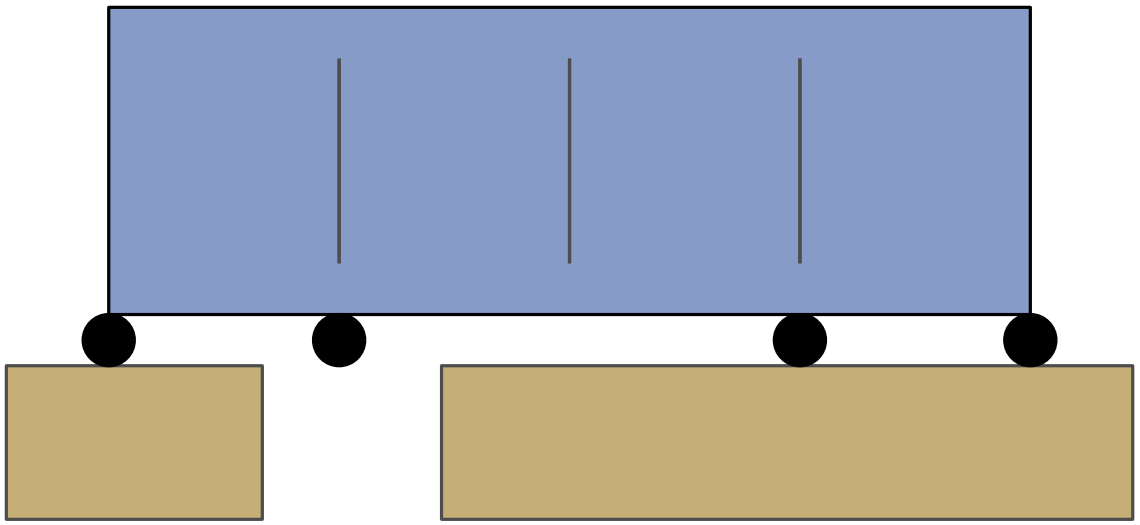

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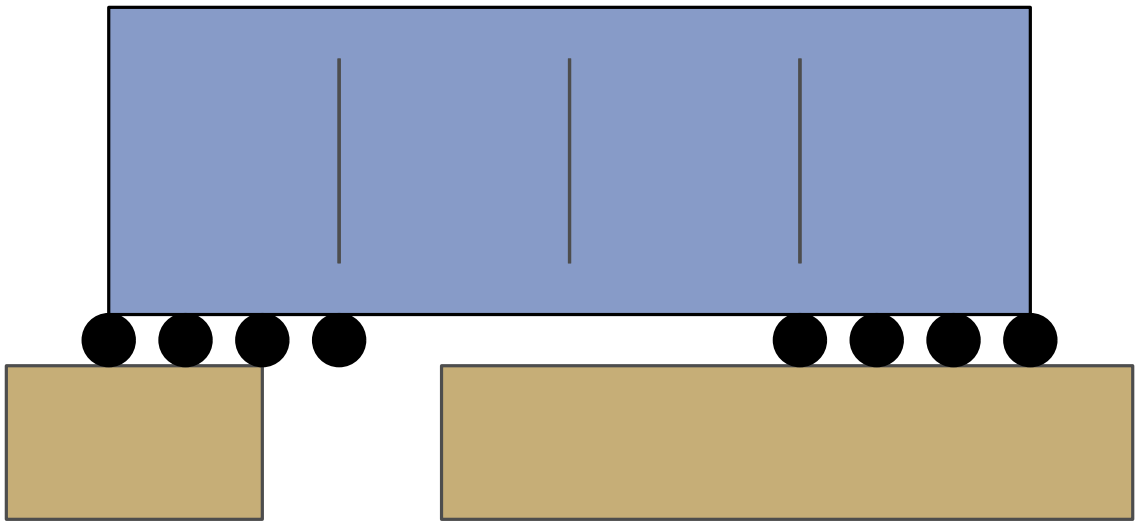

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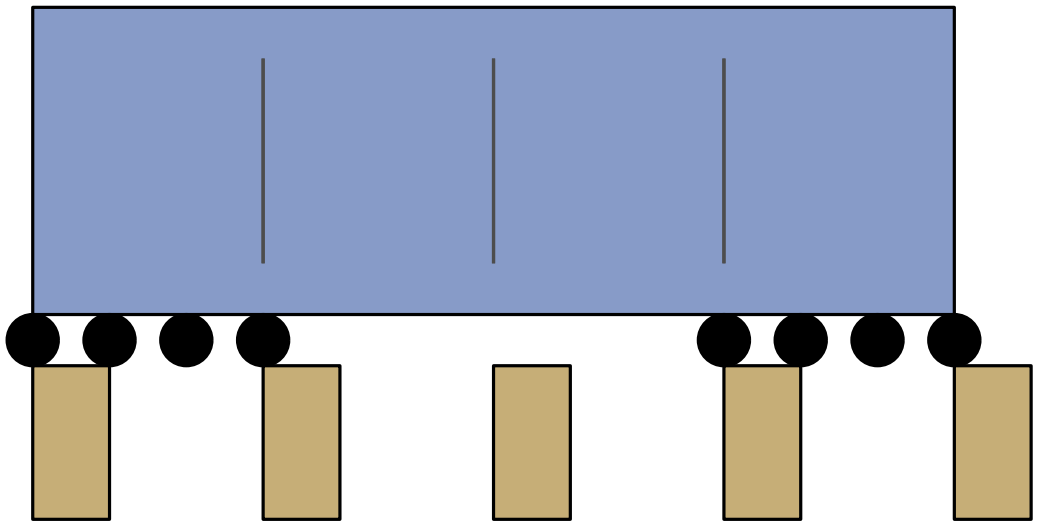

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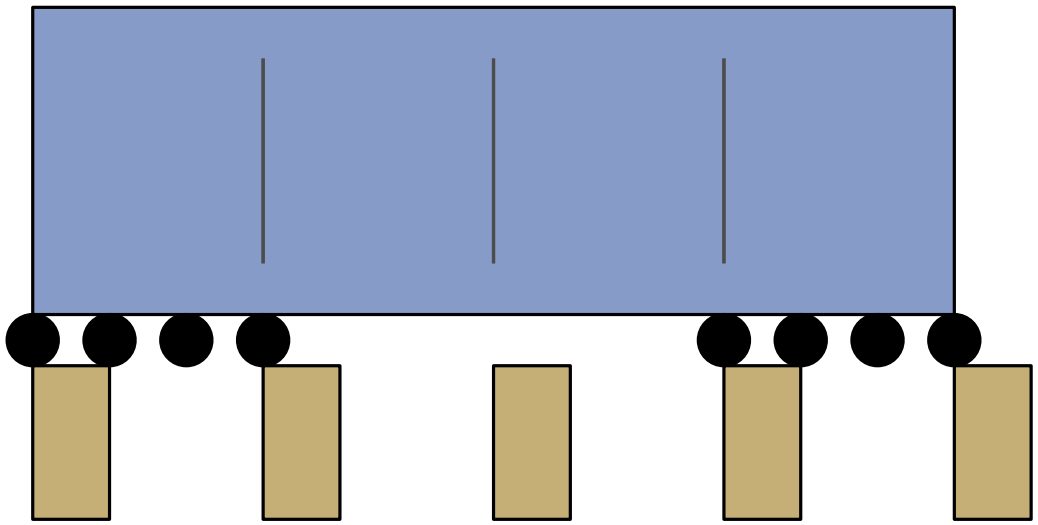

