Learn to Vaccinate: Combining Structure Learning and Effective Vaccination for Epidemic and Outbreak Control

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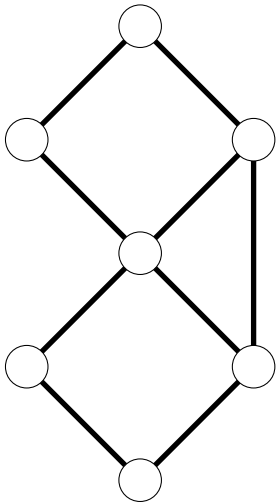
Susceptible-Infected-Susceptible (SIS) Model

- Interacting particle system with applications to
  - modeling of financial markets
  - rumor spreading in social networks
  - epidemics with reinfections



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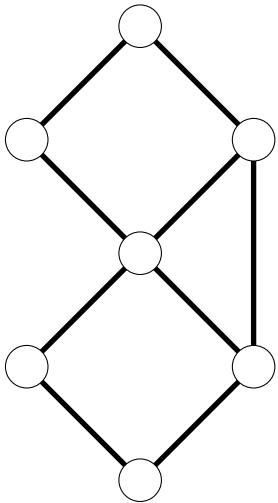

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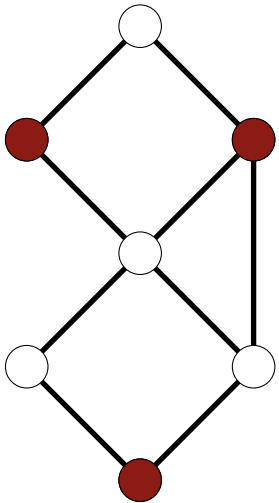

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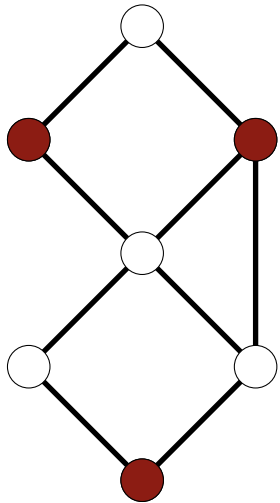

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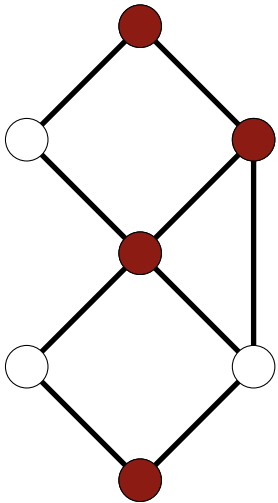

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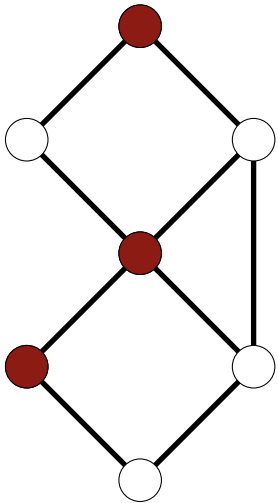

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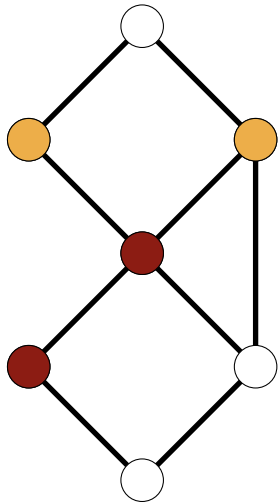
- v vaccinated: reduced infection probability



Vaccinating an Unknown Graph (VUG) Problem

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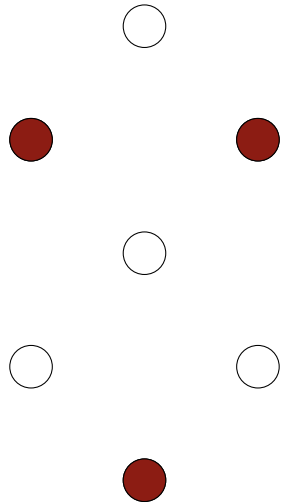
- **Challenge** infection pathways (edges) are unknown.
- **Our approach:** (1) learn the underlying graph G and (2) compute the optimal K vertices to vaccinate.

