Engineering Agreement: The Naming Game with Asymmetric and Heterogeneous Agents

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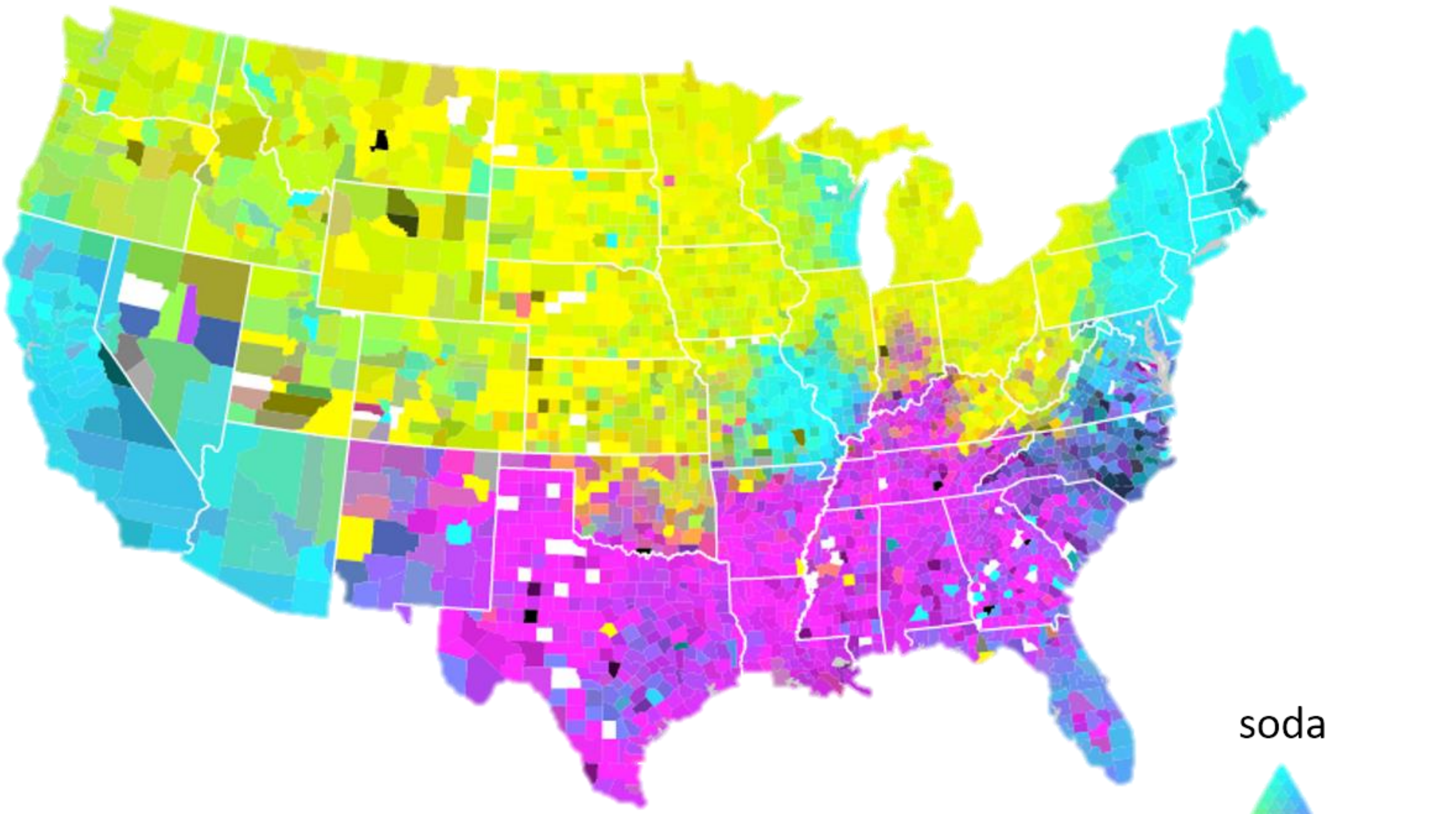
Social Convention

- Conventions are universally adopted from two or more alternatives.
- Language, etiquette, or custom.

Agreement on Convention

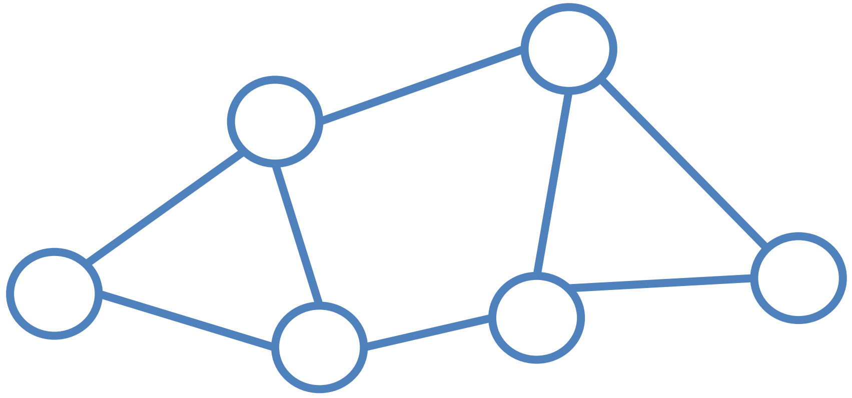


Engineering Agreement

- What can help or harm convergence?
  - Homogeneity or heterogeneity
  - Community structure
- How robust are the dynamics to possible manipulations?

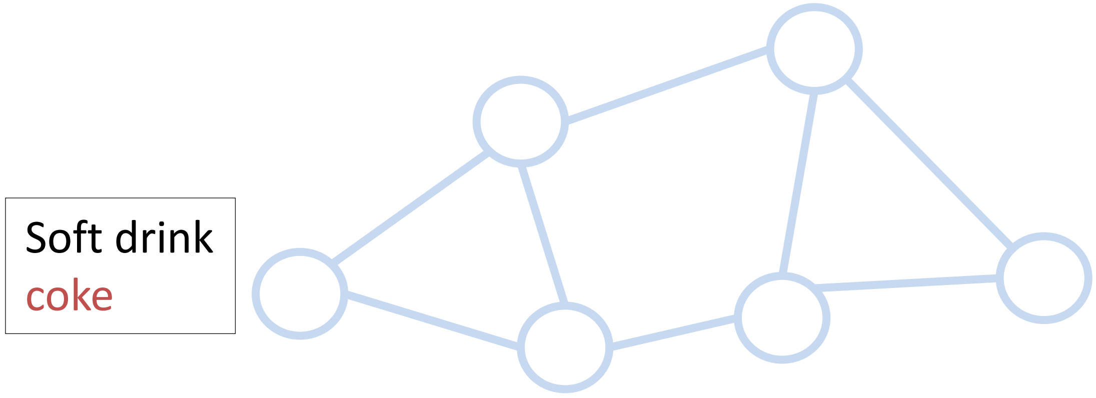
Naming Game [Baronchelli 06]

- A agent-based process on a network



Naming Game

- A agent-based process on a network
  - Each agent has inventory of names



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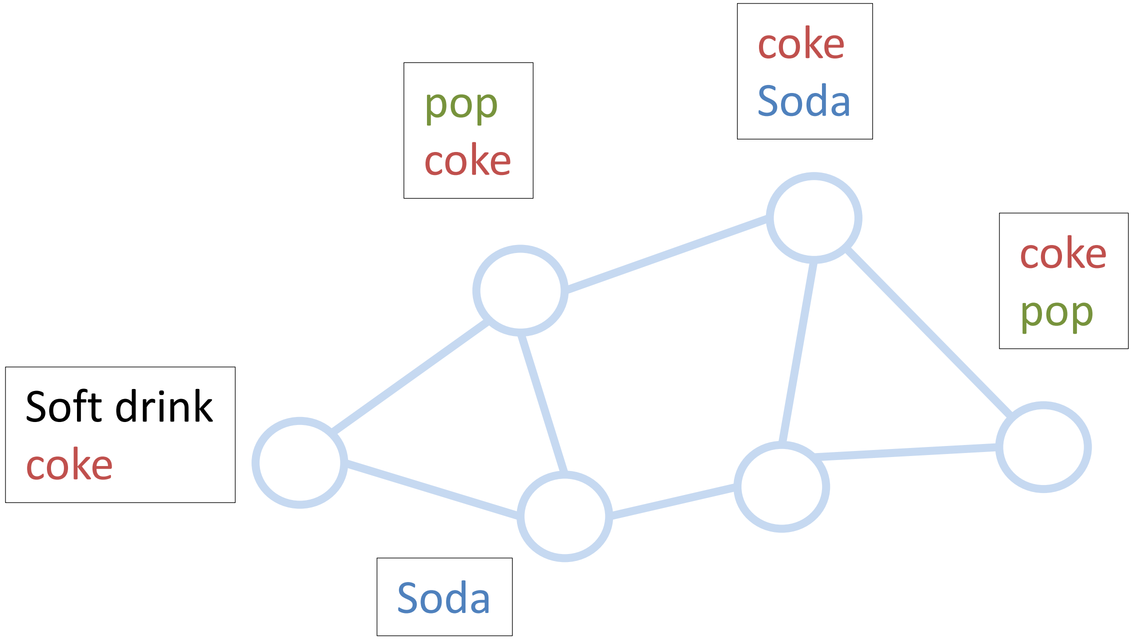
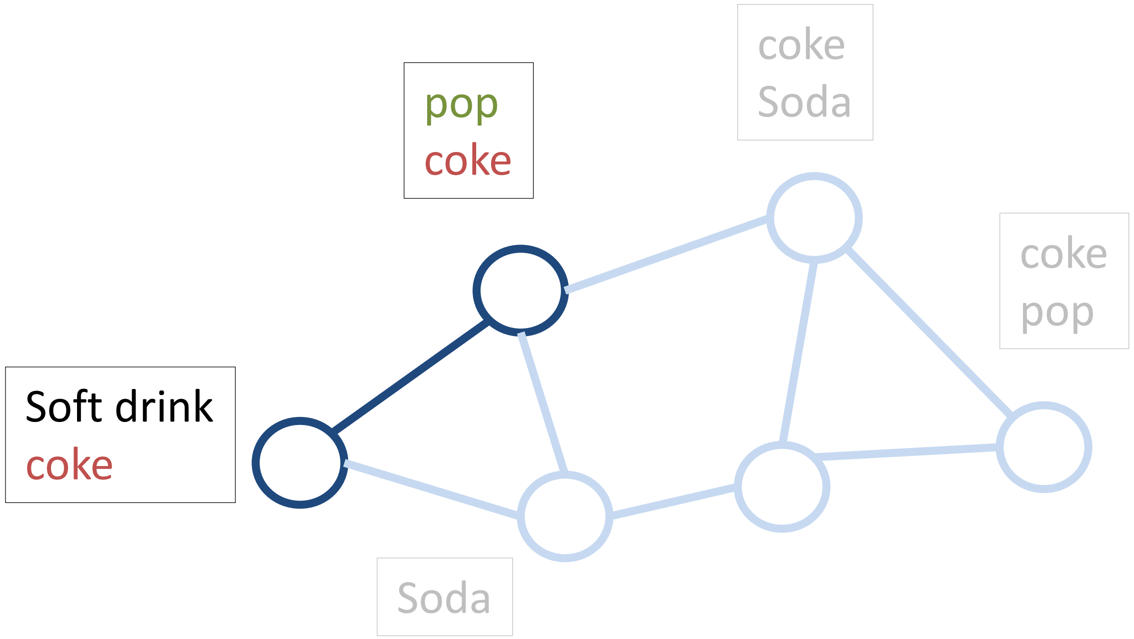


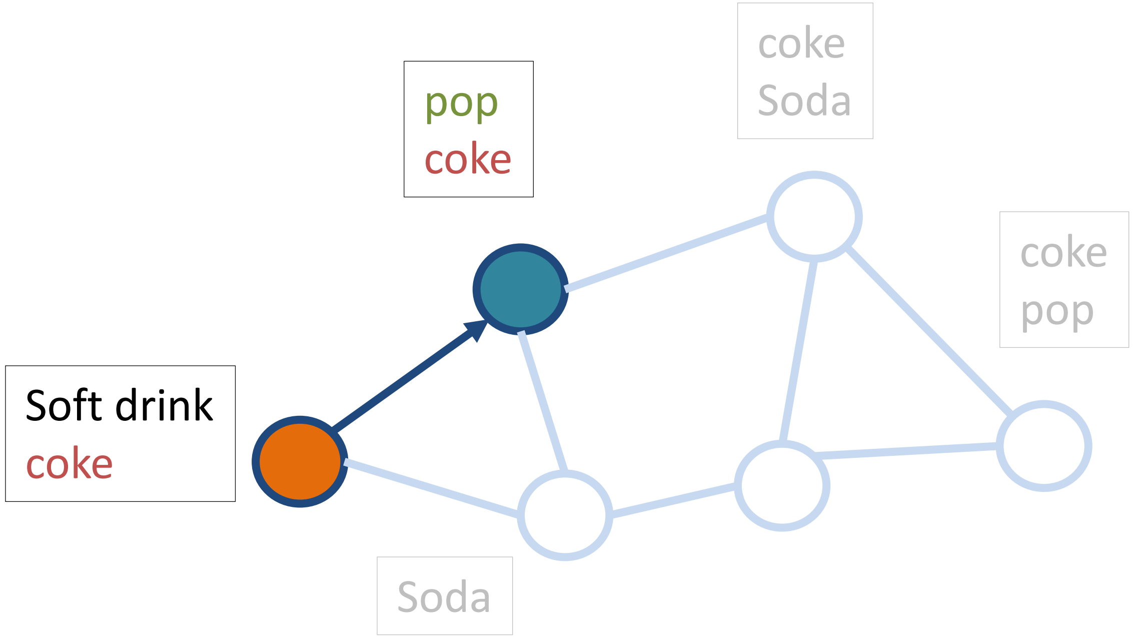
Naming Game

- A agent-based process on a network
  - Each agent has inventory of names
  - At each time an edge is selected at random



Naming Game

- A agent-based process on a network
  - Each agent has inventory of names
  - At each time an edge is selected at random, and one is speaker and the other is listener.



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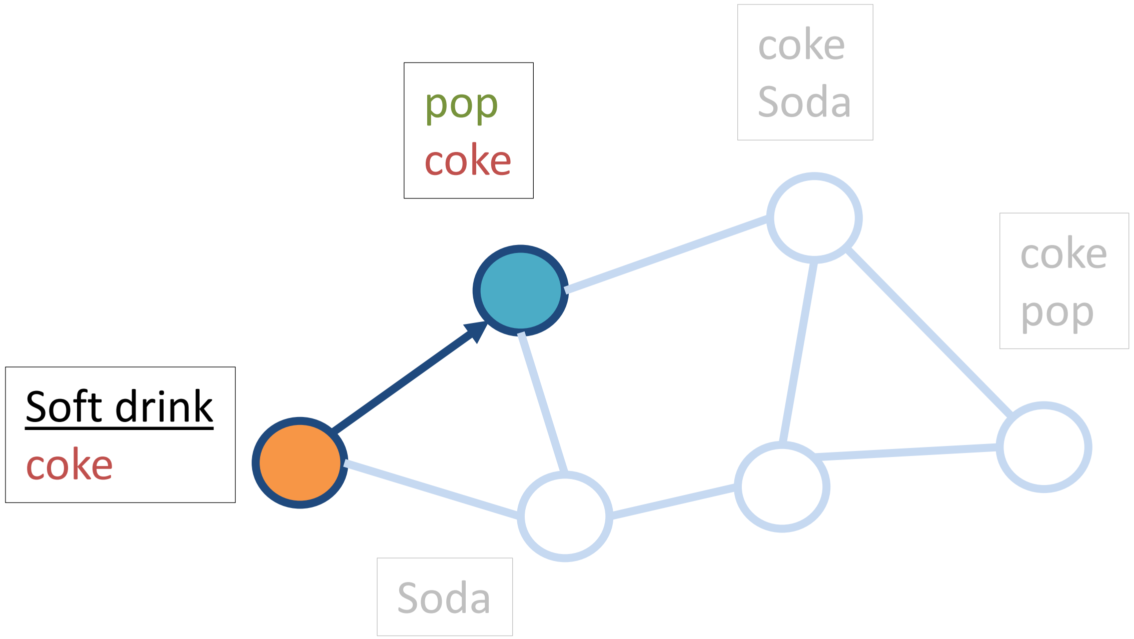
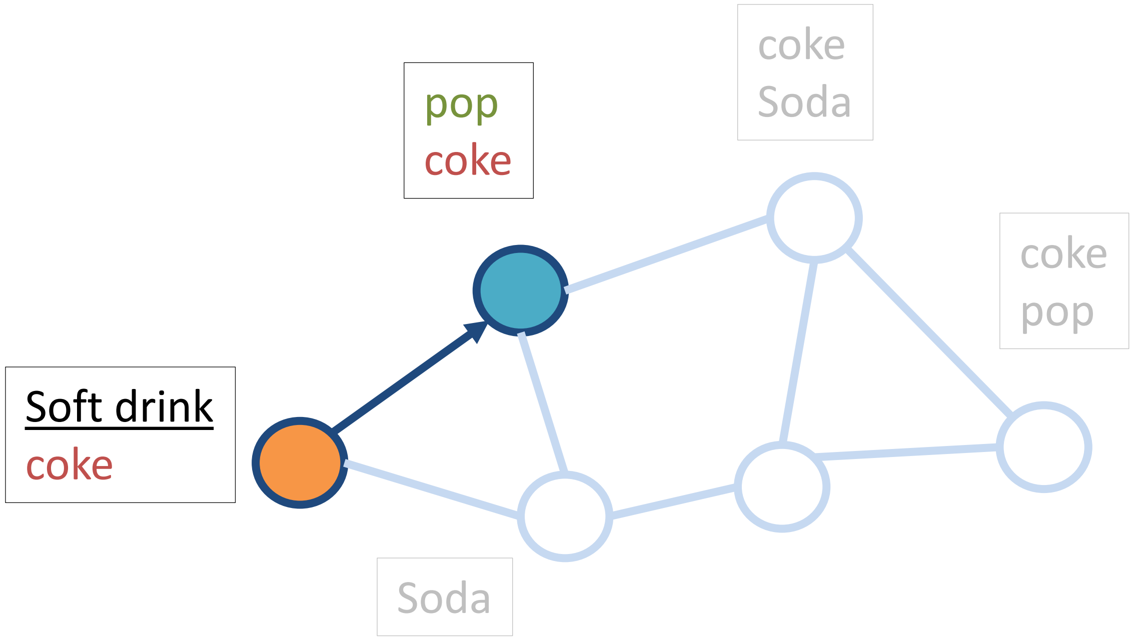