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- lower and upper bounds for the fraction of tracks

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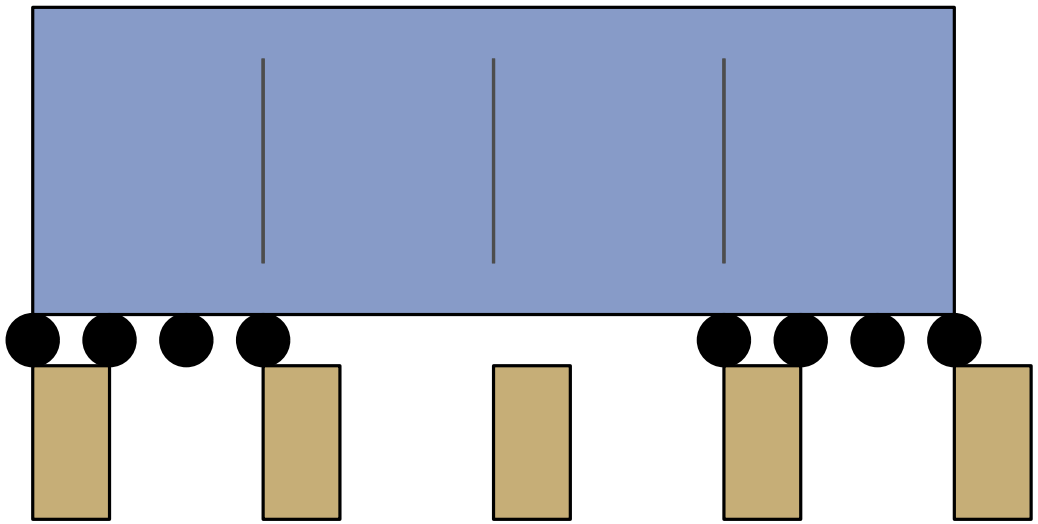

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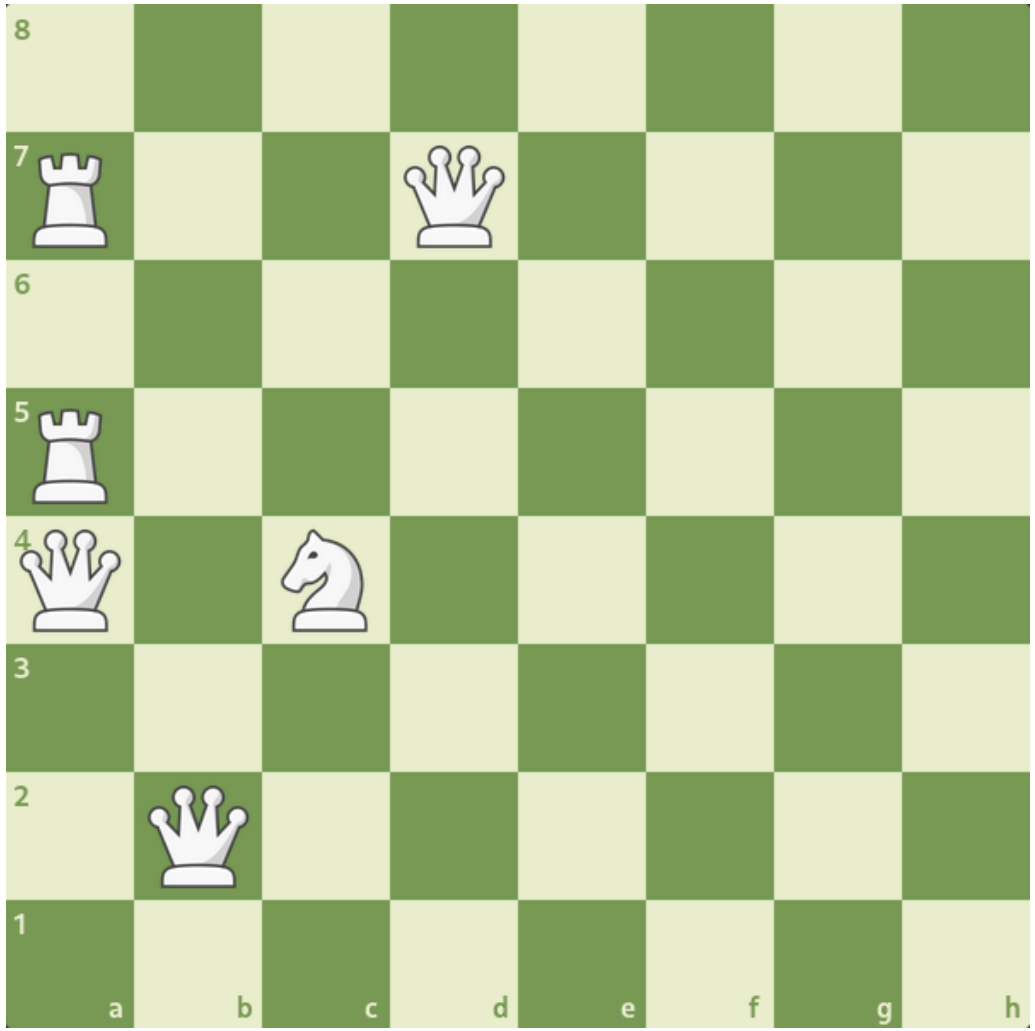
cool probabilistic arguments