Structure Learning

- Observations:
  - vertices and their infection states
  - edges **not** observed



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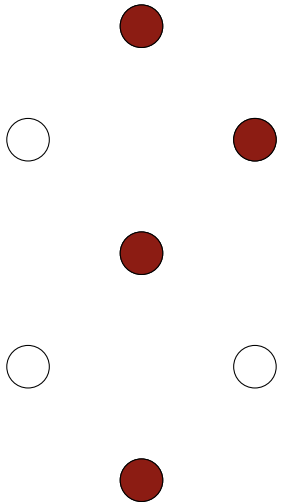

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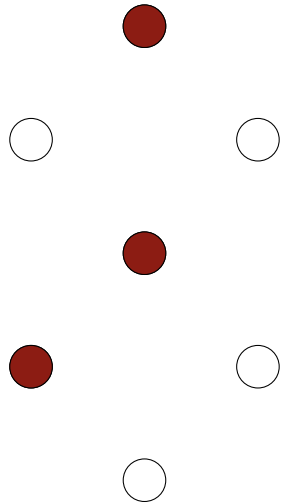

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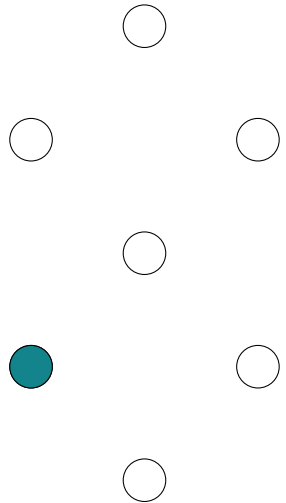

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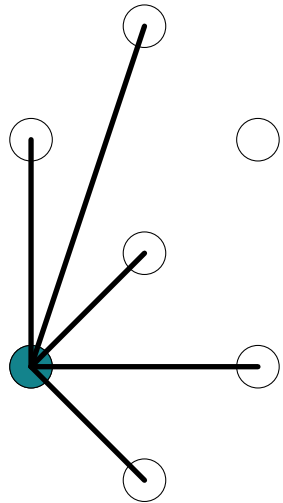

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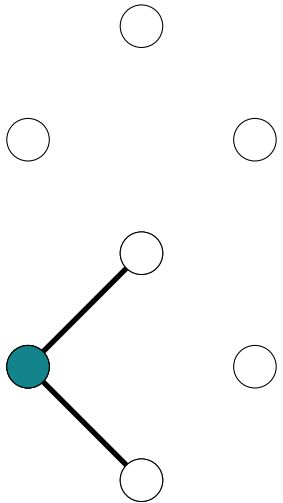

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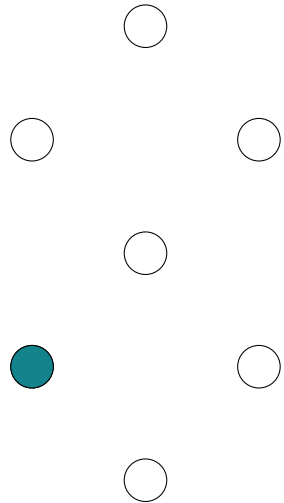
- **Theoretical results:** we provide a sample-complexity guarantee



Vaccination

- **Goal:** minimize the expected extinction time of the epidemic
- Solve proxy problem of minimizing the spectral radius of the graph
- Two strategies
  - exact polynomial-time algorithm for graphs with bounded tree-width
    $\rightarrow$ via tree-decomposition
  - fast greedy heuristic for arbitrary graphs

Experiments

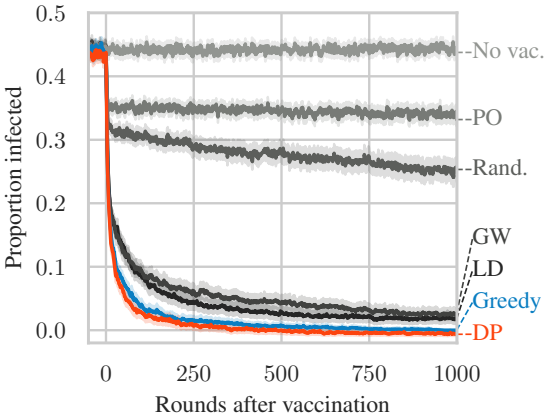


Figure: Vaccination results on flu outbreak graph (China 2009) based on learned graph

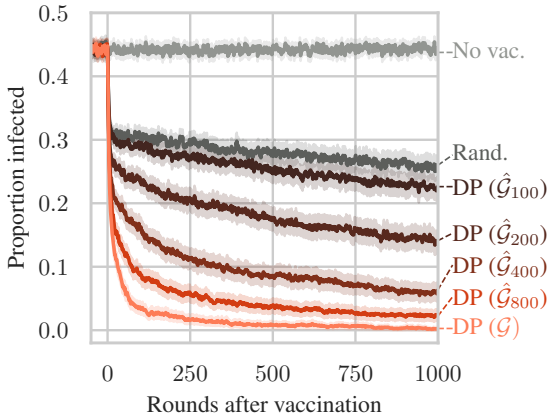


Figure: Vaccination results after different number of learning steps

Thank you for listening!

See you on Wednesday, July 16th, 4:30 pm at our poster