Naming Game

- A agent-based process on a network
  - Each agent has inventory of names
  - At each time an edge is selected at random, and one is speaker and the other is listener.
    - Failure



Naming Game

- A agent-based process on a network
  - Each agent has inventory of names
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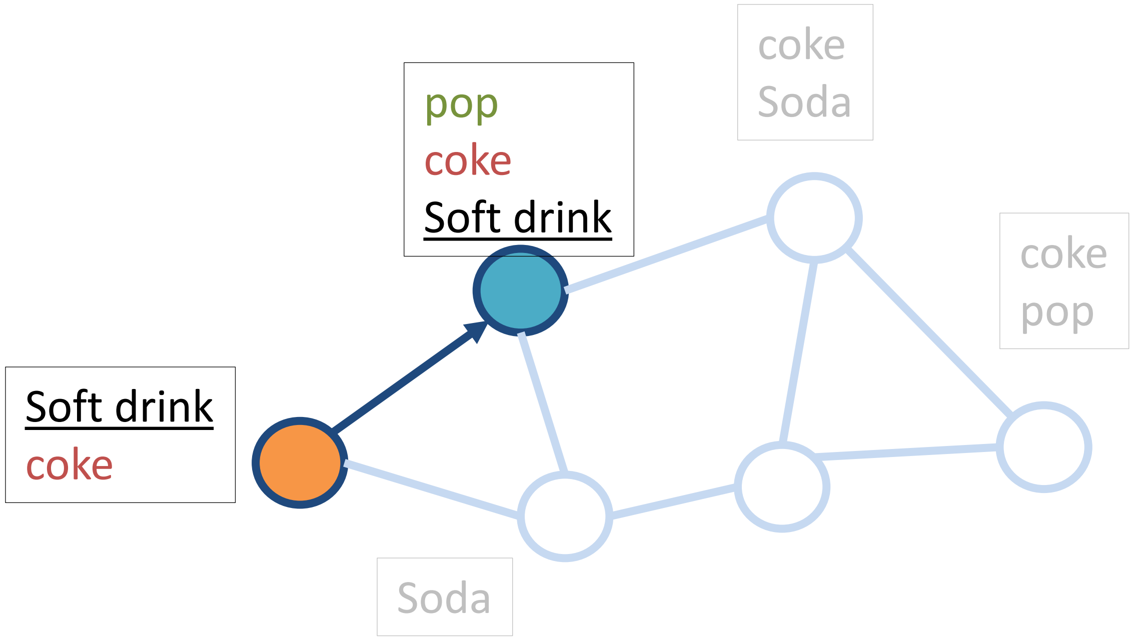
    - Failure: listener adds the new name



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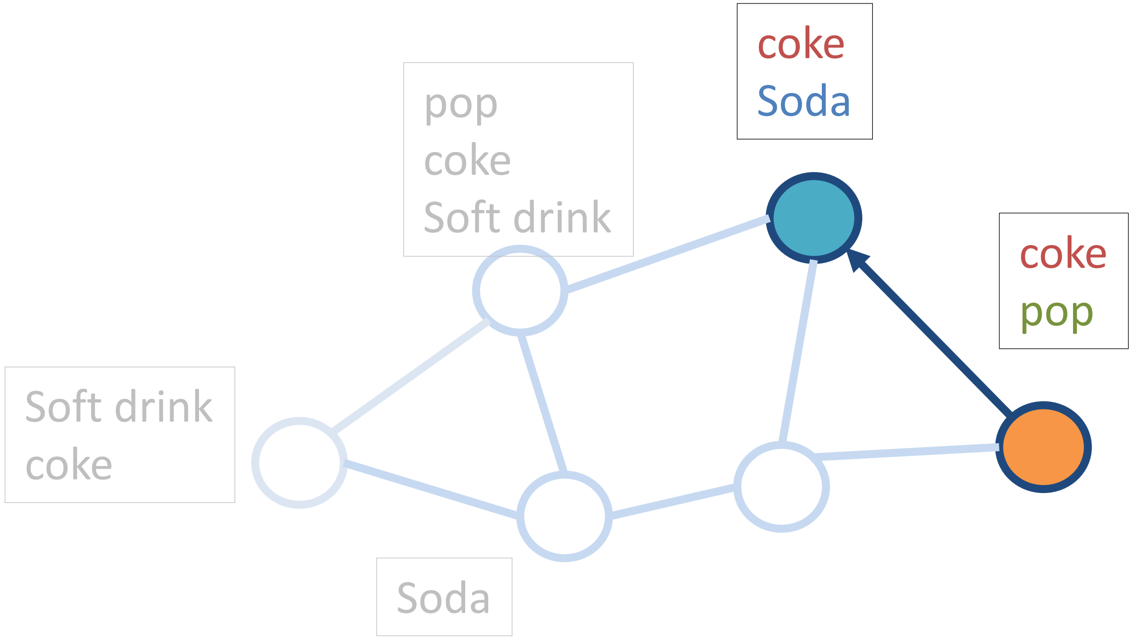

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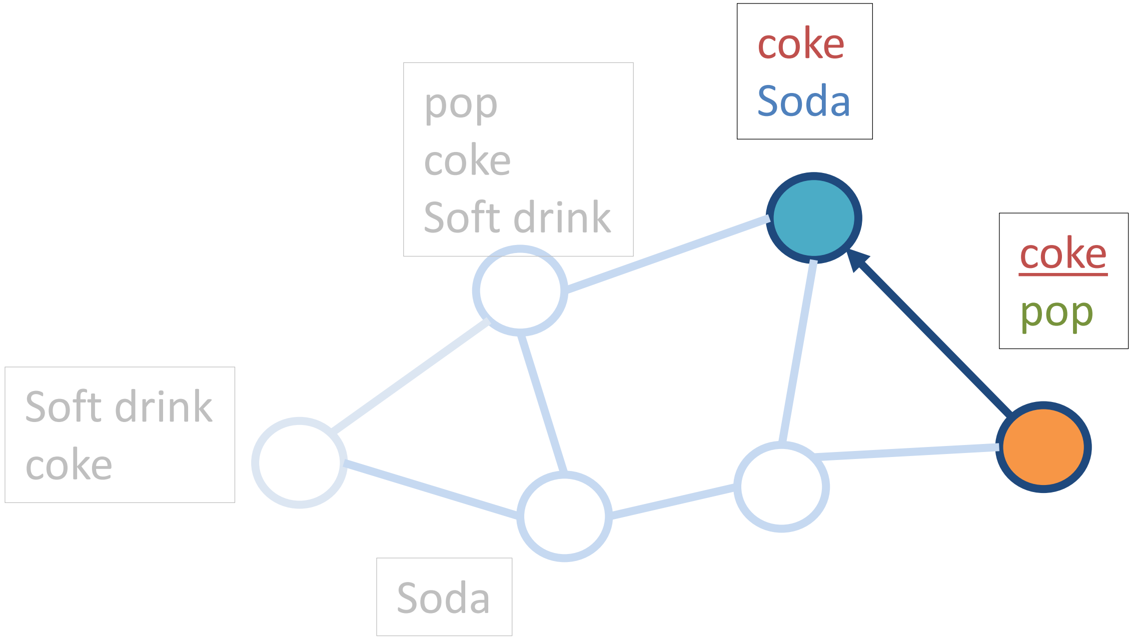

Naming Game

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  - At each time an edge is selected at random, and one is speaker and the other is listener.
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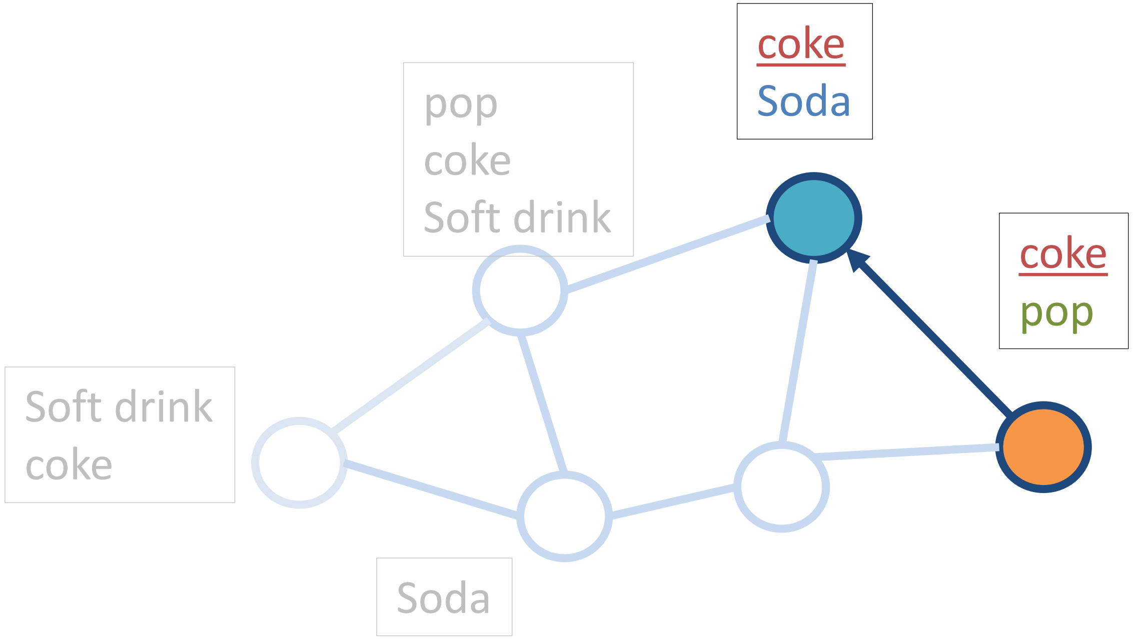
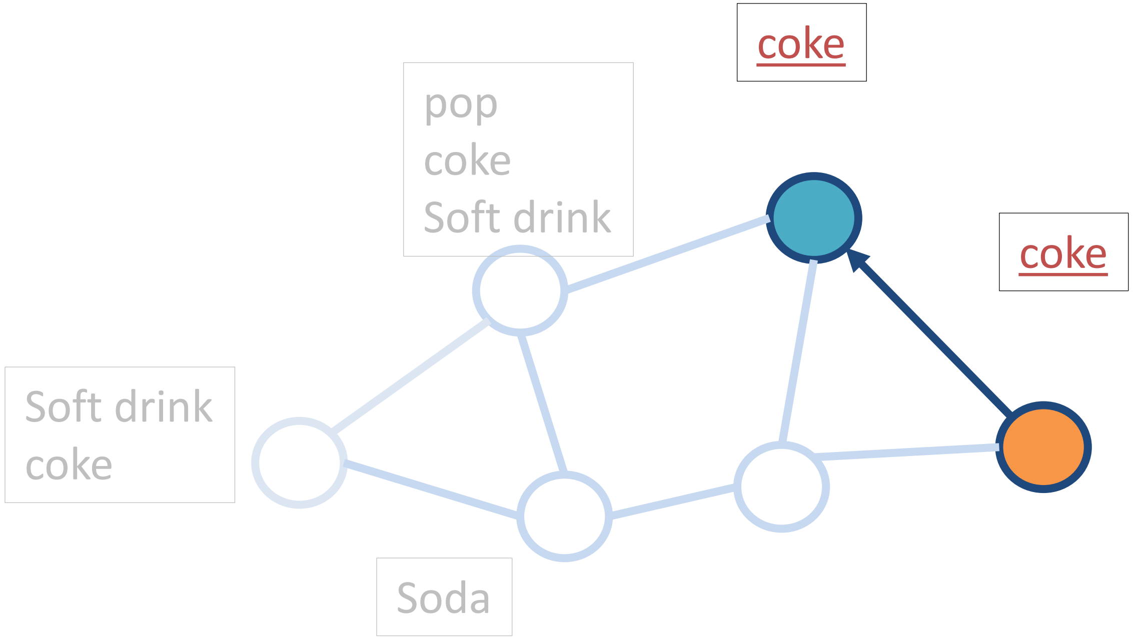
    - Success



Naming Game

- A agent-based process on a network
  - Each agent has inventory of names
  - At each time an edge is selected at random, and one is speaker and the other is listener.
    - Failure: listener adds the new name
    - Success: both remove all other names



Naming Game

- A agent-based process on a network
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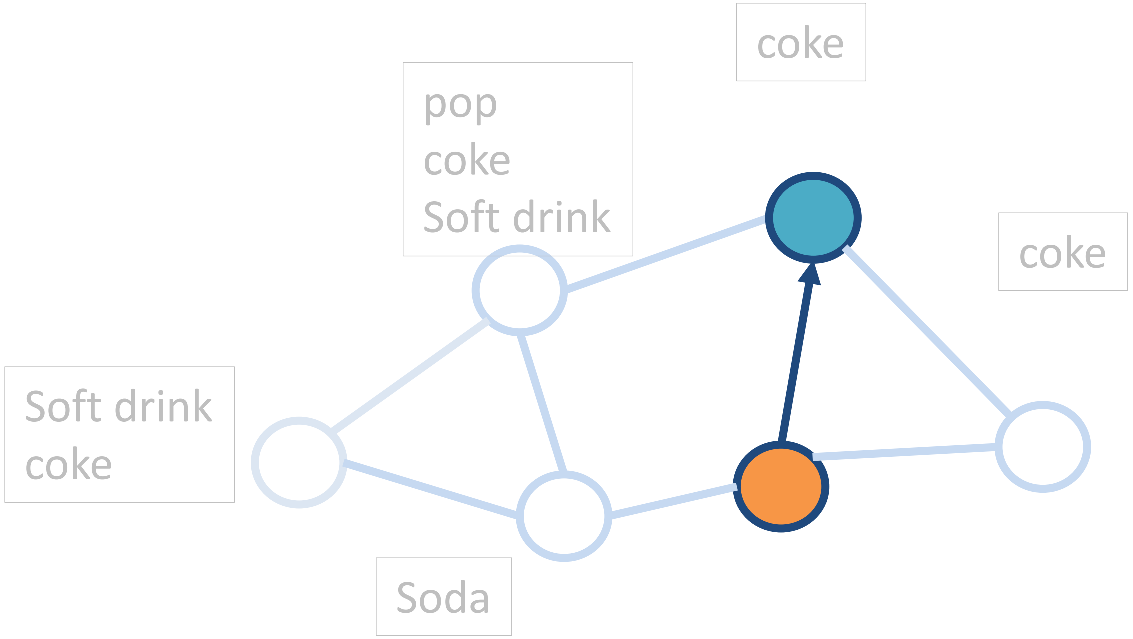
  - At each time an edge is selected at random, and one is speaker and the other is listener.
    - Failure: listener adds the new name
    - Success: both remove all other names
    - Empty