adversariall wheel placement

algorithms for track building

Topic 4: Chess Is Hard Even for a Single Player



Solo Chess

- capture one piece in every move

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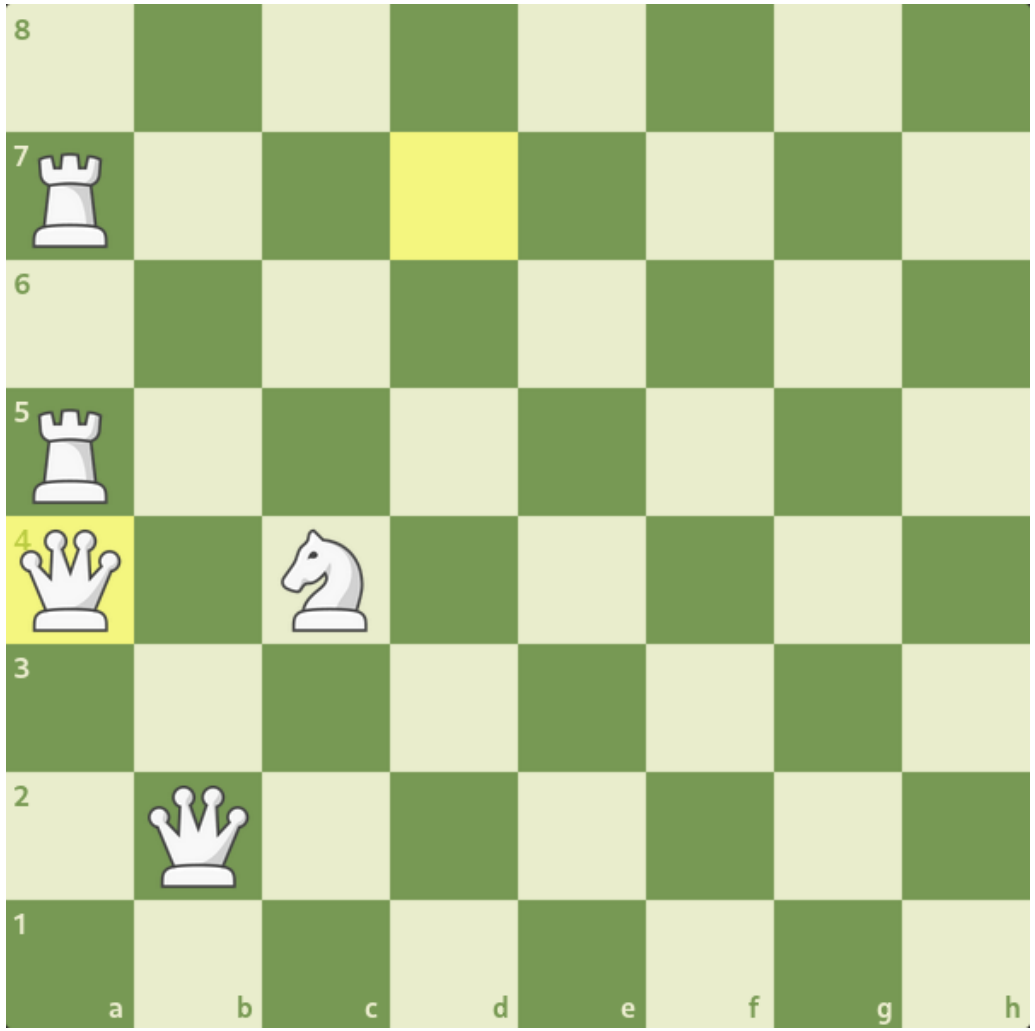

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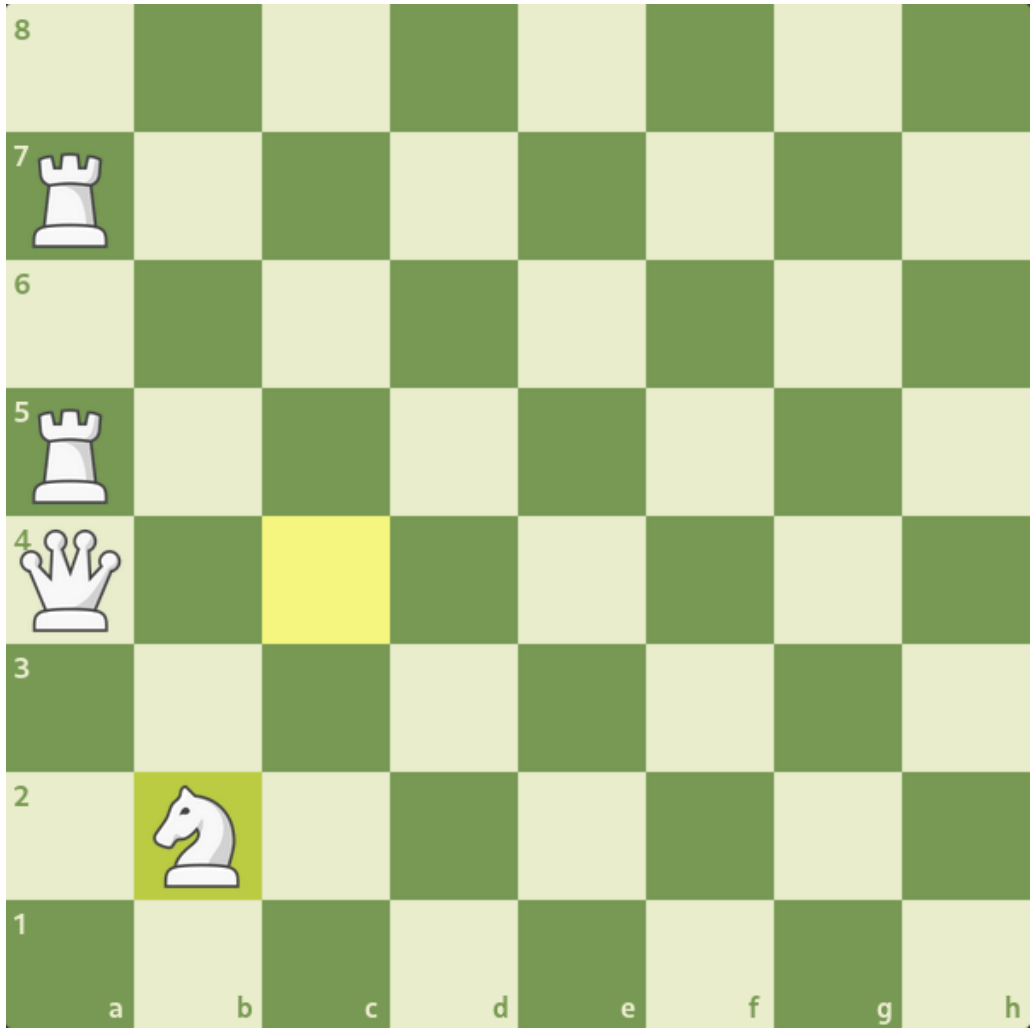

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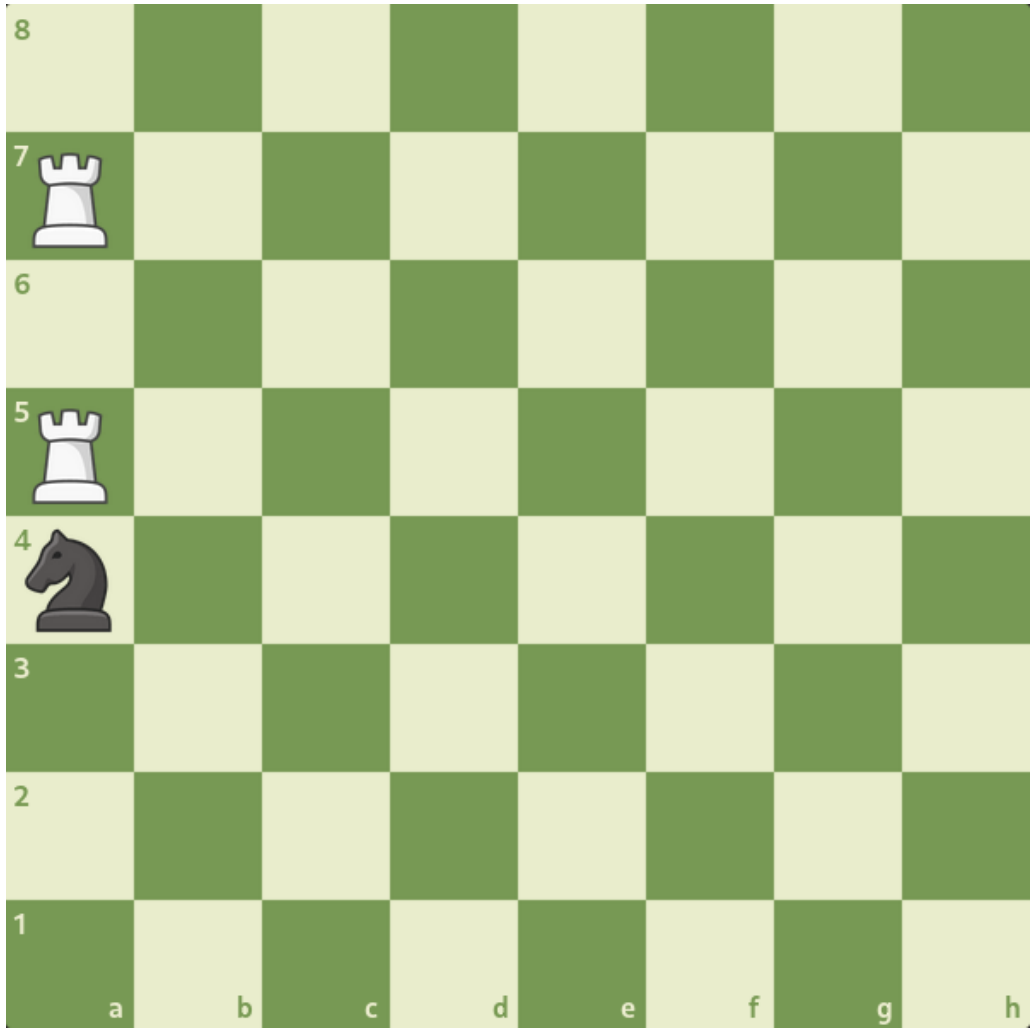

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- capture one piece in every move
- each piece moves at most twice

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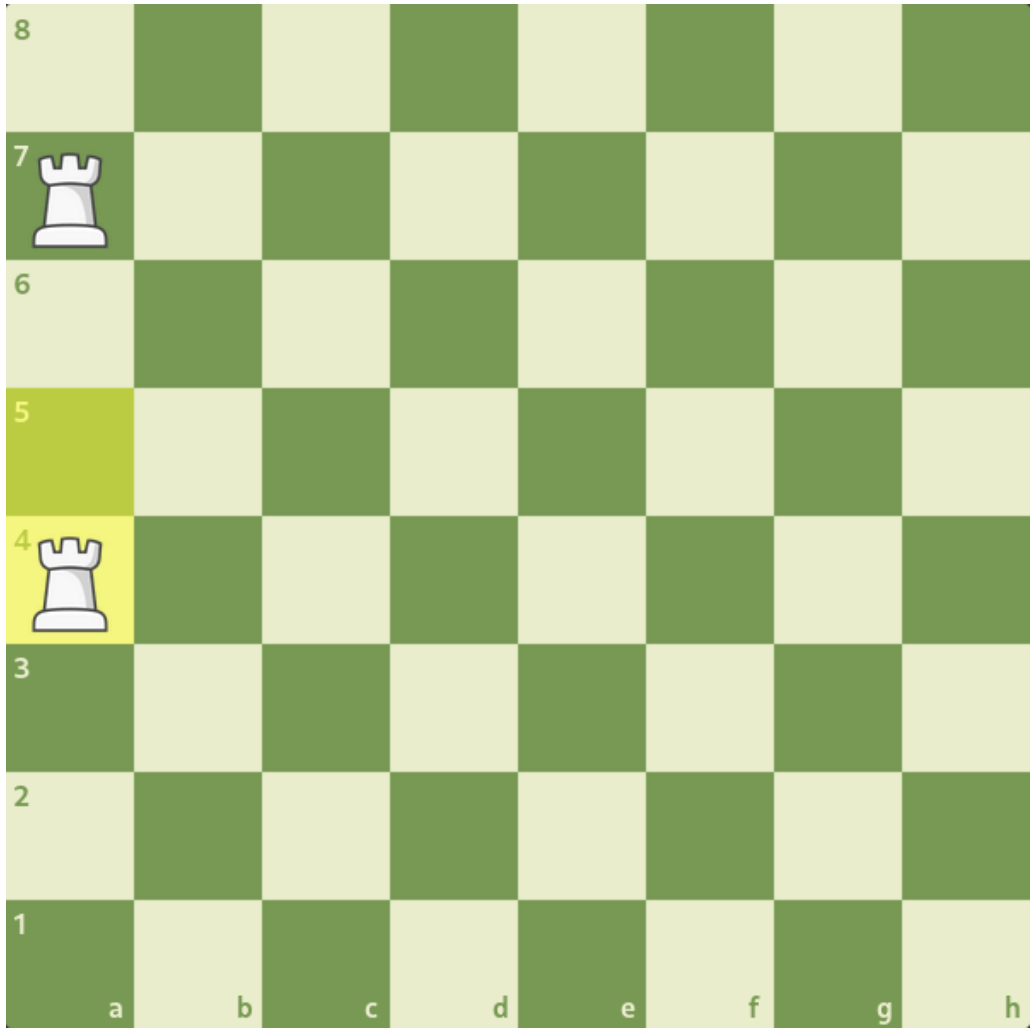