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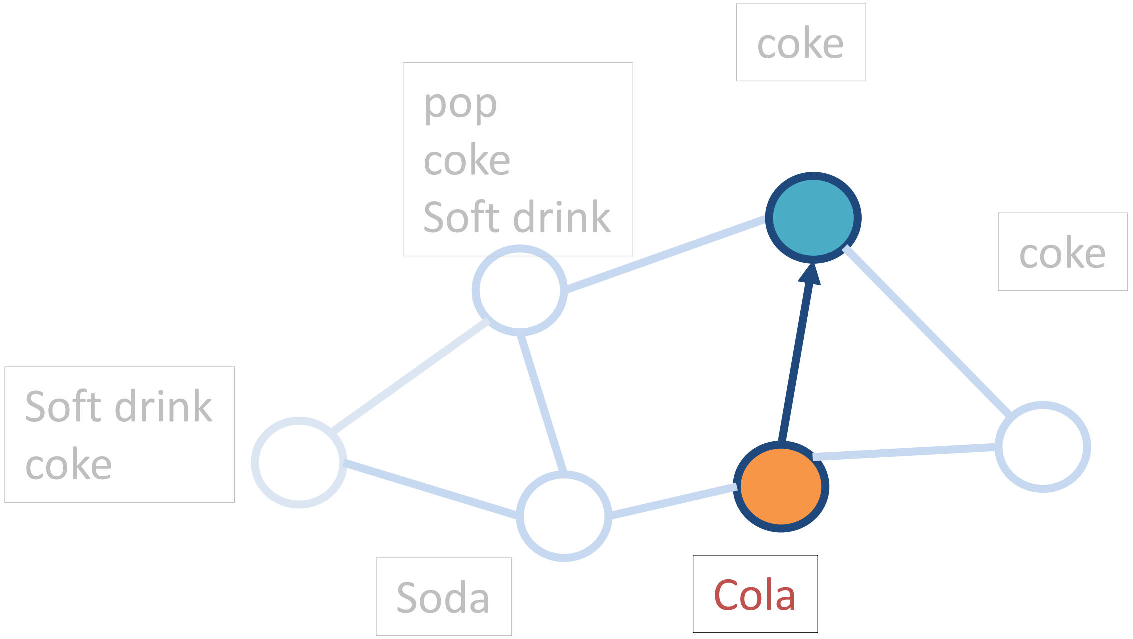
    - Success: both remove all other names
    - Empty: speaker invent a new word



Naming Game

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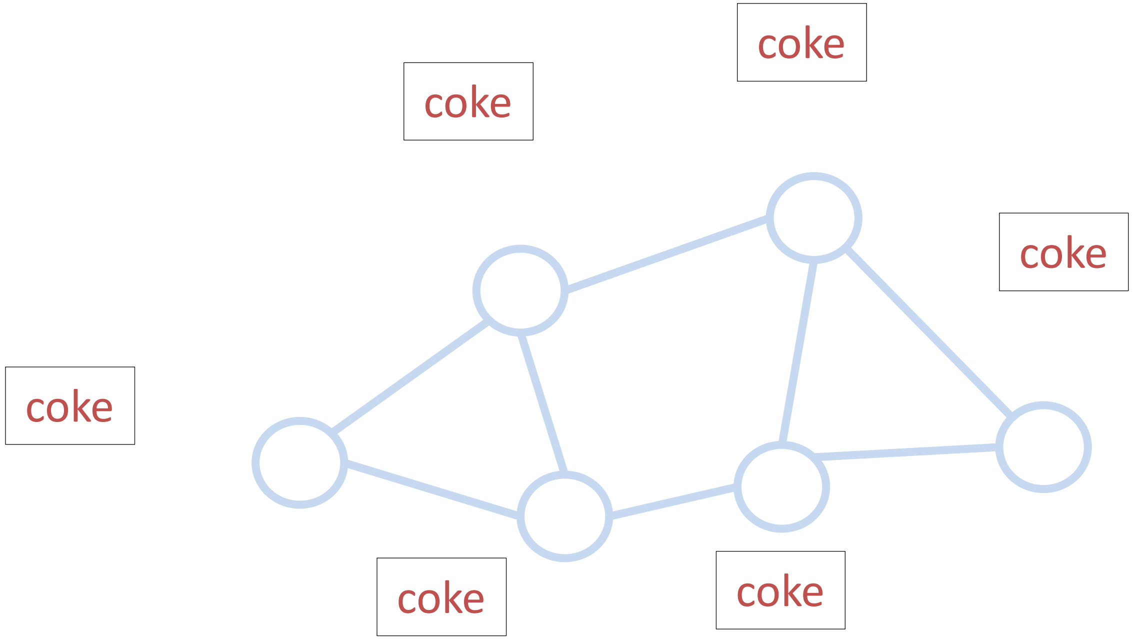
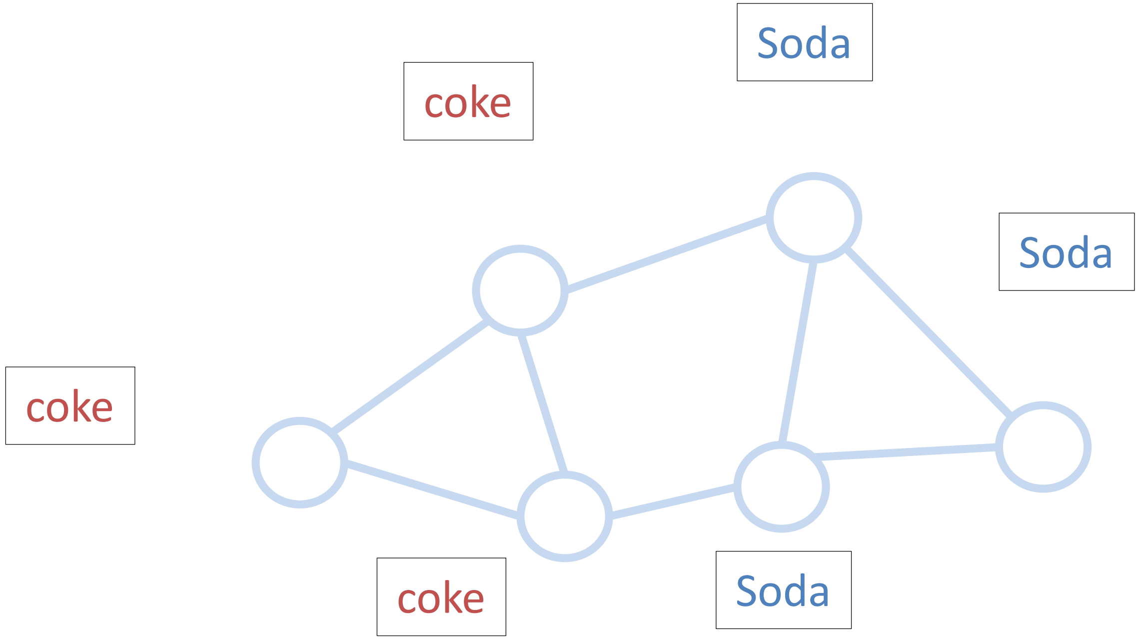
  - At each time an edge is selected at random, and one is speaker and the other is listener.
    - Failure: listener adds the new name
    - Success: both remove all other names
    - Empty: speaker invent a new word
  - Convergence



Different initial states

Empty initial states

Segregated initial states

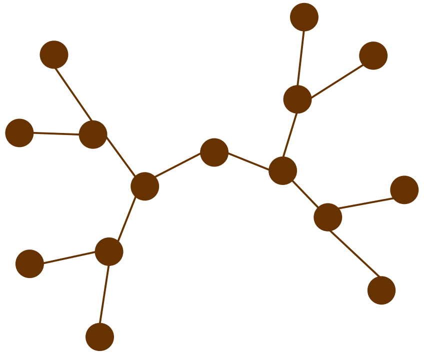


Motivating Questions

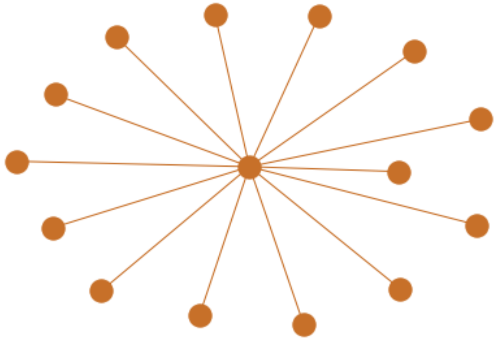
- What can help or harm convergence?
  - Homogeneity or heterogeneity
  - Community structure
- How robust are the dynamics to possible manipulations?

Different graphs

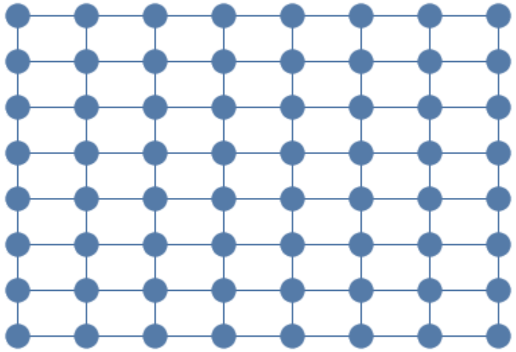
d-ary tree



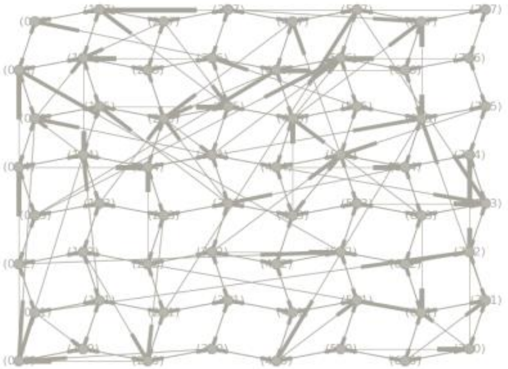
star



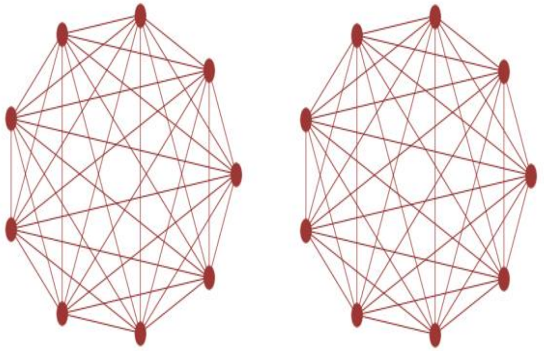
grid



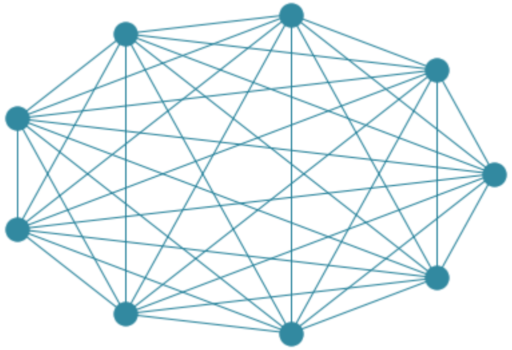
Kleinberg



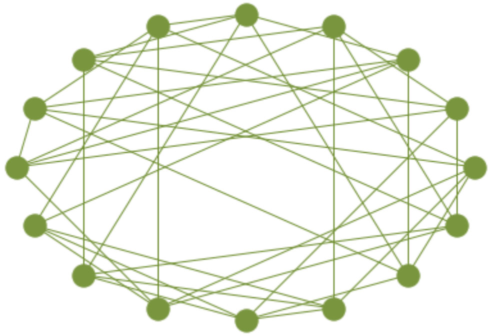
disjoint cliques



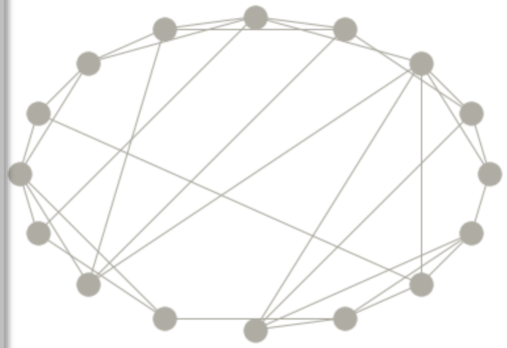
complete



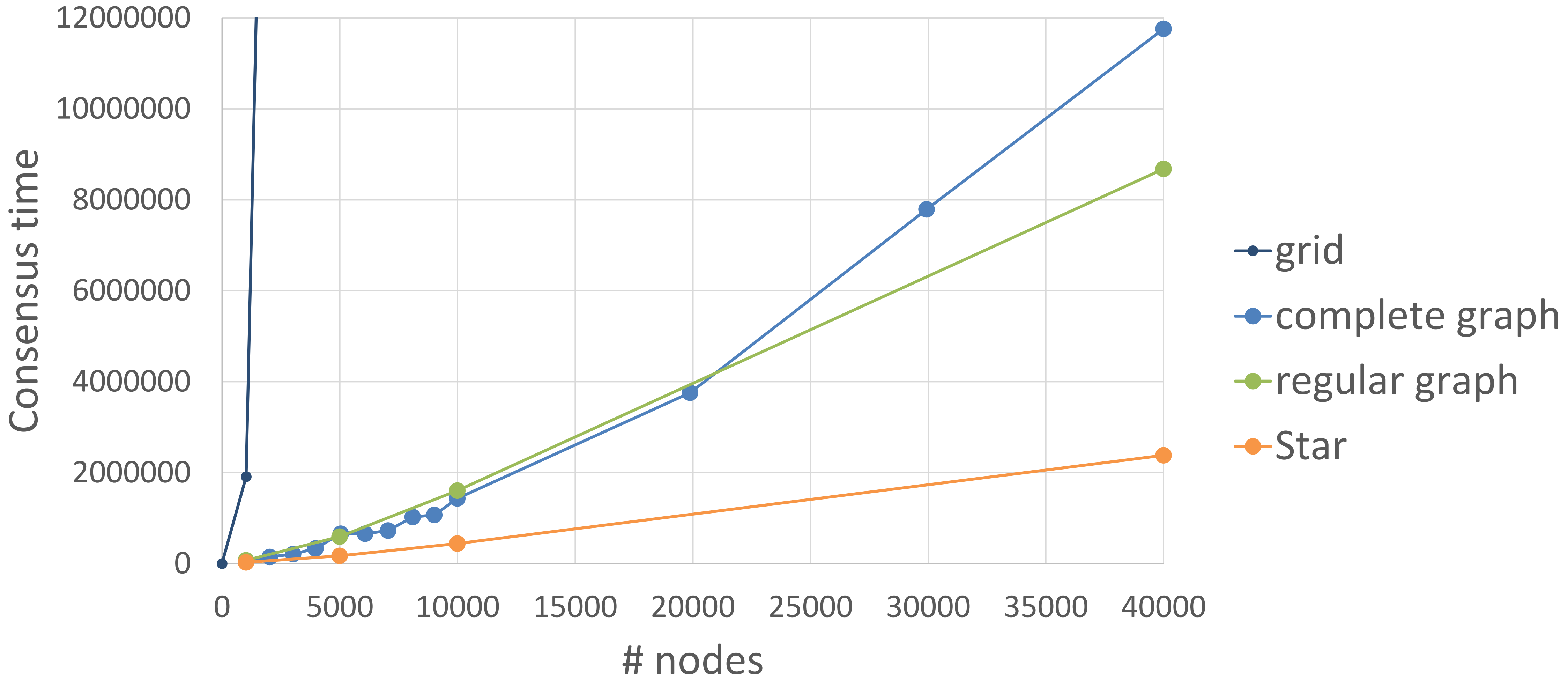
regular



Watts-Strogatz



Fast and Slow Convergence



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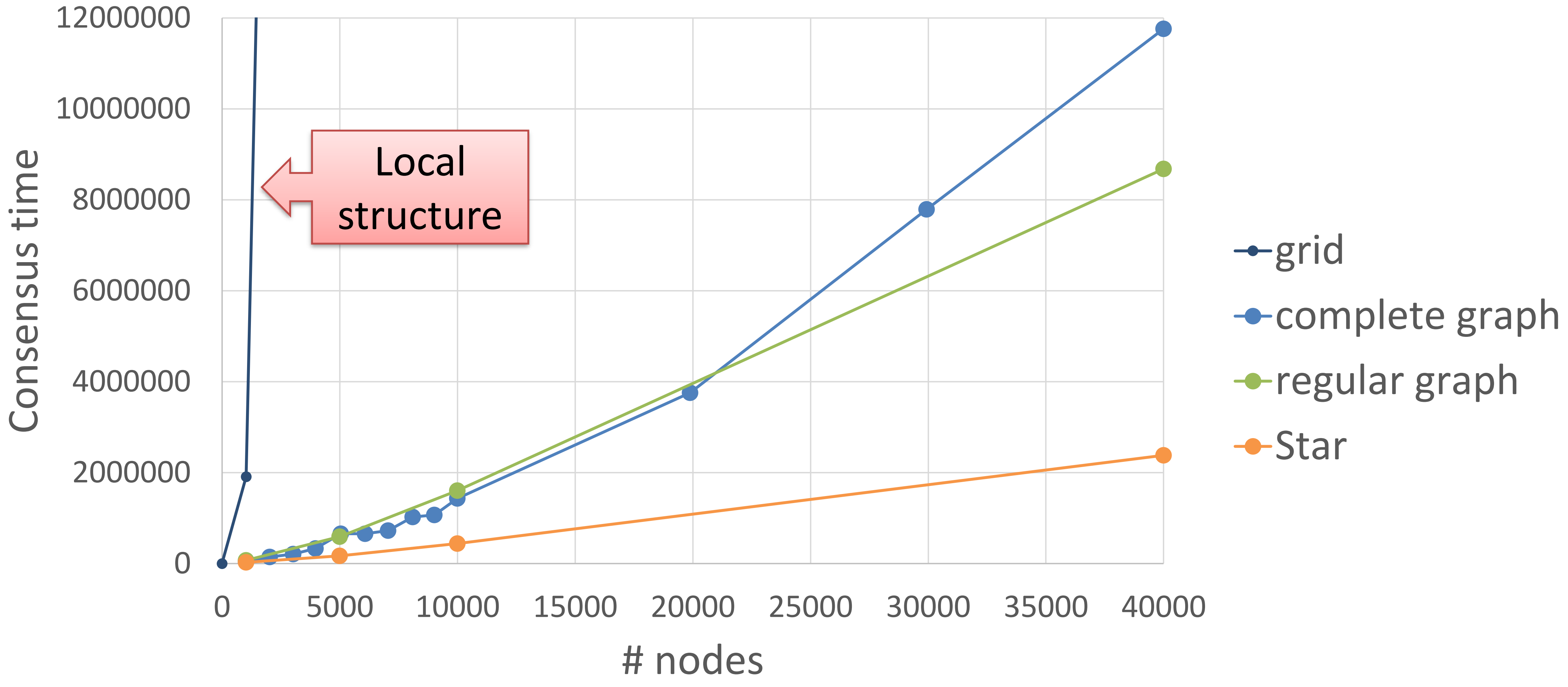