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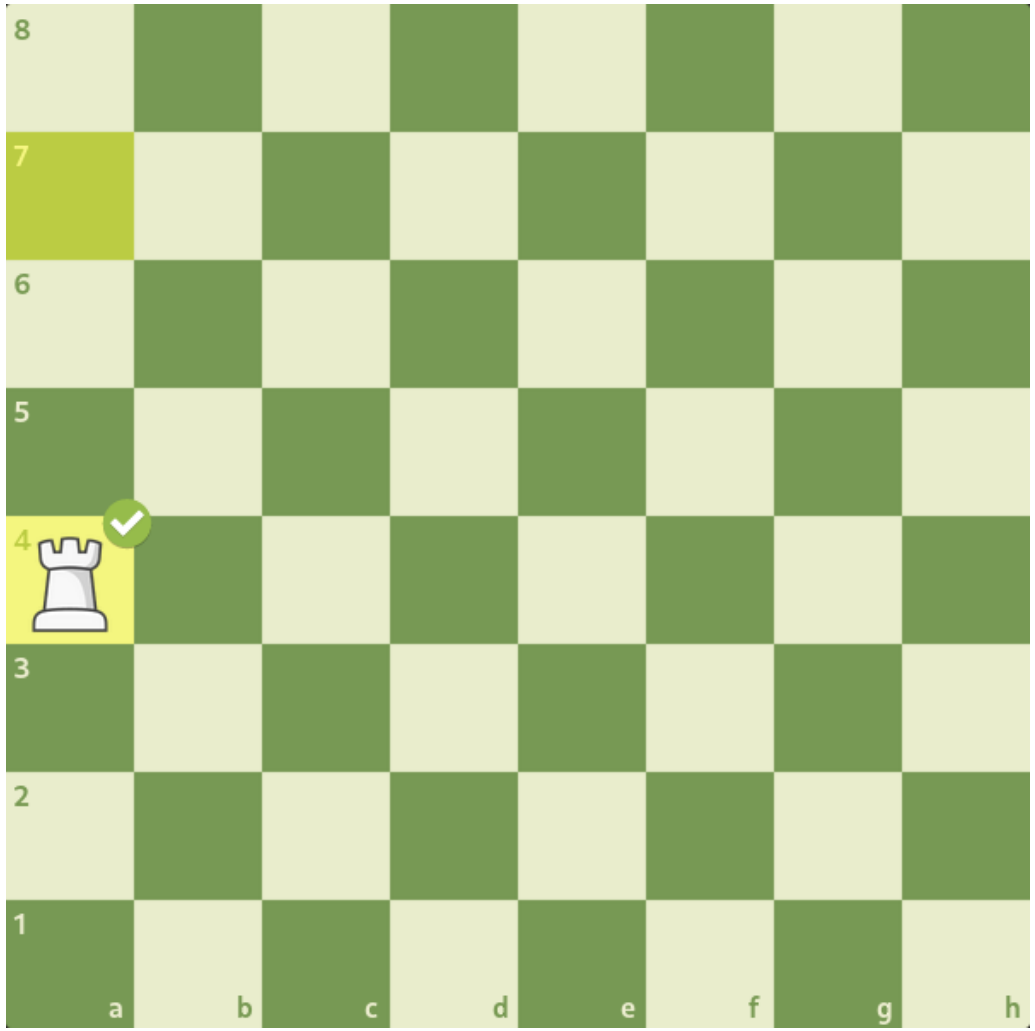

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- game is won if only one piece remains

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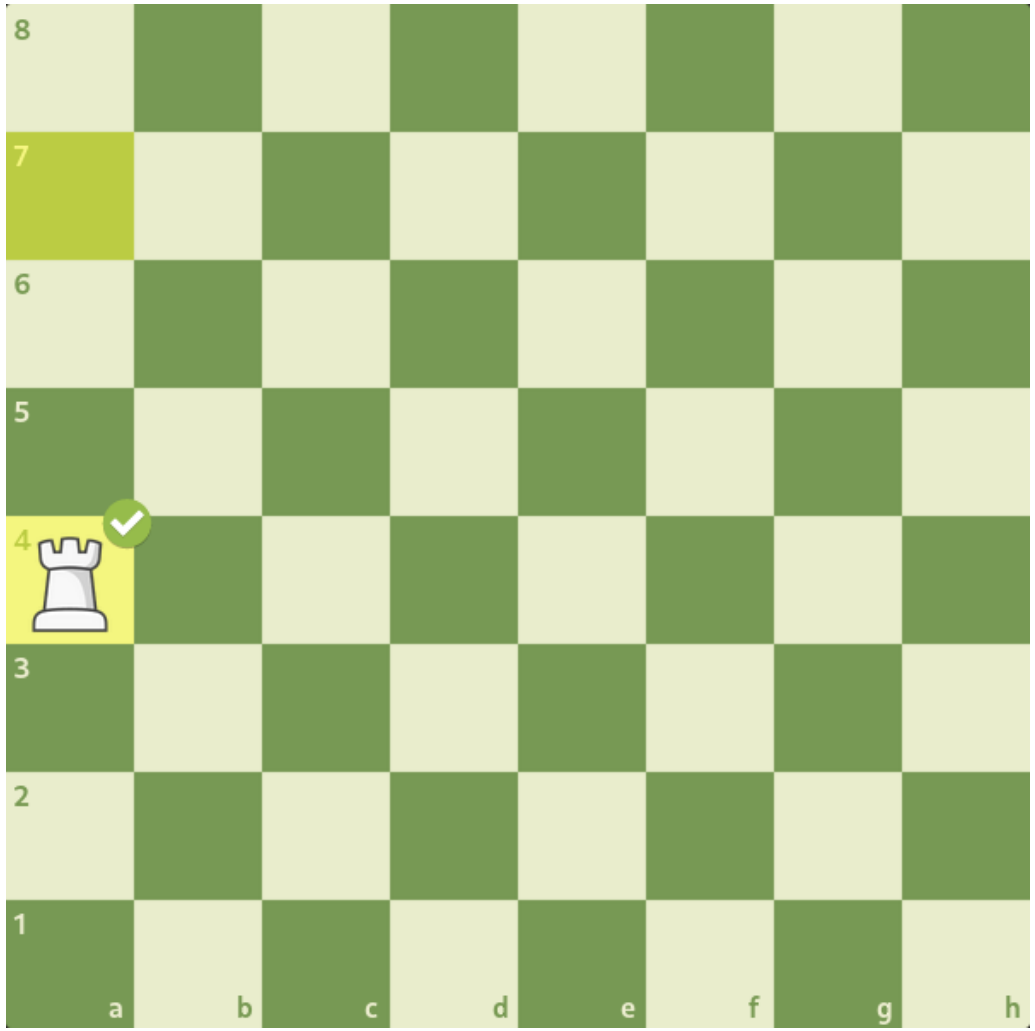

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GENERALIZED SOLO CHESS

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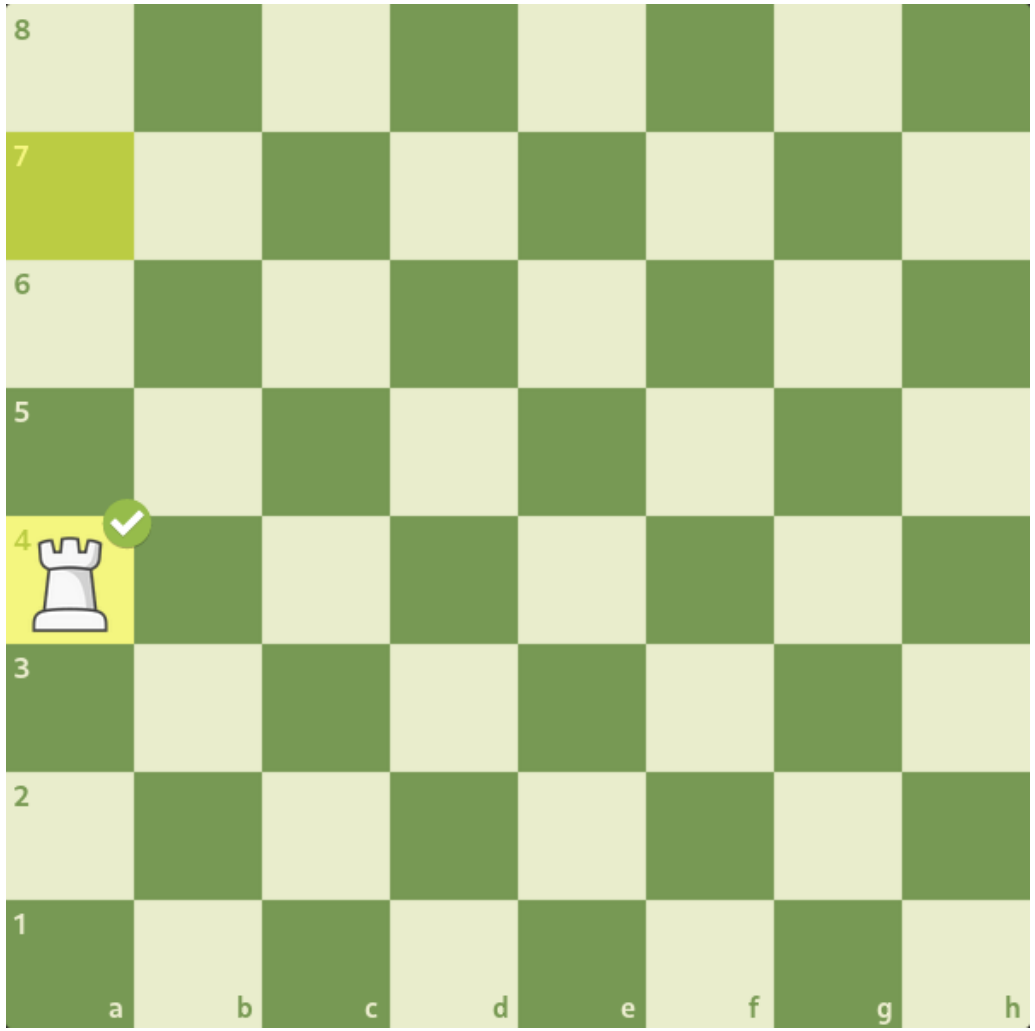

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Generalized Solo Chess

- infinite 2-dimensional board
- maximum number of moves may be different for each piece

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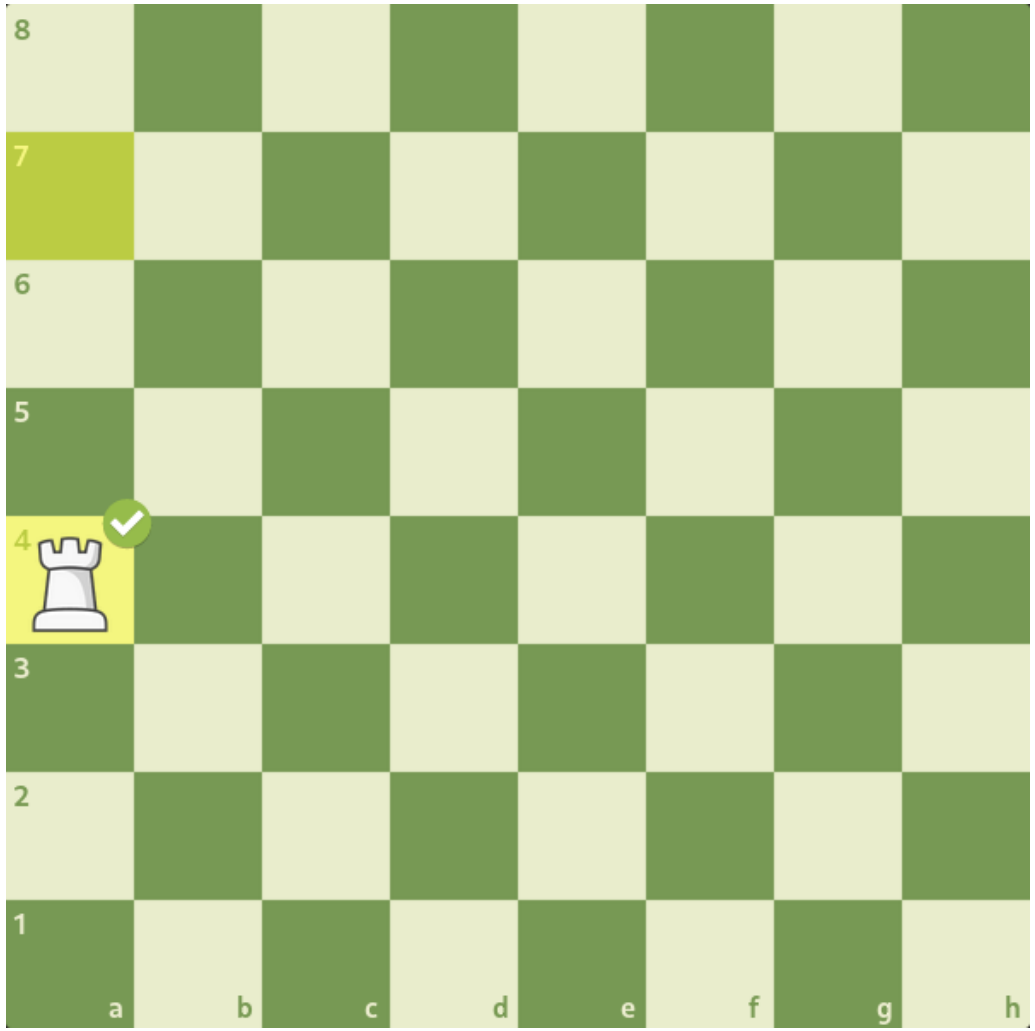

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Generalized Solo Chess

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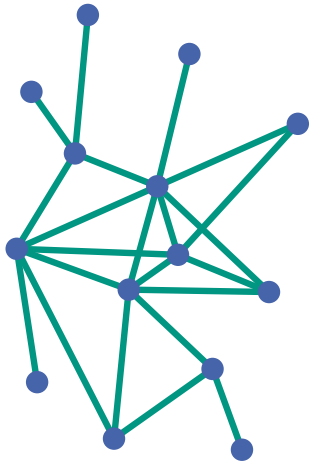
Is there a winning sequence of moves?