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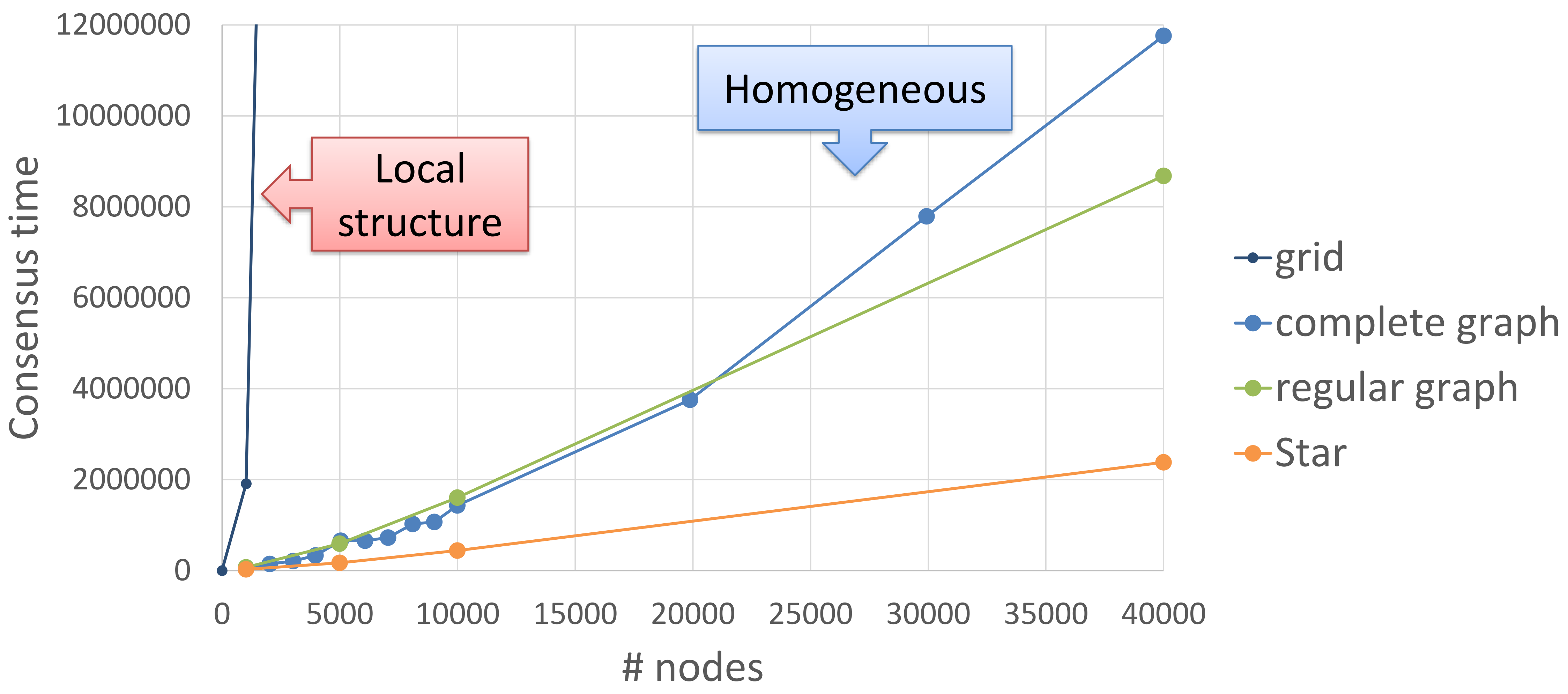

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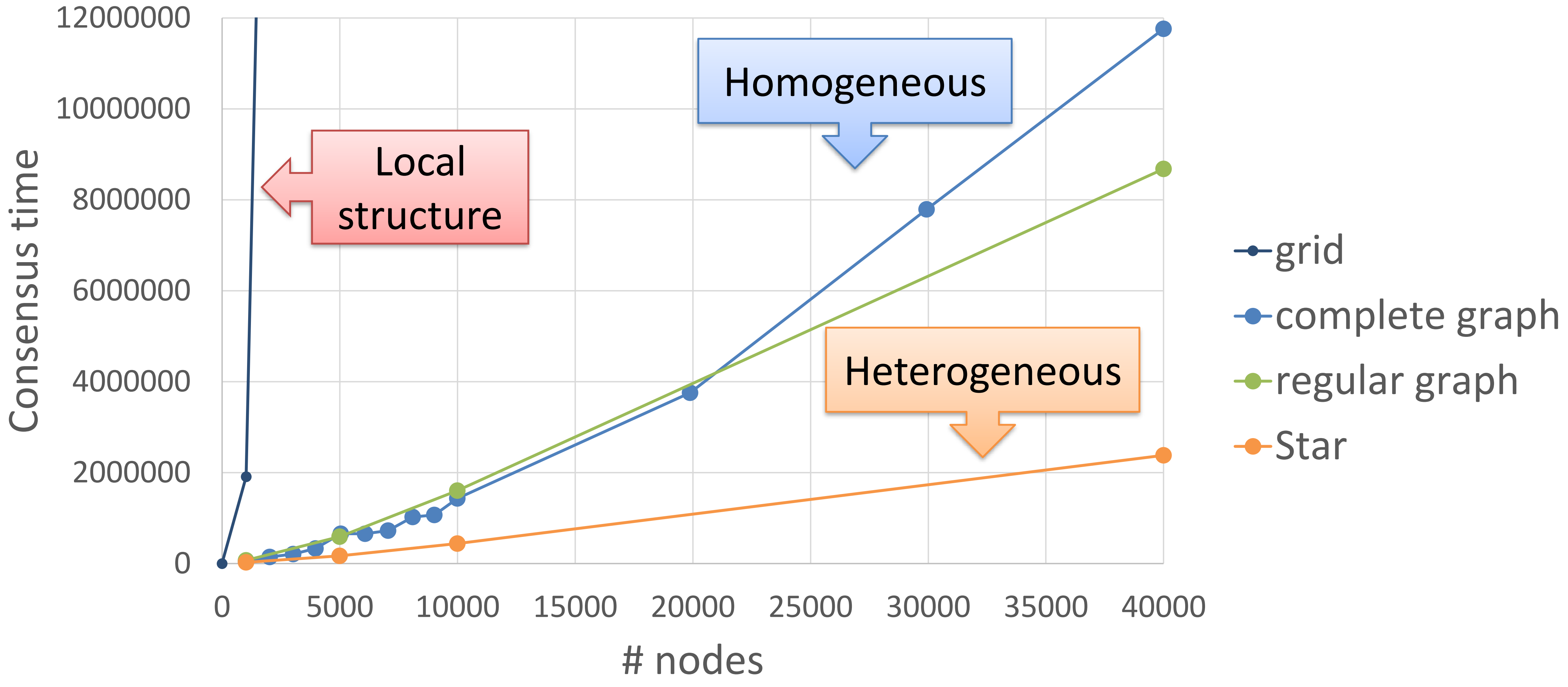
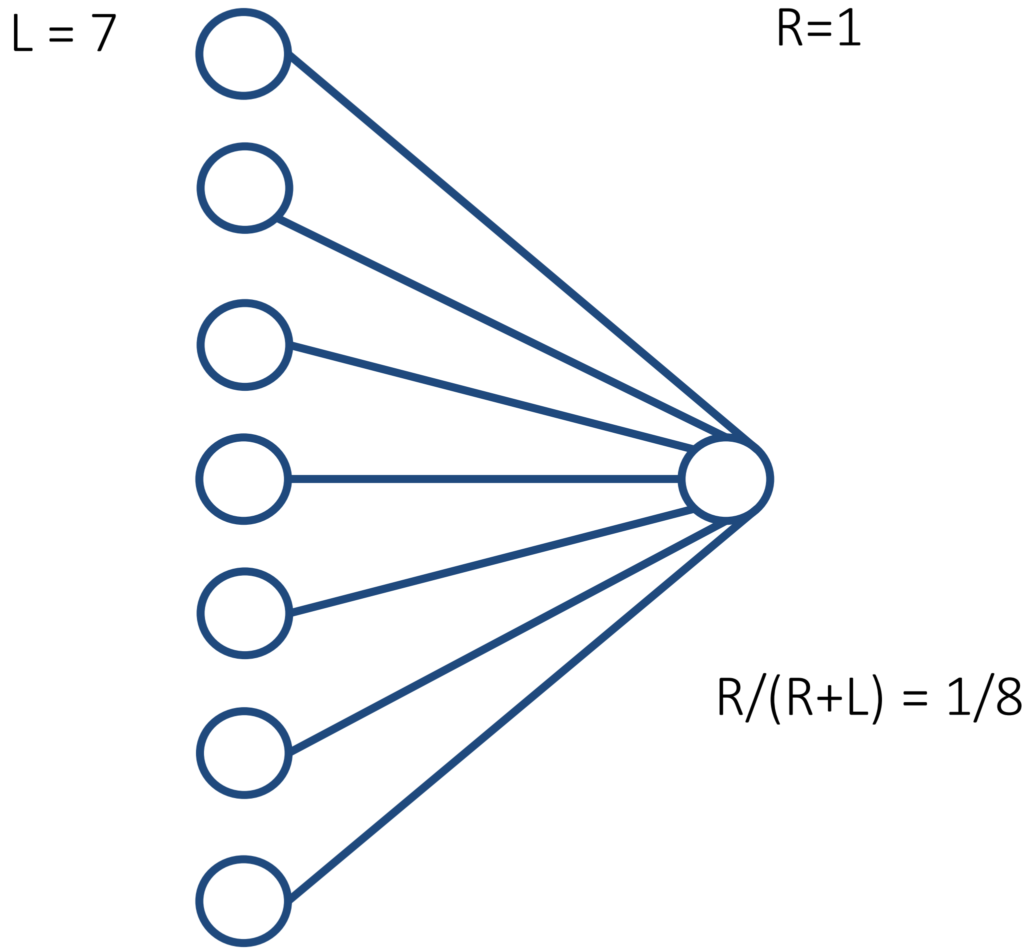
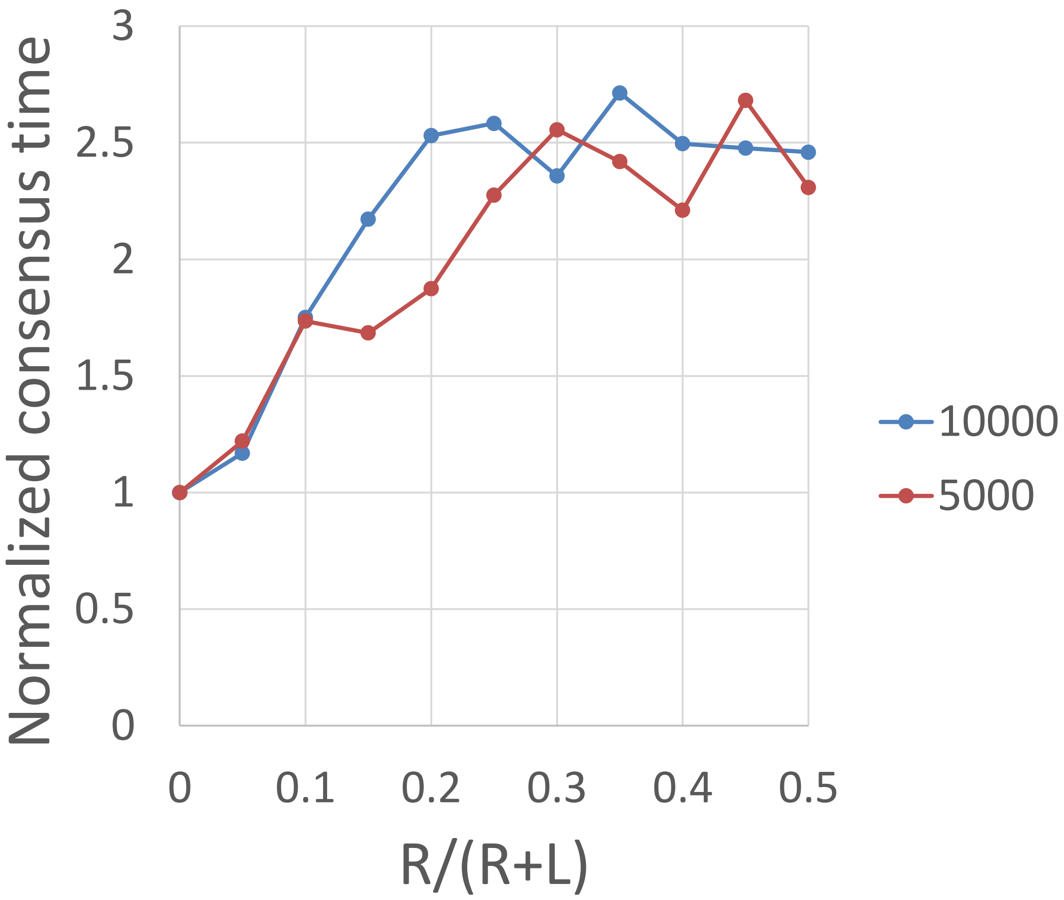


Heterogeneous





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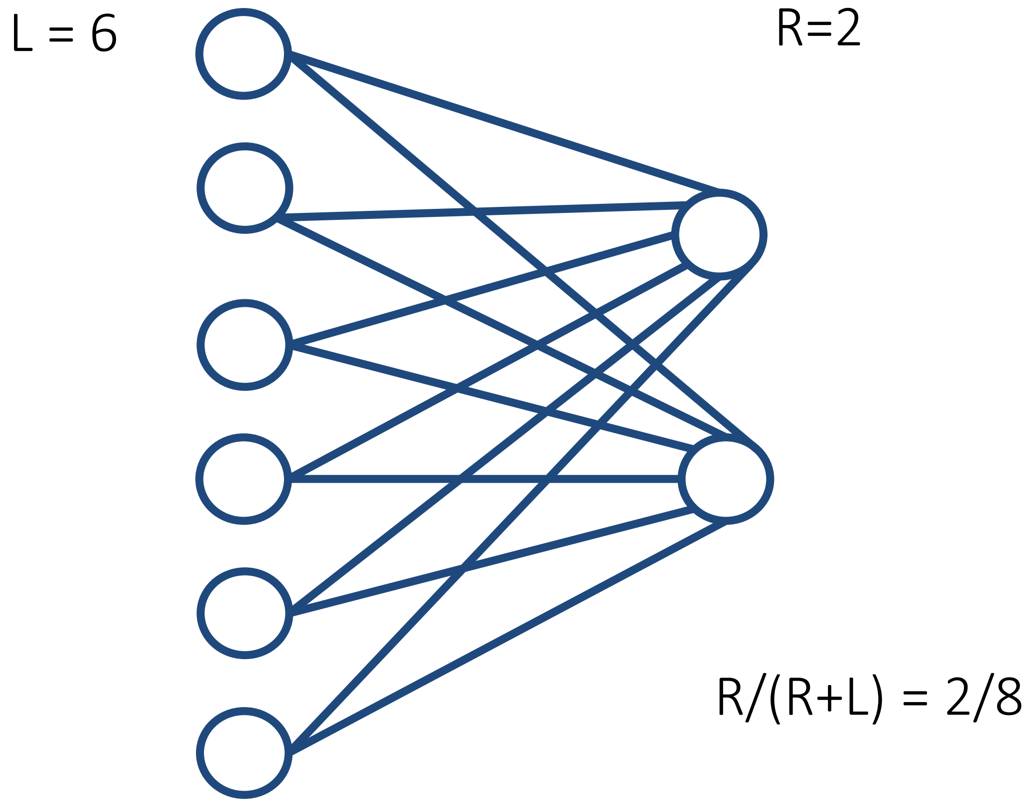