Topic 5: A Simple Algorithm for Graph Reconstruction

The Problem

- The world is full of graphs (the internet, social networks, your brain, etc.)
- They consist of vertices and edges



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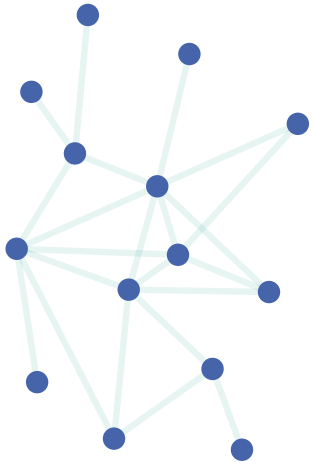
  - No one knows the whole internet graph



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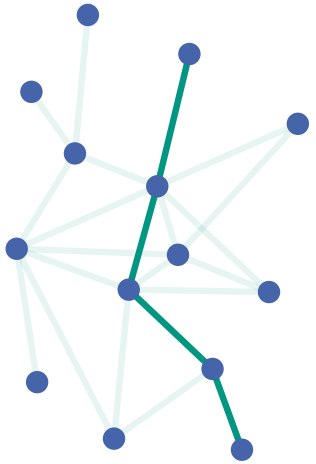

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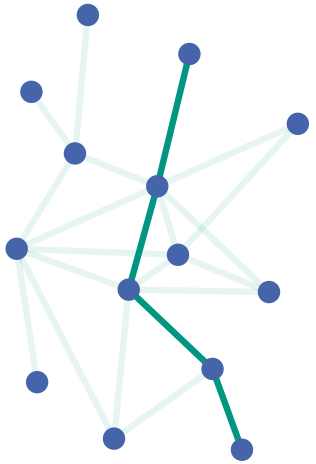
The Solution?

- We perform measurements to determine distances between the vertices in the graph
  - “The packet visited 3 routers before reaching the target computer”

Topic 5: A Simple Algorithm for Graph Reconstruction

The Problem



- The world is full of graphs (the internet, social networks, your brain, etc.)
- They consist of vertices and edges
- Sometimes we only know the vertices of the graph but not the edges
  - No one knows the whole internet graph

The Solution?

- We perform measurements to determine distances between the vertices in the graph
  - “The packet visited 3 routers before reaching the target computer”
- Formally, this is modelled using an *oracle* that answers queries like: “What is the distance between these two vertices?”

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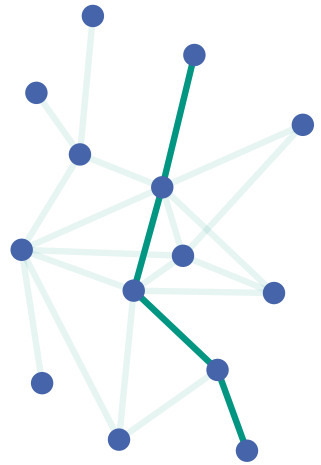

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Reconstruction Algorithms

- Performance measured by counting queries (In general $\Omega(n^2)$ queries needed for graphs with n vertices)
- In the paper: A simple algorithm requiring $\tilde{O}(n)$ queries on graphs with special structure

Topic 6: Baba is You

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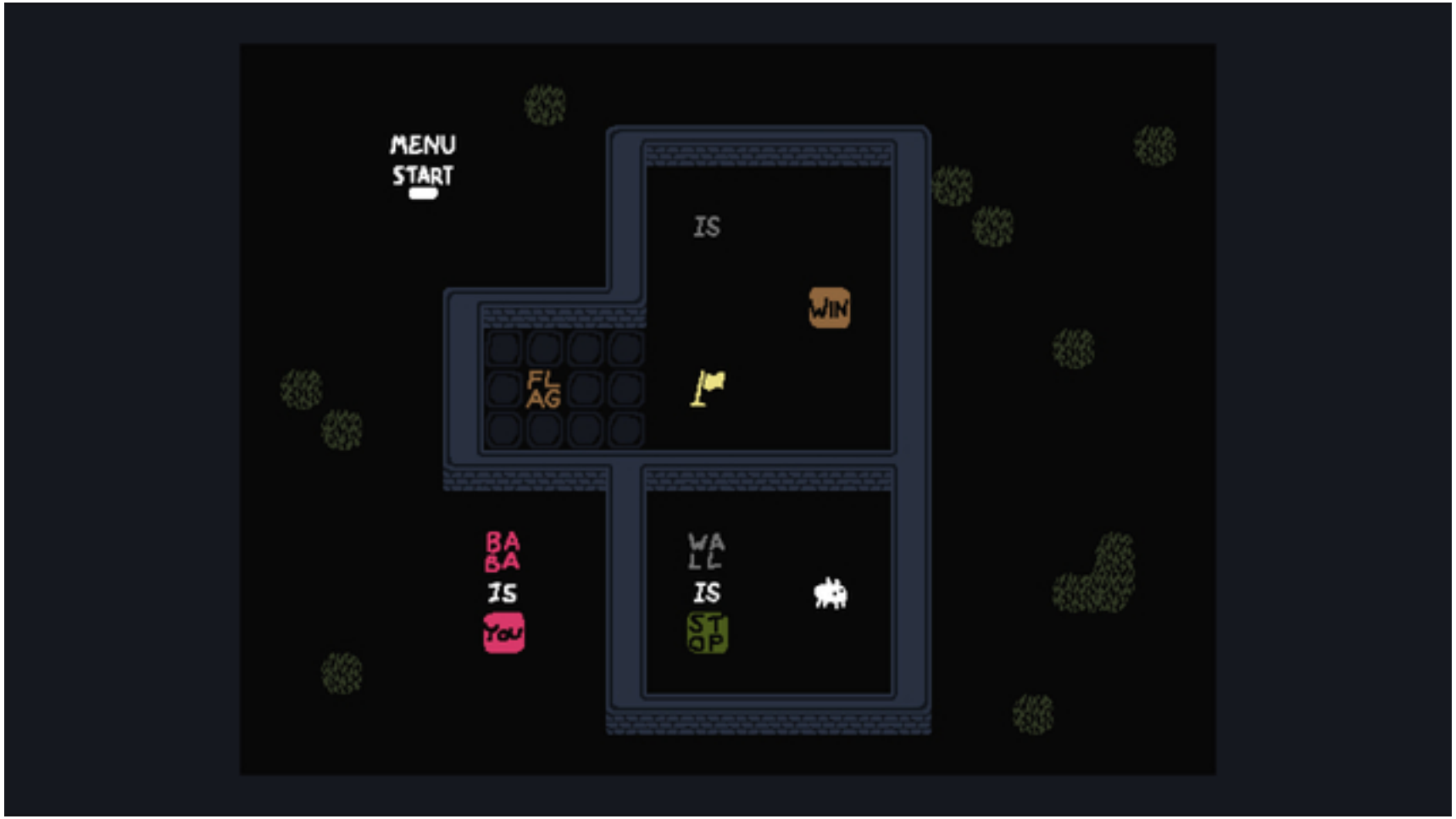