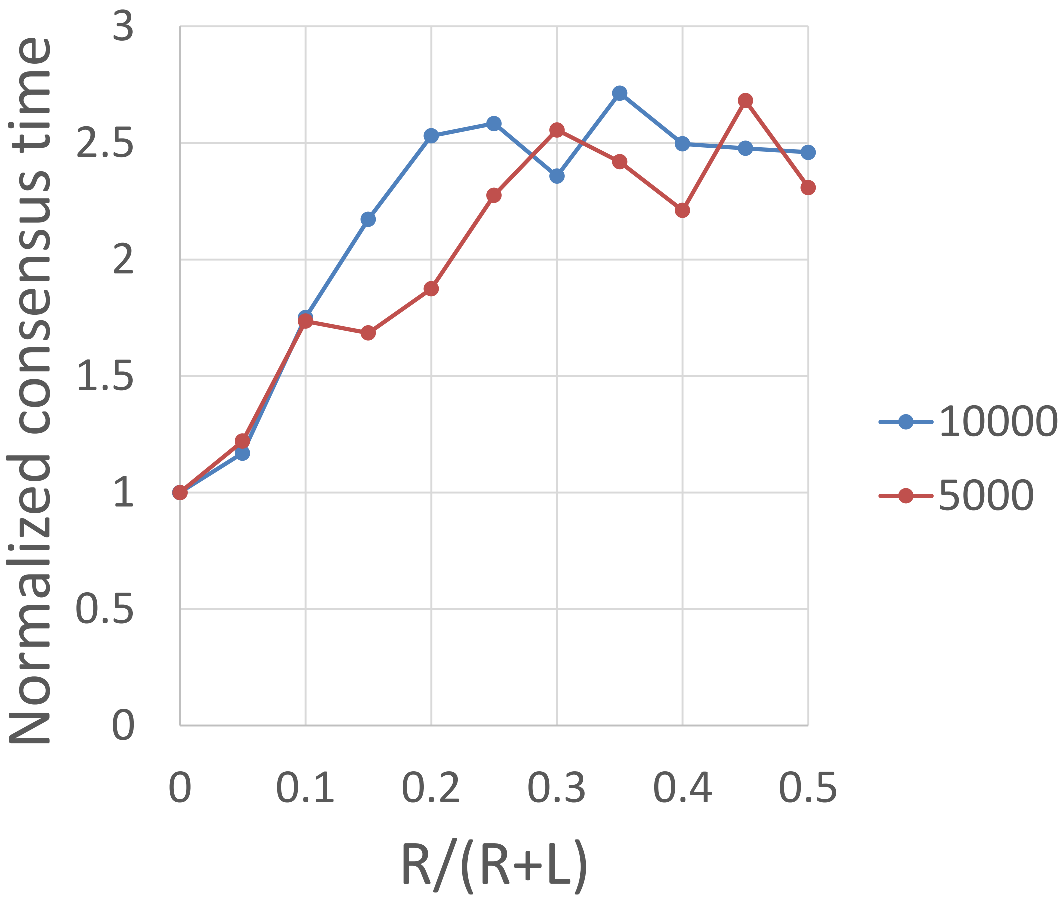

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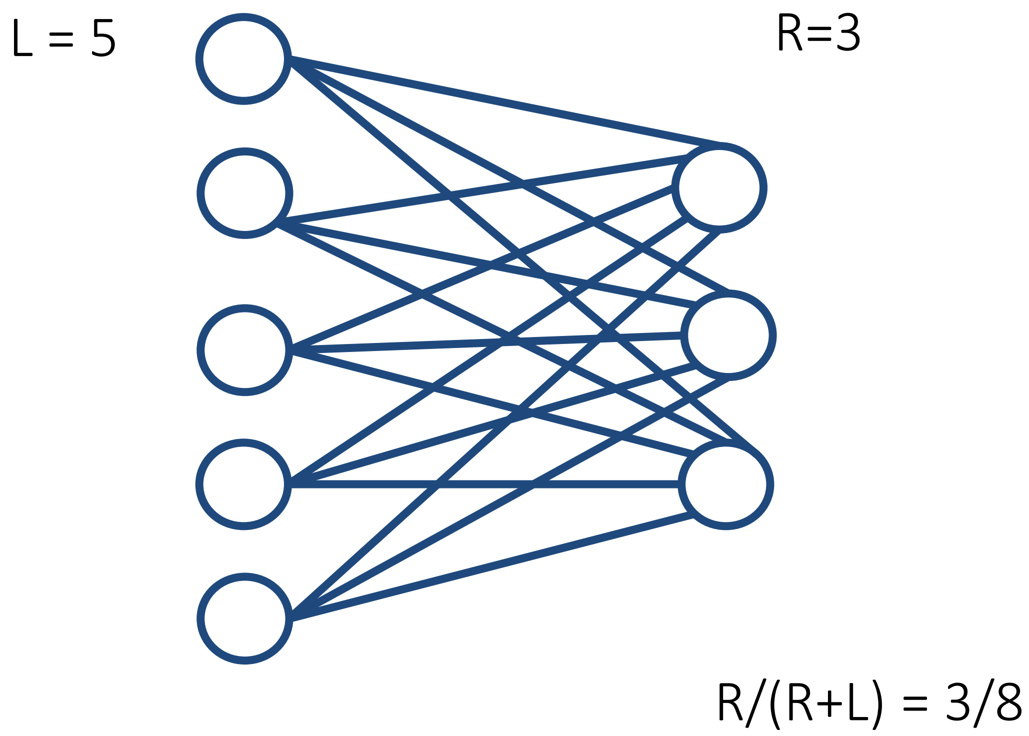
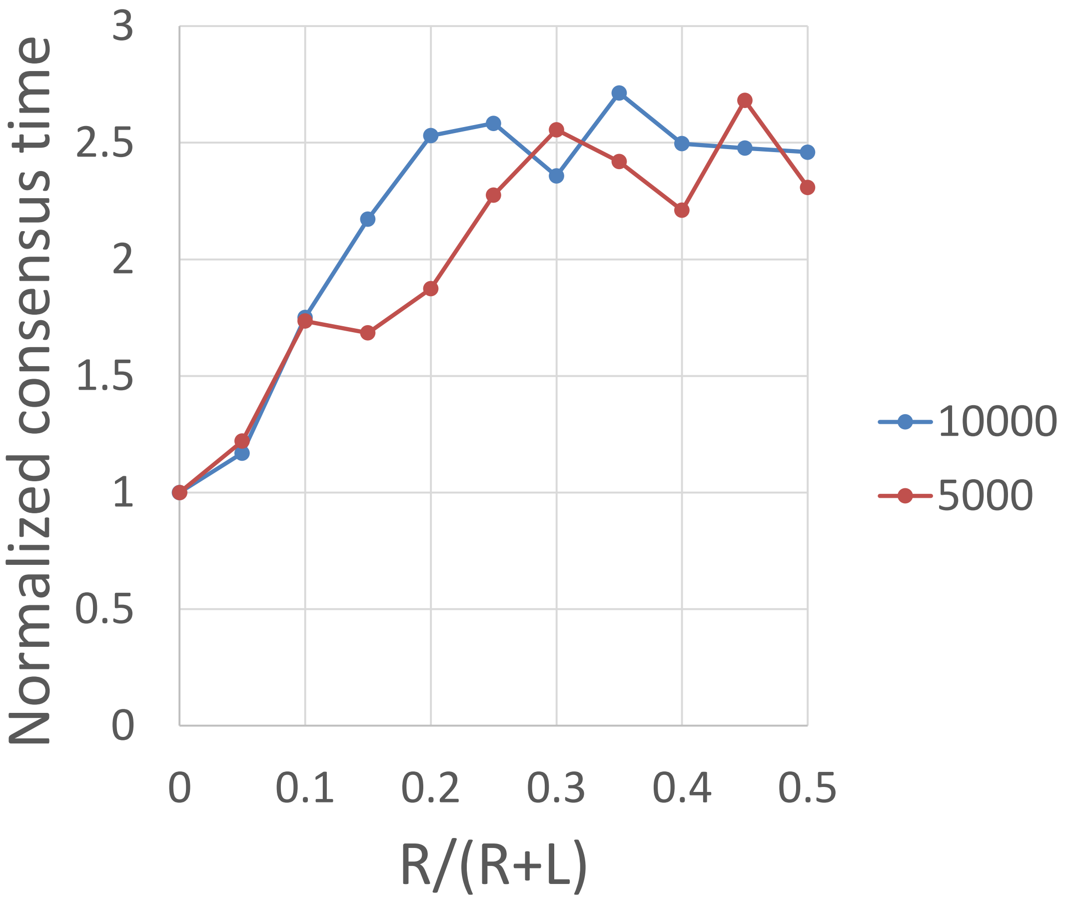
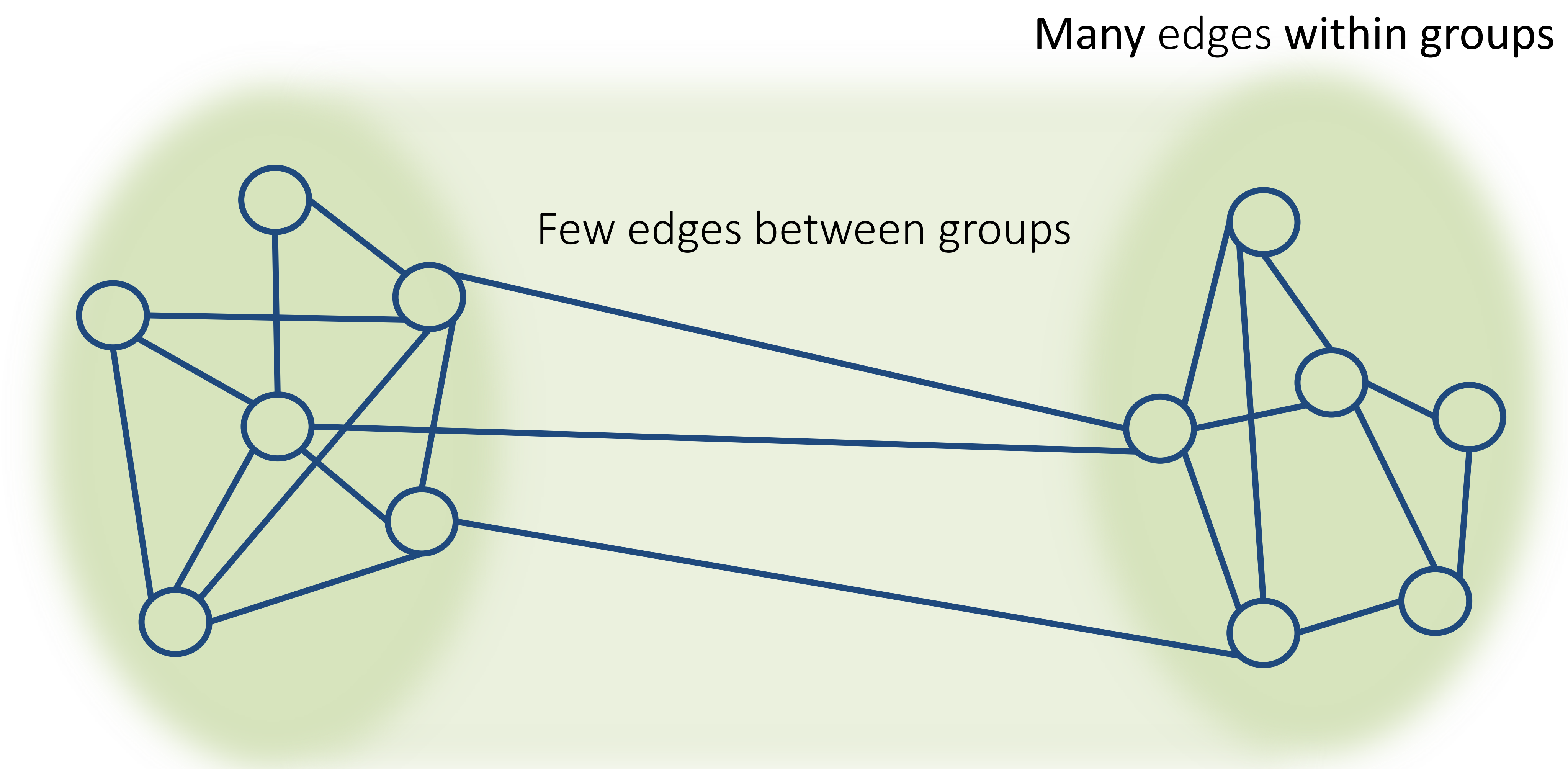




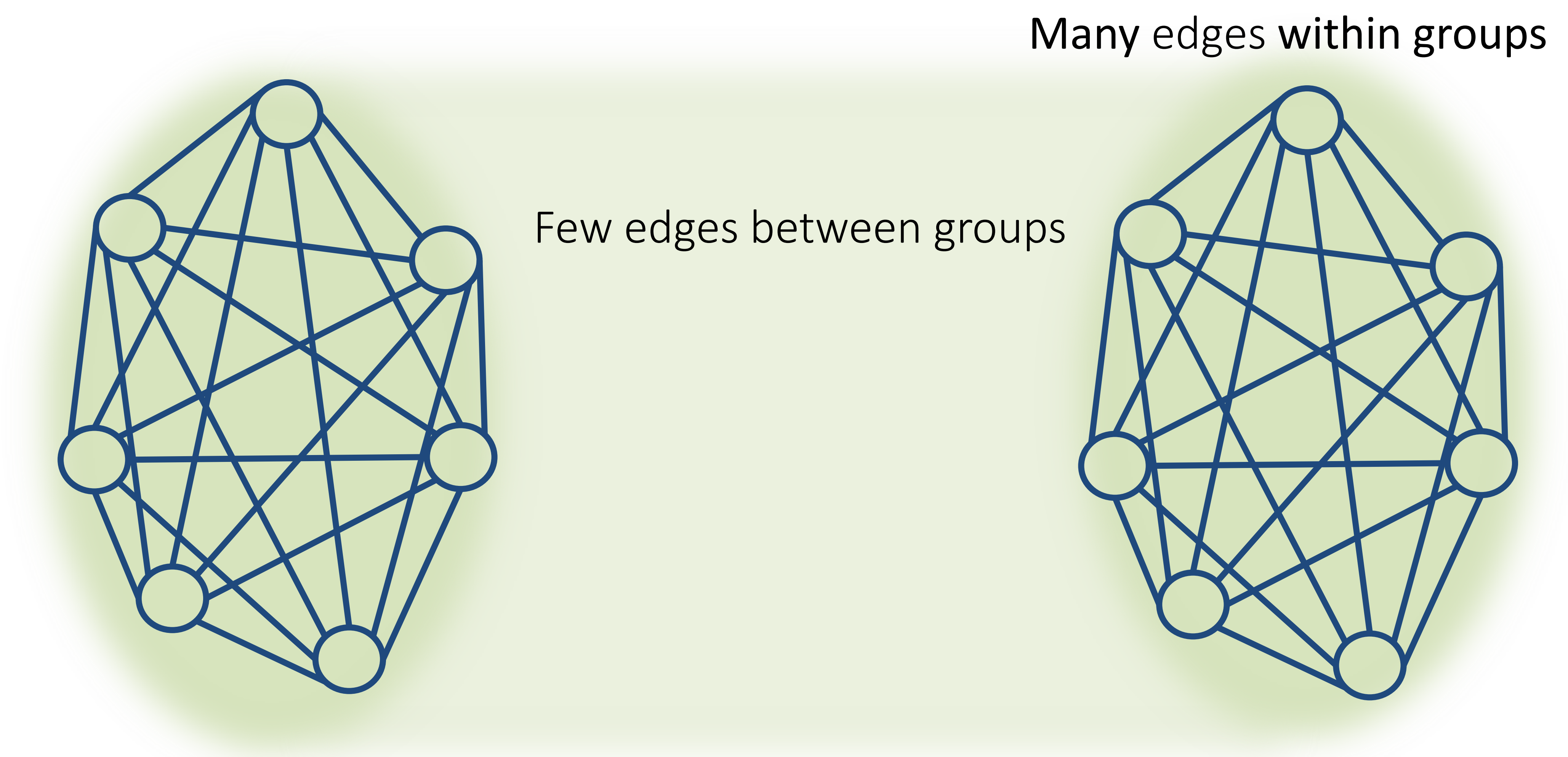
Motivating Questions

- What can help or harm convergence?
  - Homogeneity or heterogeneity
  - Community structure
- How robust are the dynamics to possible manipulations?

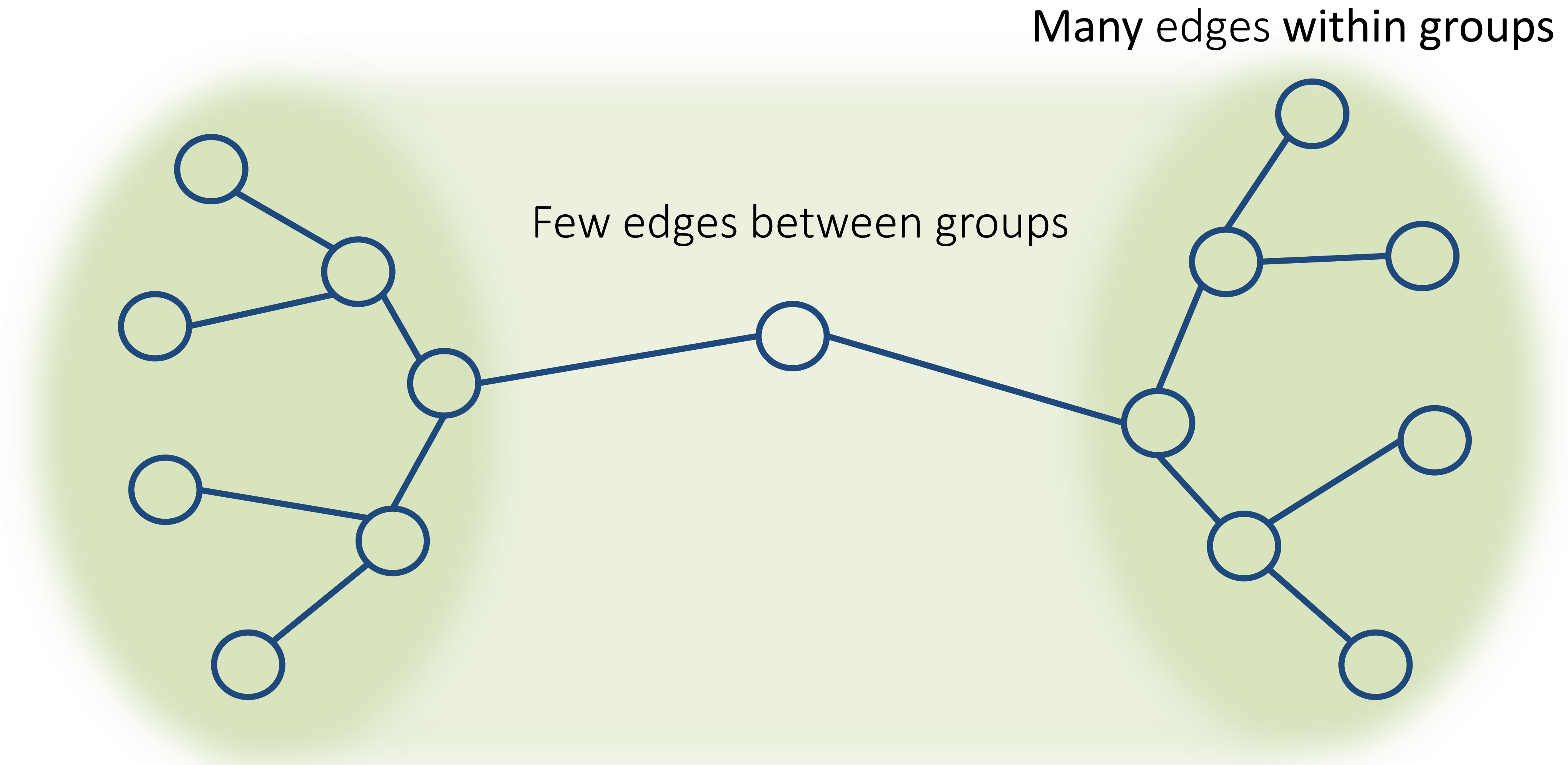
Community Structure



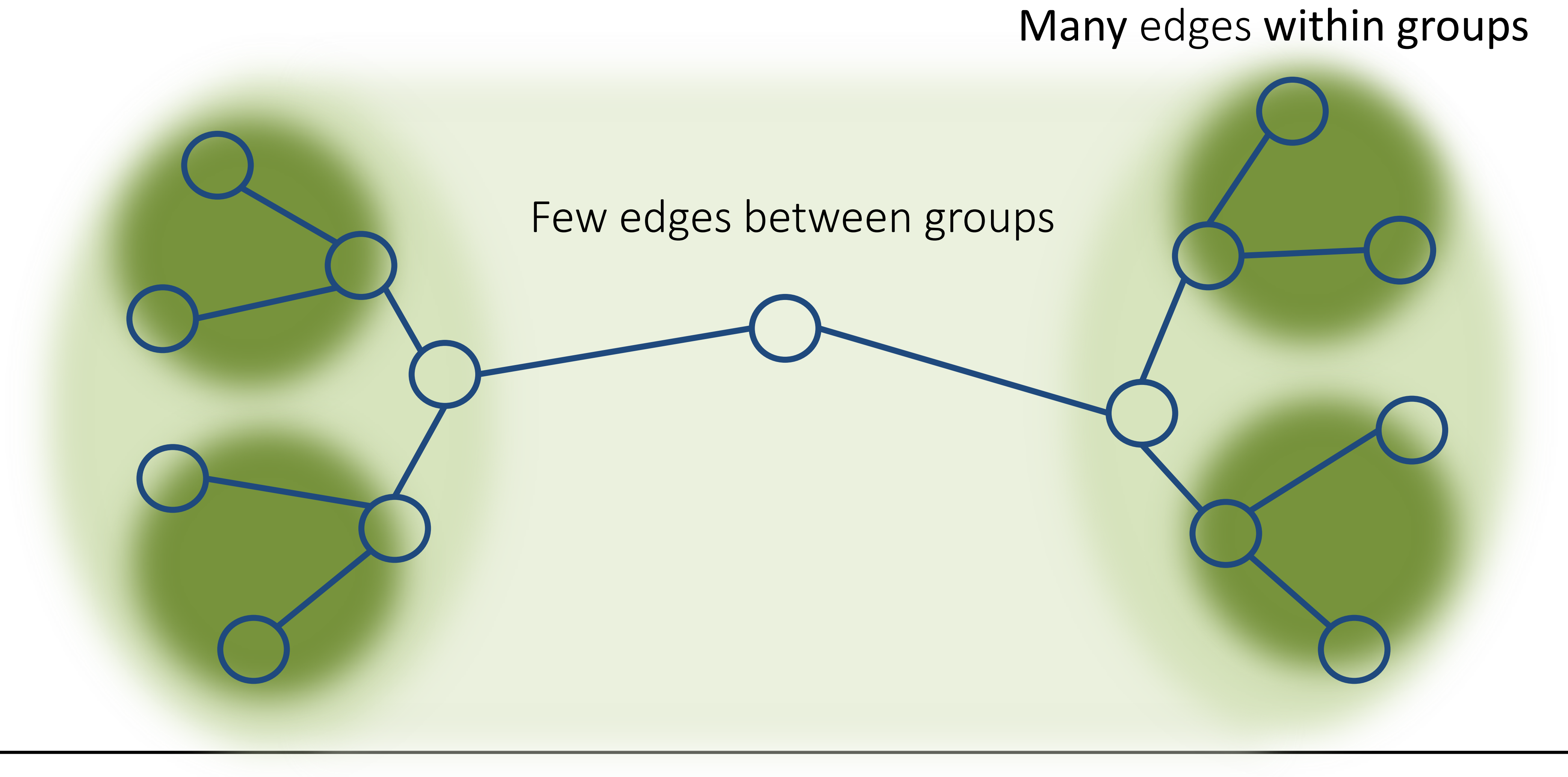
Disjoint cliques



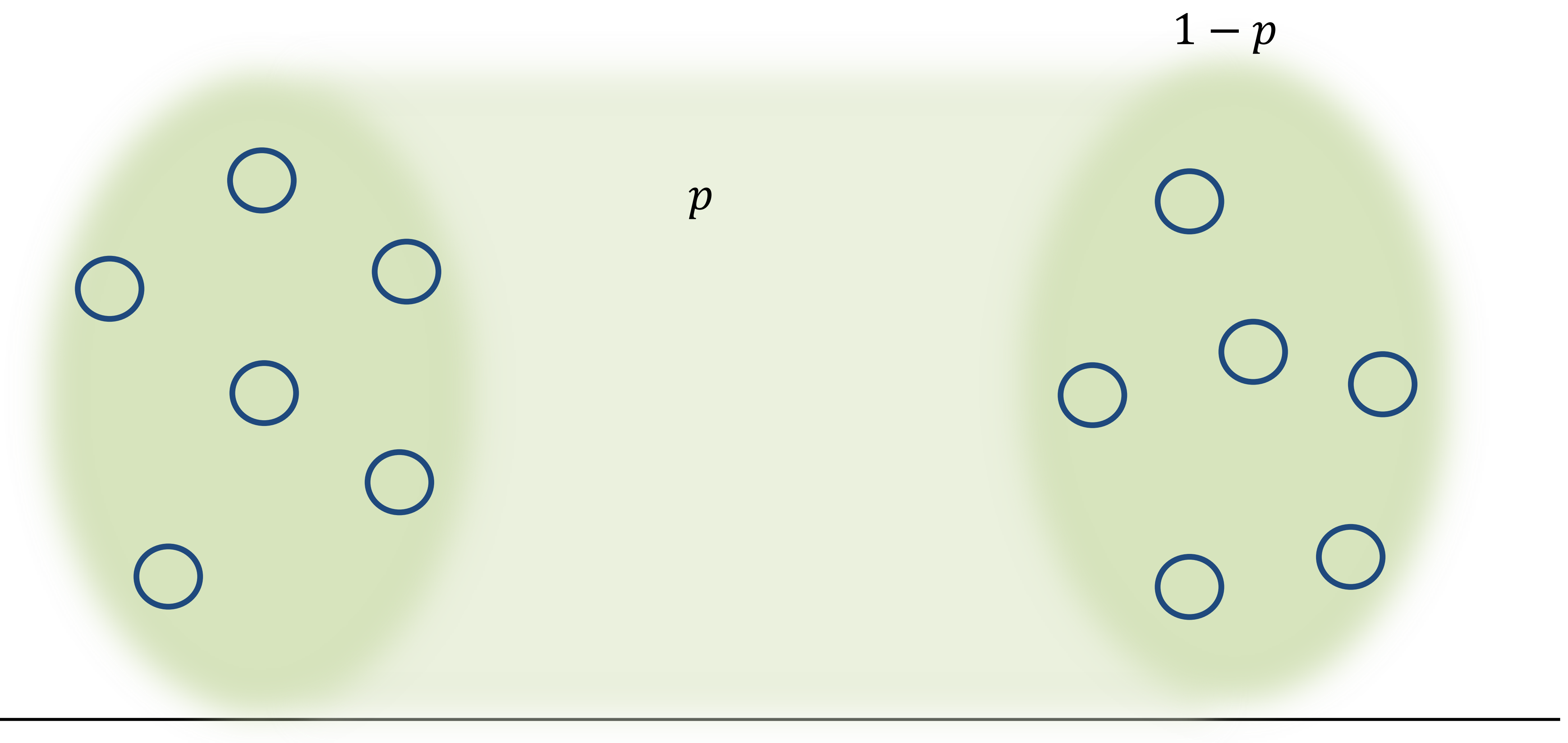
Tree Structure



Tree Structure



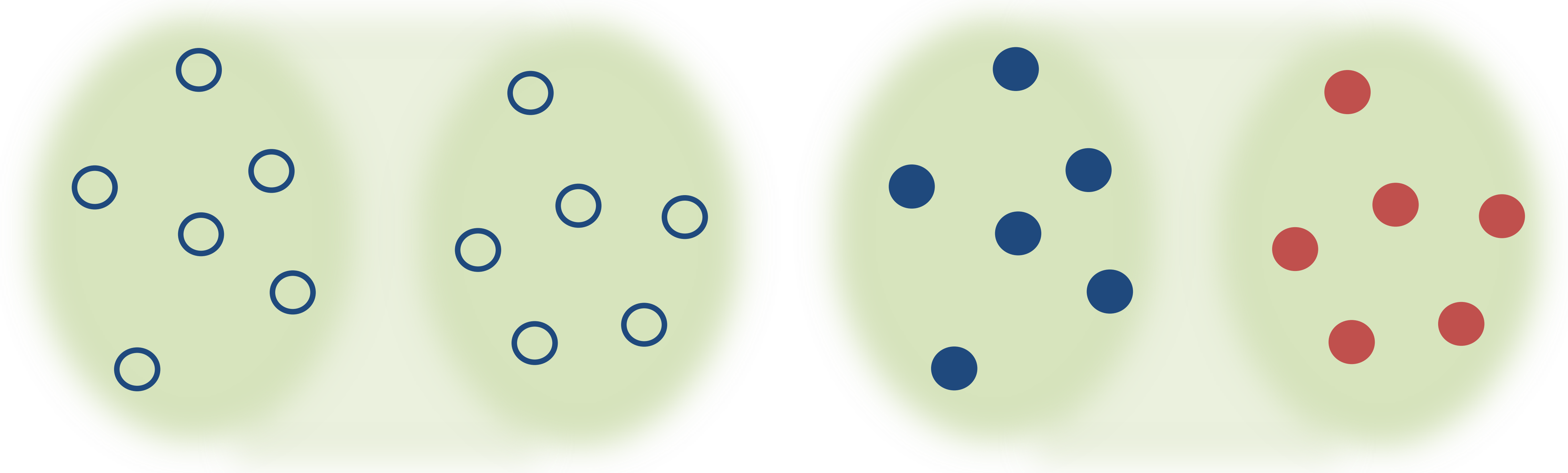
Adding Homogeneity



Community Structure

Empty initial states

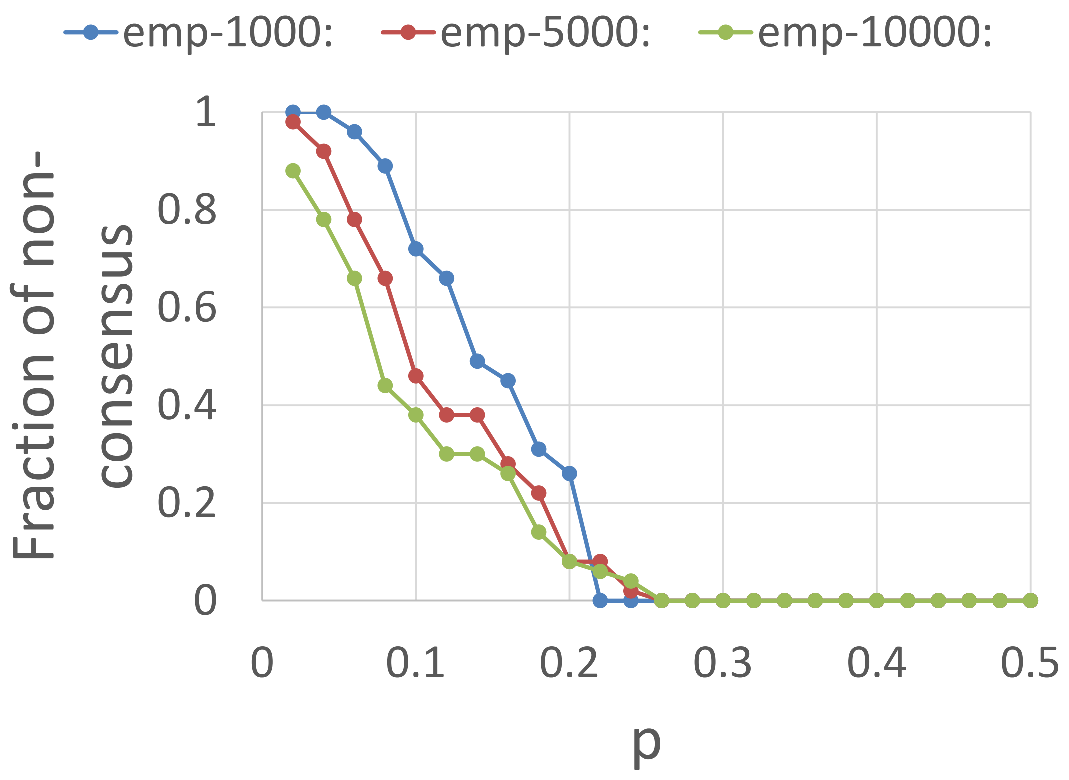
Segregated initial states



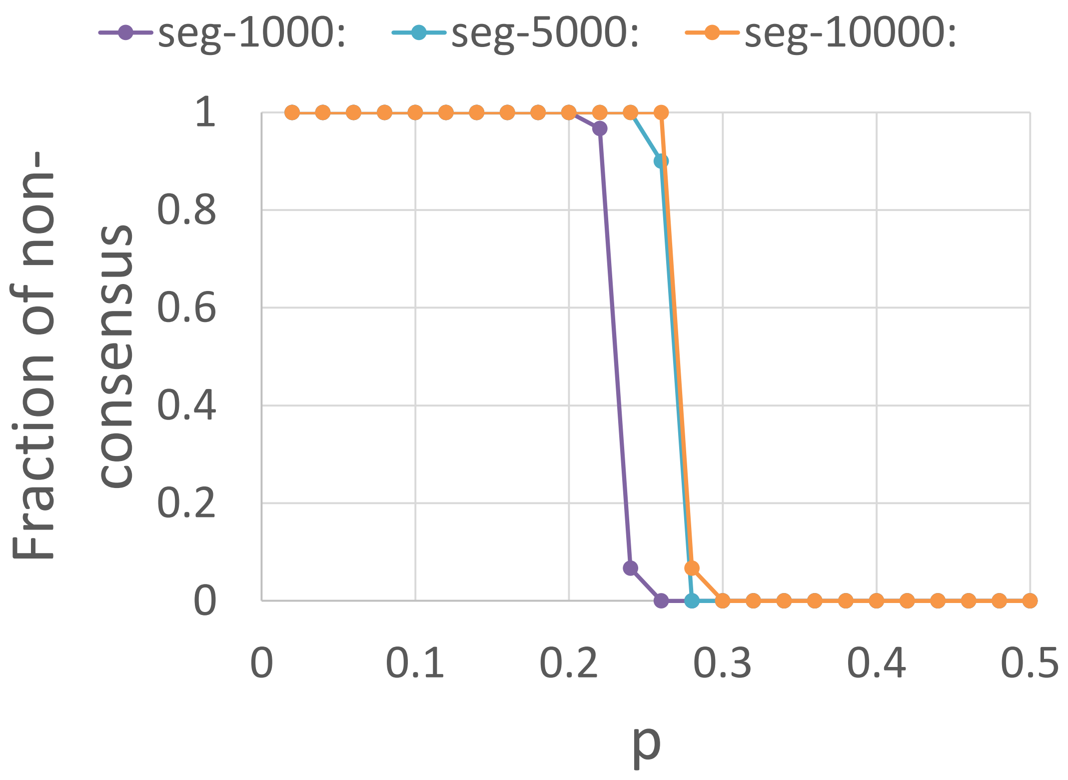
p $1-p$ p $1-p$

Simulation on Disjoint Cliques

Empty initial states



Segregated initial states