Topic 6: Baba is You

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Topic 6: Baba is You is Undecidable

Topic 7: Product structure extension of the Alon–Seymour–Thomas theorem

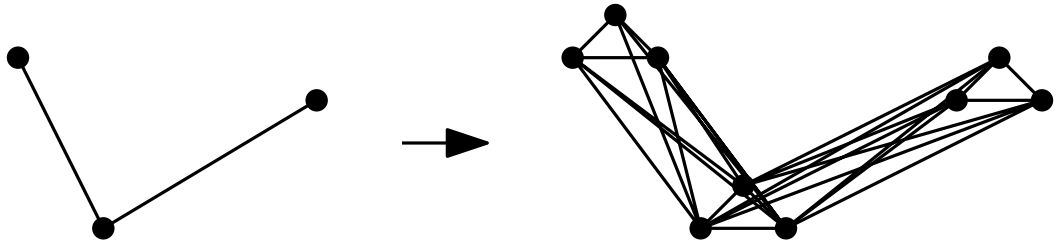
Theorem (Distel et al., 2023+)

Every planar graph is a subgraph of $H \boxtimes K_m$.

very *simple* graph (bounded treewidth)

clique of size $m \in O(\sqrt{n})$

blow-up vertices of H with cliques of size m:



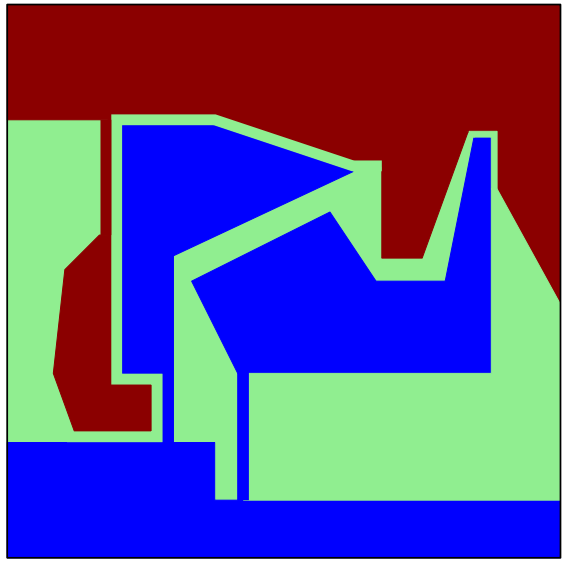
- qualitative strengthening of the planar separator theorem
- introduction of several advanced graph-theoretical concepts
- technical proof via stronger theorems
- rewarded by nice structural insights
- **prerequisites: familiarity with minors and Menger's theorem**

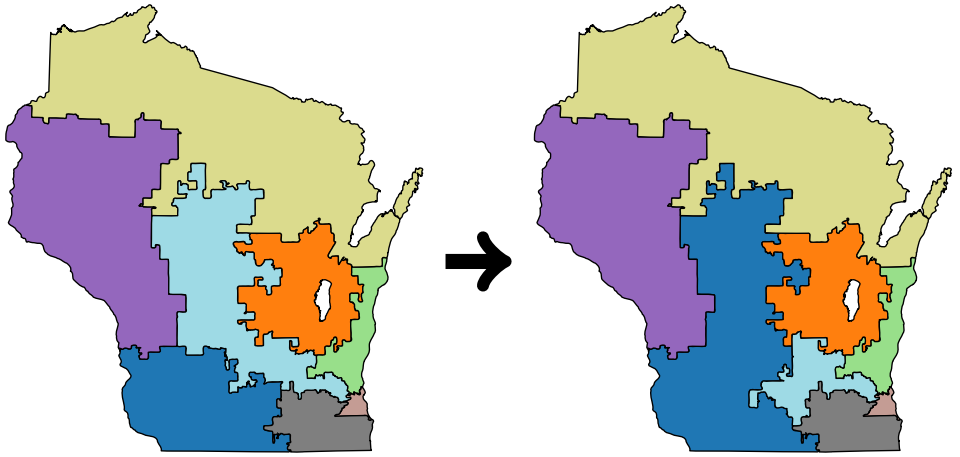
https://arxiv.org/abs/2212.08739

Topic 8: Reconfiguration of Polygonal Subdivisions via Recombination

Problem:

- Given subdivided polygon
- Merge and then split two neighboring areas
- Keep areas connected
- (How fast) Can we reconfigure?





Results:

- Any area-compatible maps can be reconfigured
- Low move count for few areas

Topics: overview

1. Point Sets with Many Triangulations
2. Computing Tree Decompositions with Small Independence Number
3. Train Tracks with Gaps
4. Chess Is Hard Even for a Single Player
5. A Simple Algorithm for Graph Reconstruction
6. Baba is You is Undecidable
7. Product structure extension of the Alon–Seymour–Thomas theorem
8. Reconfiguration of Polygonal Subdivisions via Recombination

Comments

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- Slides: we recommend to use Ipe

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- Can some arguments be simplified?
- Is your presentation fun? Interactive?

Some more comments

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  - introduction, related work, (applications)
  - selected topics in detail
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  - check grammar and spelling!
  - regularly read what you just wrote
    - check correctness, clarity
    - what is the purpose of a sentence / paragraph?
  - should sentences / paragraphs be rearranged?

Even more comments

Mutual Reviews

- written statement (form provided)
- optionally: annotations
- Structure:
  - short summary of the content
  - strengths and weaknesses of the work
  - review of the text (comprehensibility, structure, accuracy, language, topic coverage, ambiguities, . . .)
- be constructive: detailed comments and correction instructions
- as detailed as you would like to get review for your work
- objective and fair

Organization

Website

- `https://scale.iti.kit.edu/teaching/2023ws/seminar`
- you find these slides there
- other information like dates of the talks
- slides of all participants

Next week: Ipe tutorial

- install ipe and make sure it works
  - get and install ipe: ipe.otfried.org
  - make sure LaTeX is installed
  - open Ipe and check whether LaTeX works: press “ℓ”; click somewhere in the drawing area; insert some text; click Ok; check whether it nicely rendered your text (it might be necessary to press “Ctrl+ℓ” to make sure it renders correctly)
- bring a laptop and a mouse