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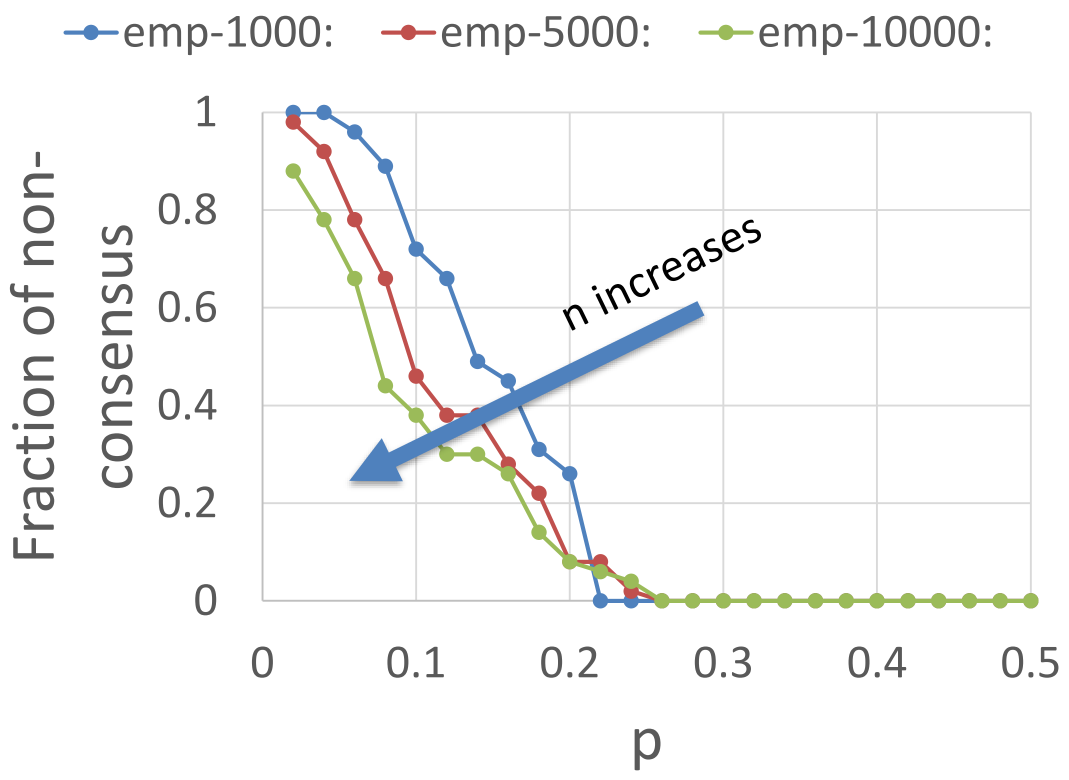

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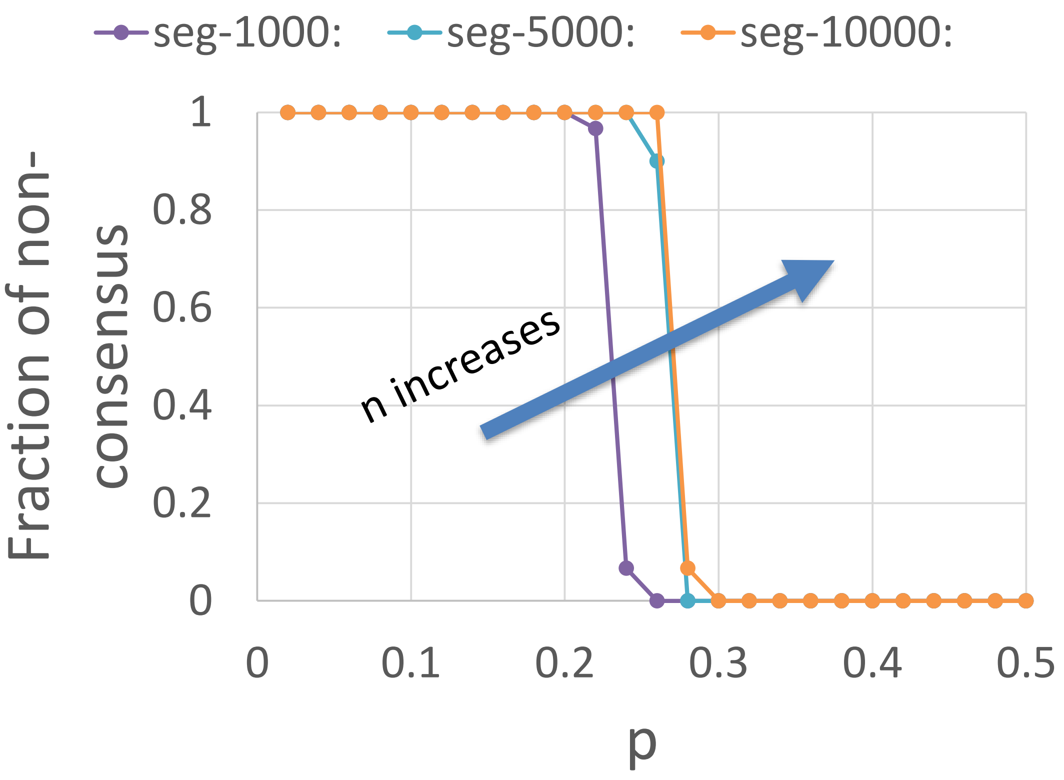
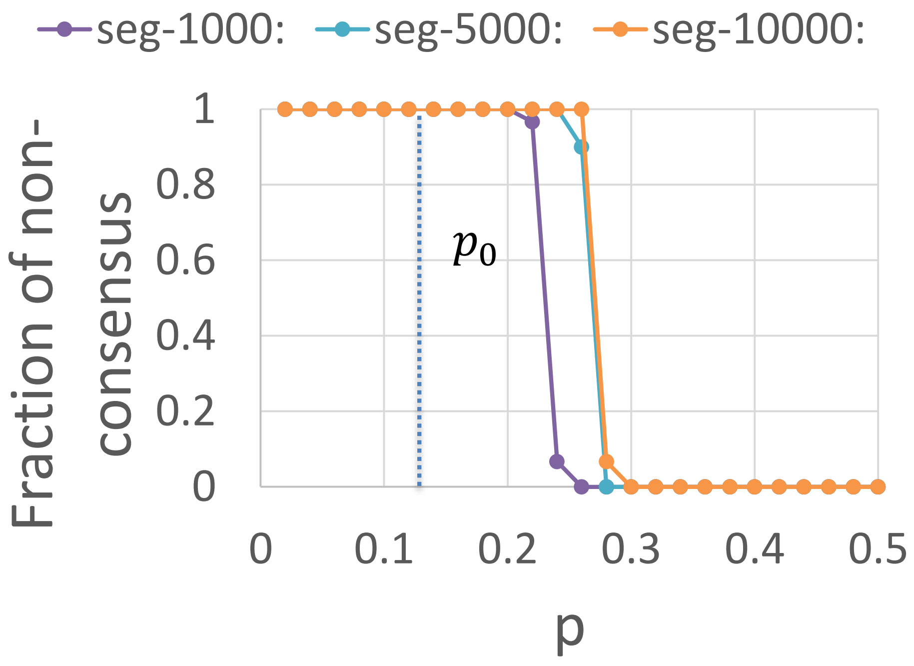


Theoretical Analysis

- Segregated start: for $p < p_0 \approx 0.110$, consensus time$=$ $\exp(\Omega(n))$



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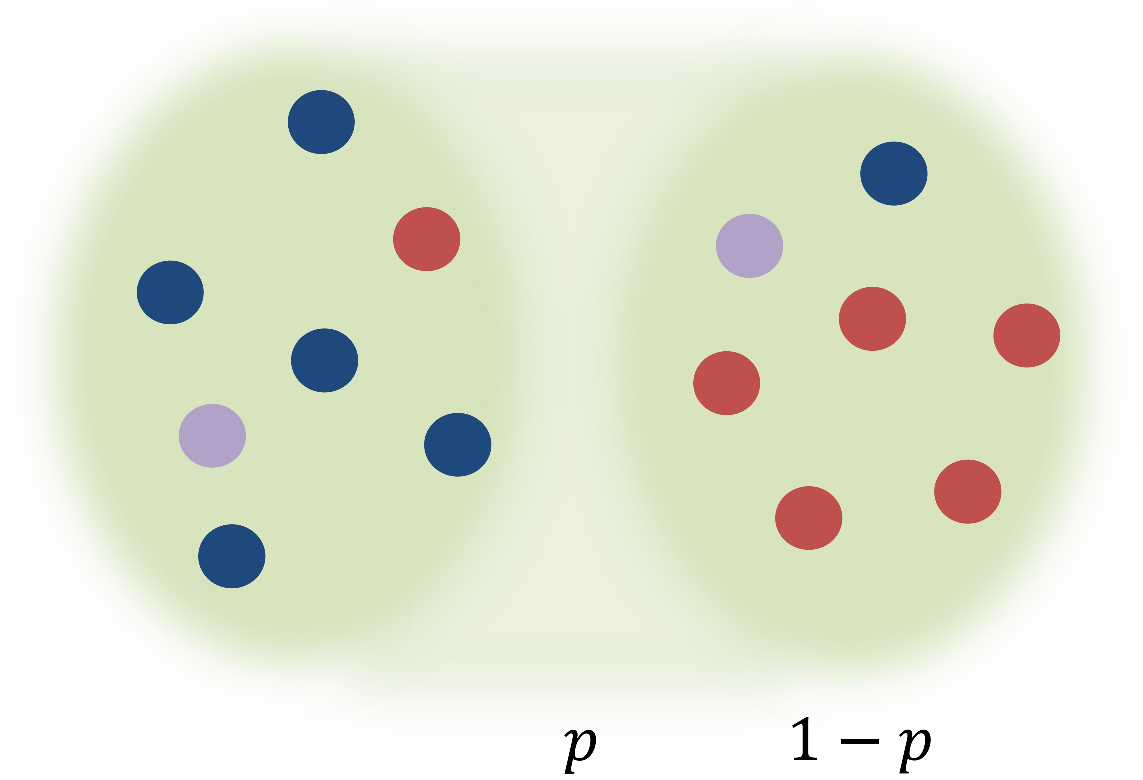

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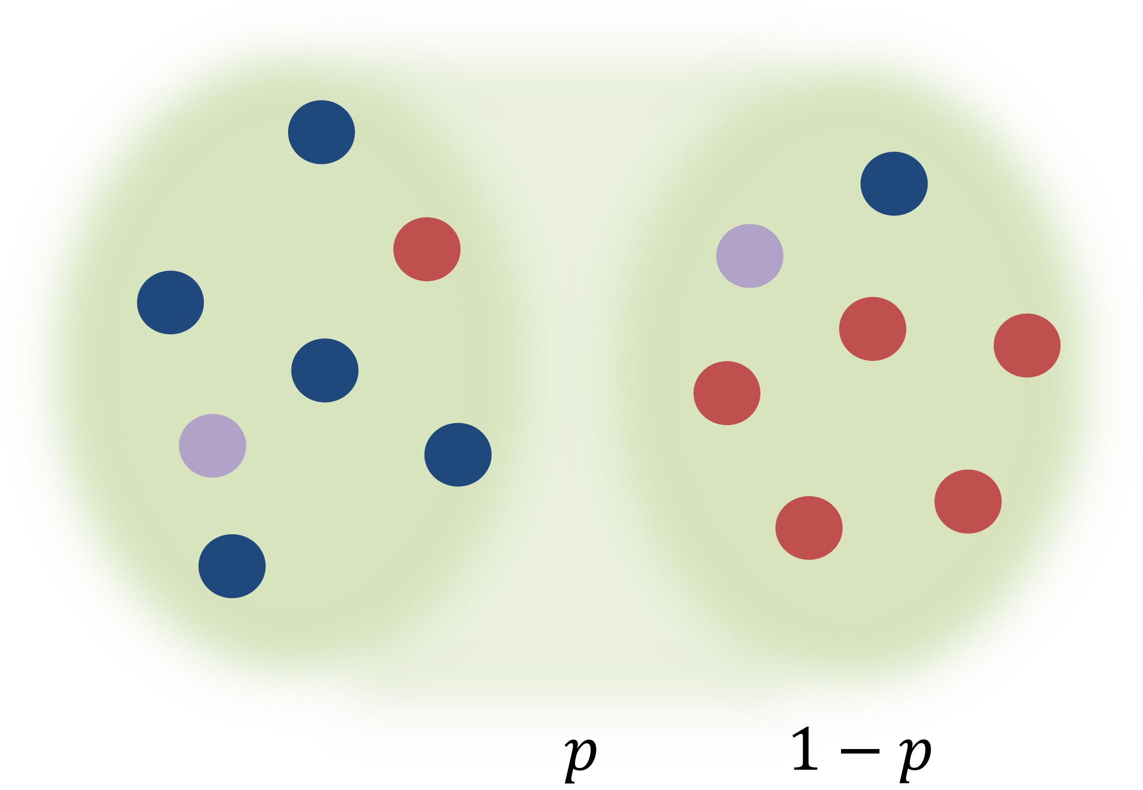
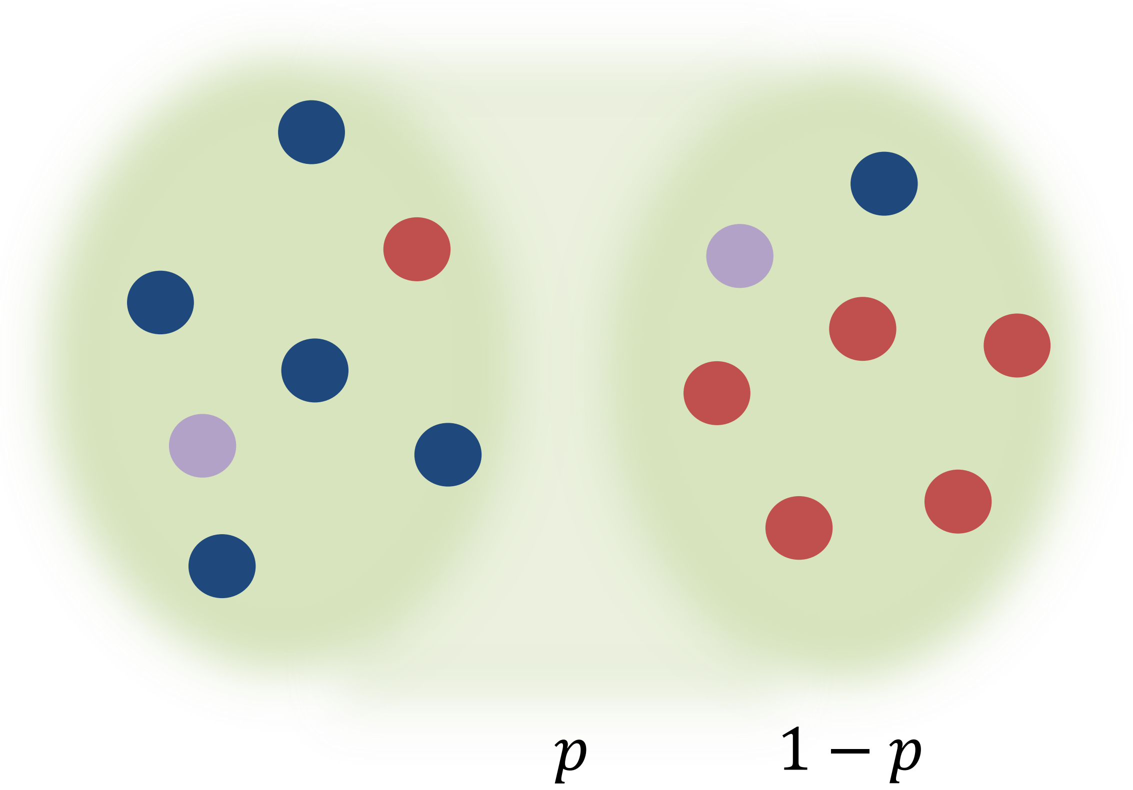
  - Mean field approximation



Theoretical Analysis

- Segregated start: for $p < p_0 \approx 0.110$, consensus time$=$ $\exp(\Omega(n))$
  - Mean field approximation
  - Stability of autonomous system
    - Local stability
    - Global stability



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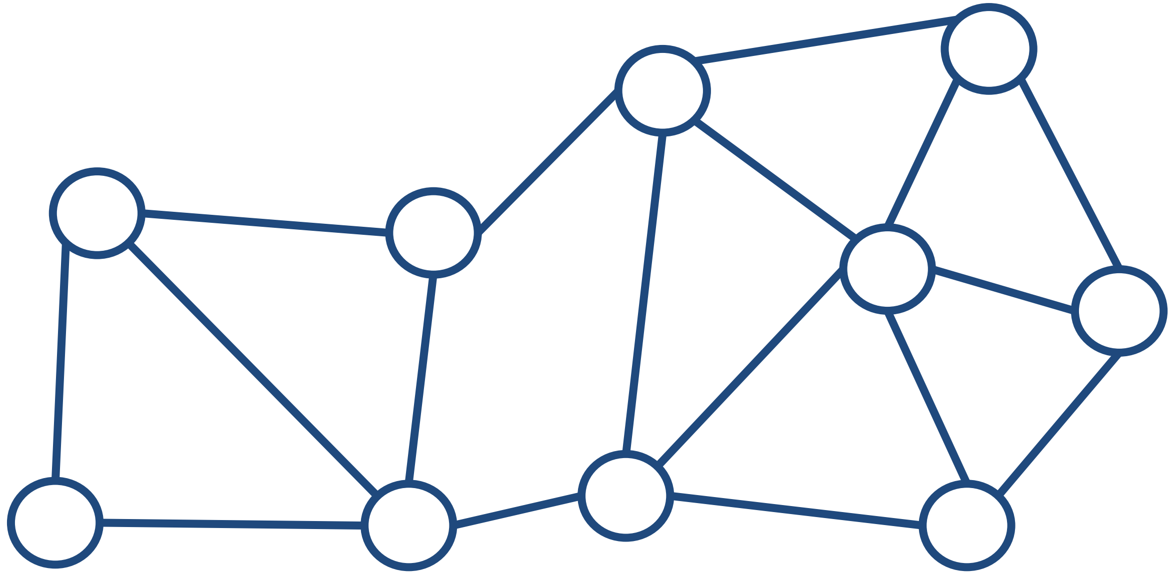
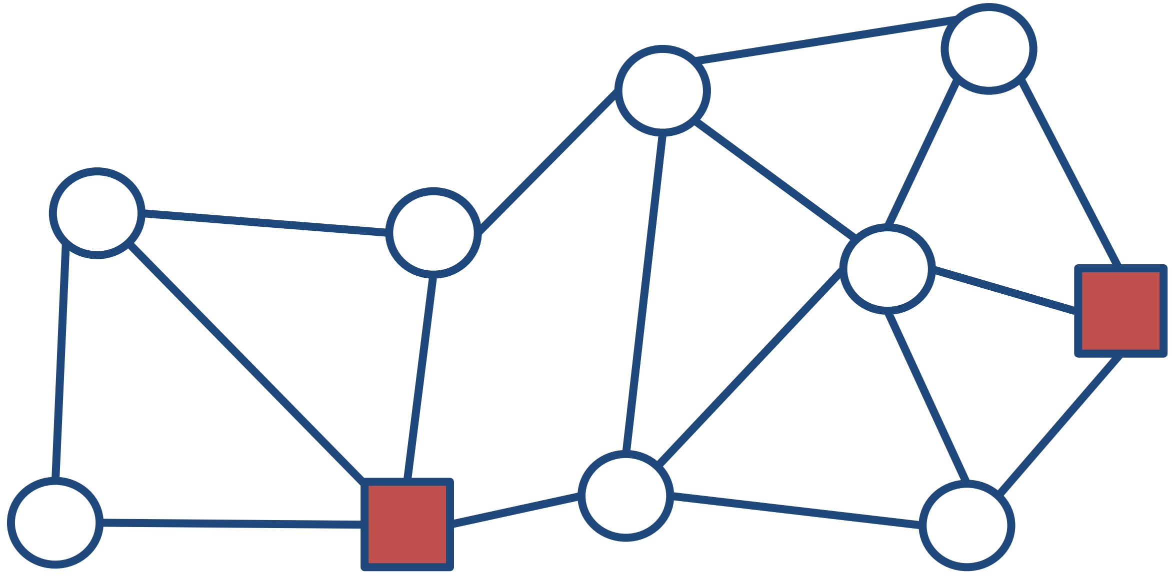
Robustness



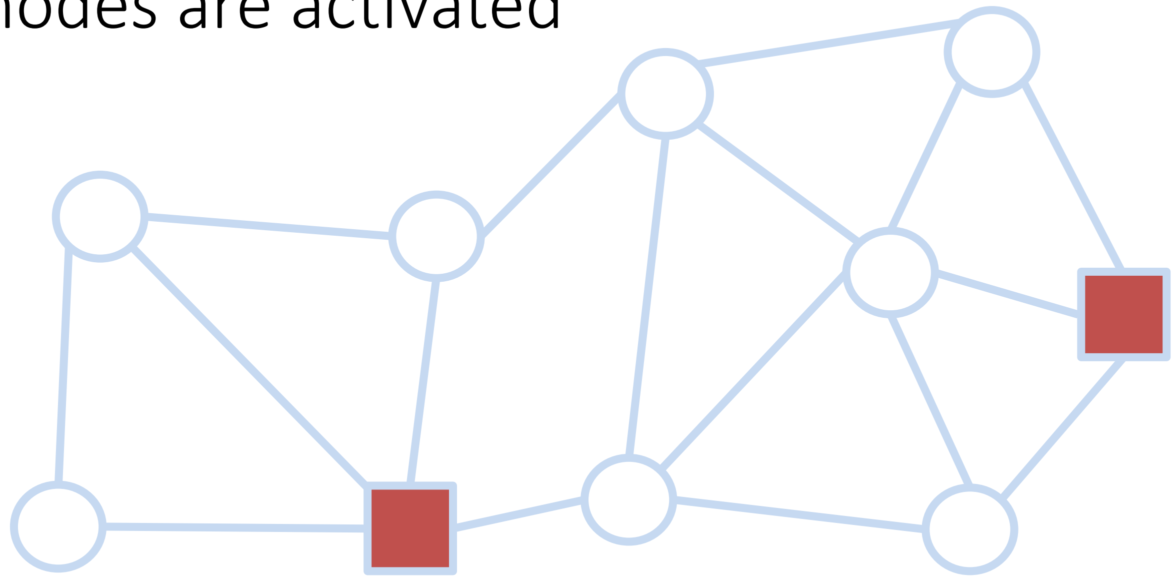
Stubborn nodes

- How and when can such nodes affect the name to which the dynamics converge?



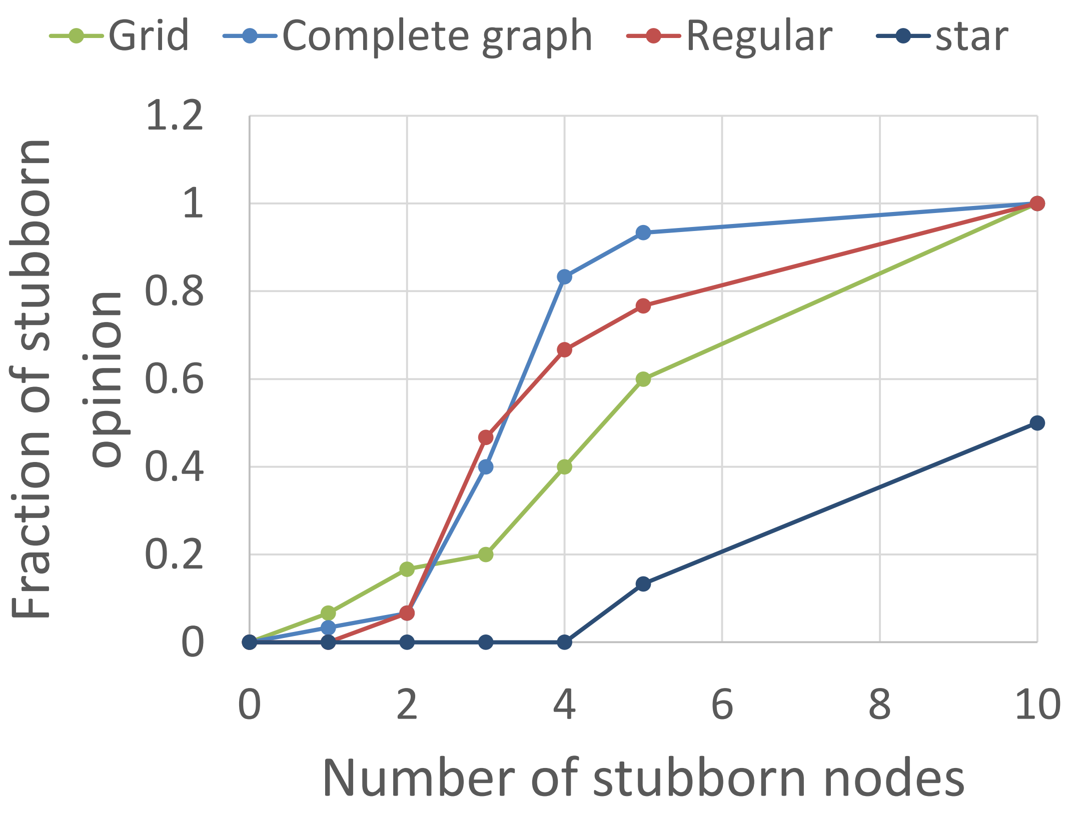
Stubborn nodes

- How and when can such nodes affect the name to which the dynamics converge?
  - The network topology
  - The time when the stubborn nodes are activated



Stubborn nodes and network

Graph size = 1000



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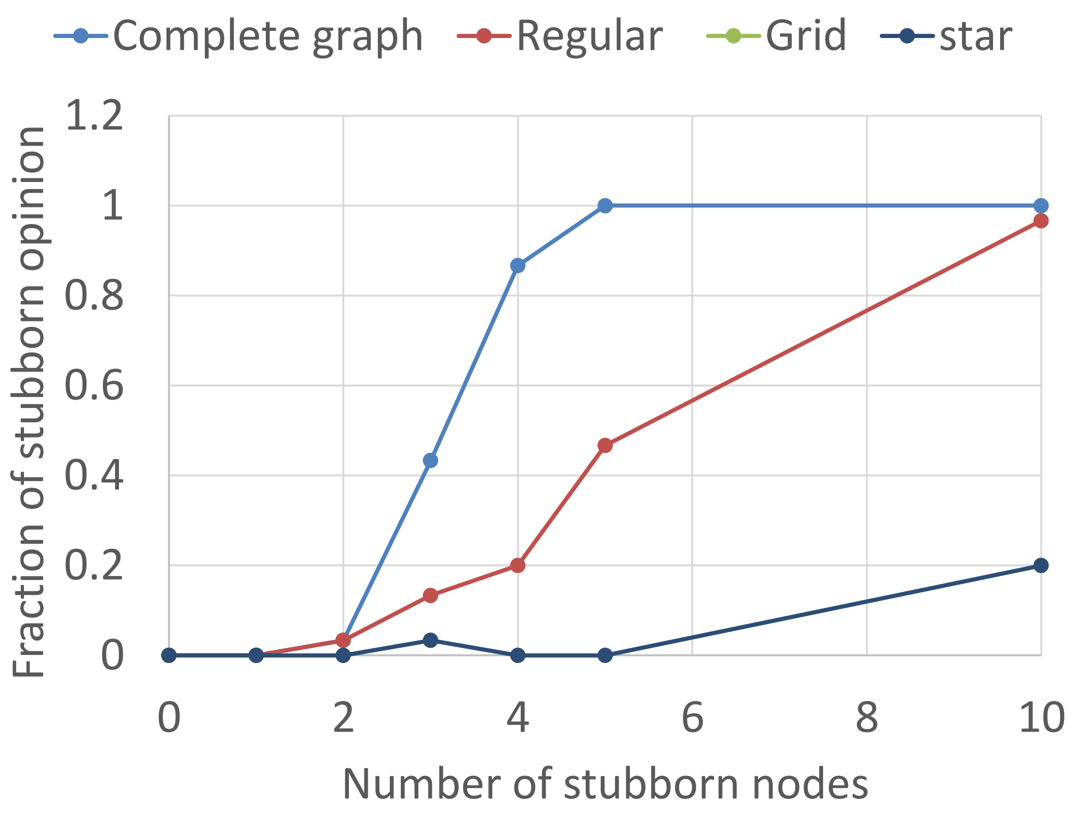
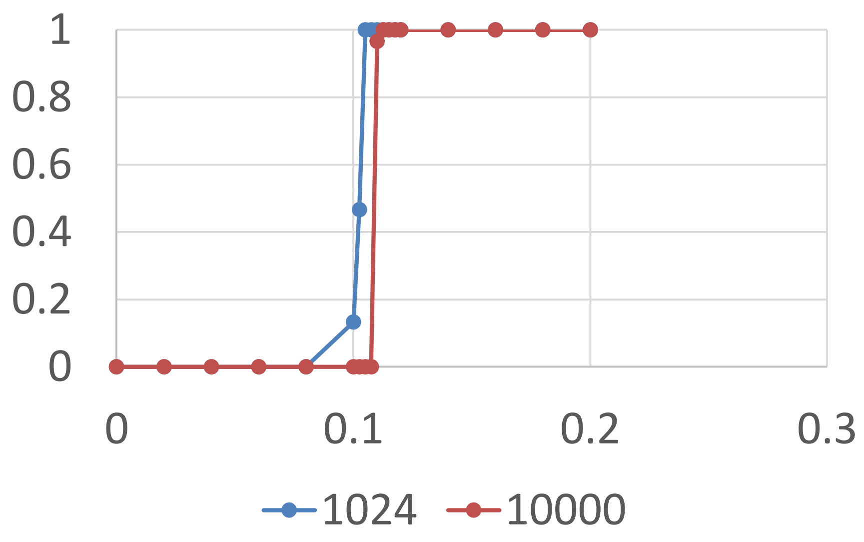


Adding stubborn nodes after consensus

- After consensus: with $p < p_0 \approx 0.108$ fraction of stubborn nodes, the consensus time $= \exp(\Omega(n))$.



Engineering Agreement

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QUESTIONS?