

Opinion Maximization in Social Networks

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joint work with



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Which are the most influential nodes
in a social network?

When influential nodes

- buy products or adopt opinions.....
- others follow them

Influential nodes create trends

Product/action marketing [...]

- select **k** initial adopters in a social network
- to **maximize** the spread of adoption of a **product / action / ...**

Products

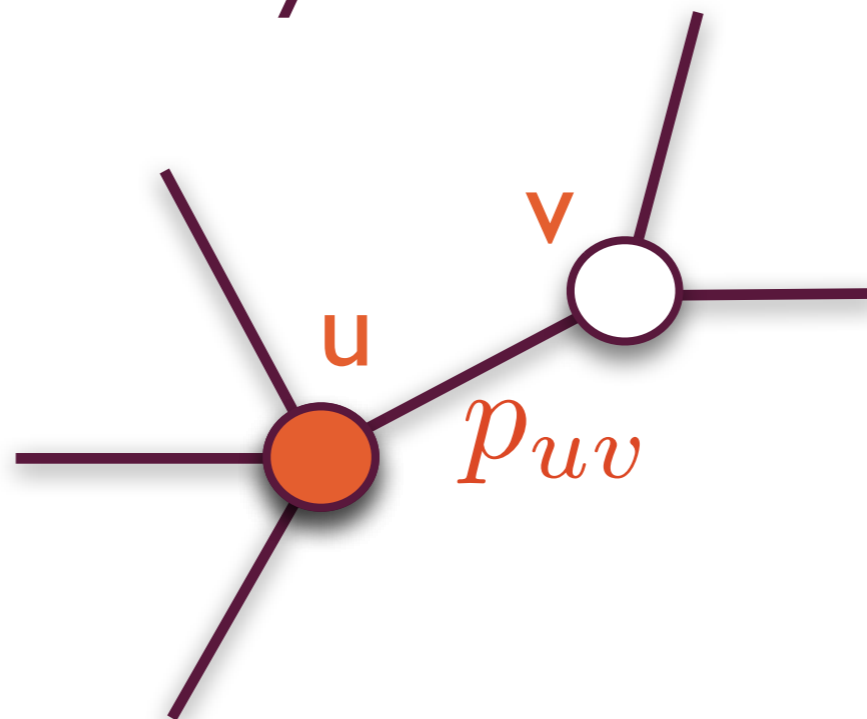


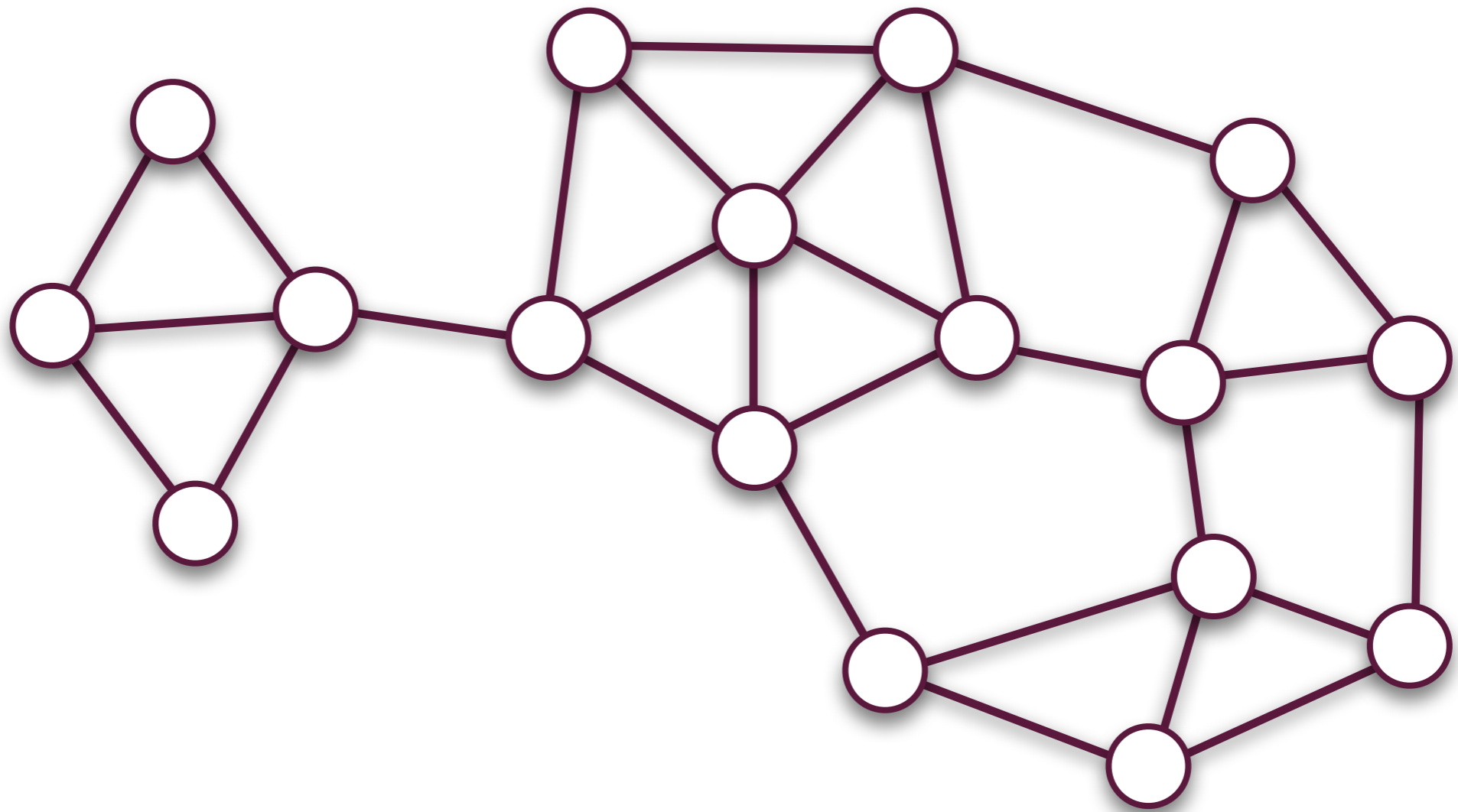
Actions in social networks (re-tweets)



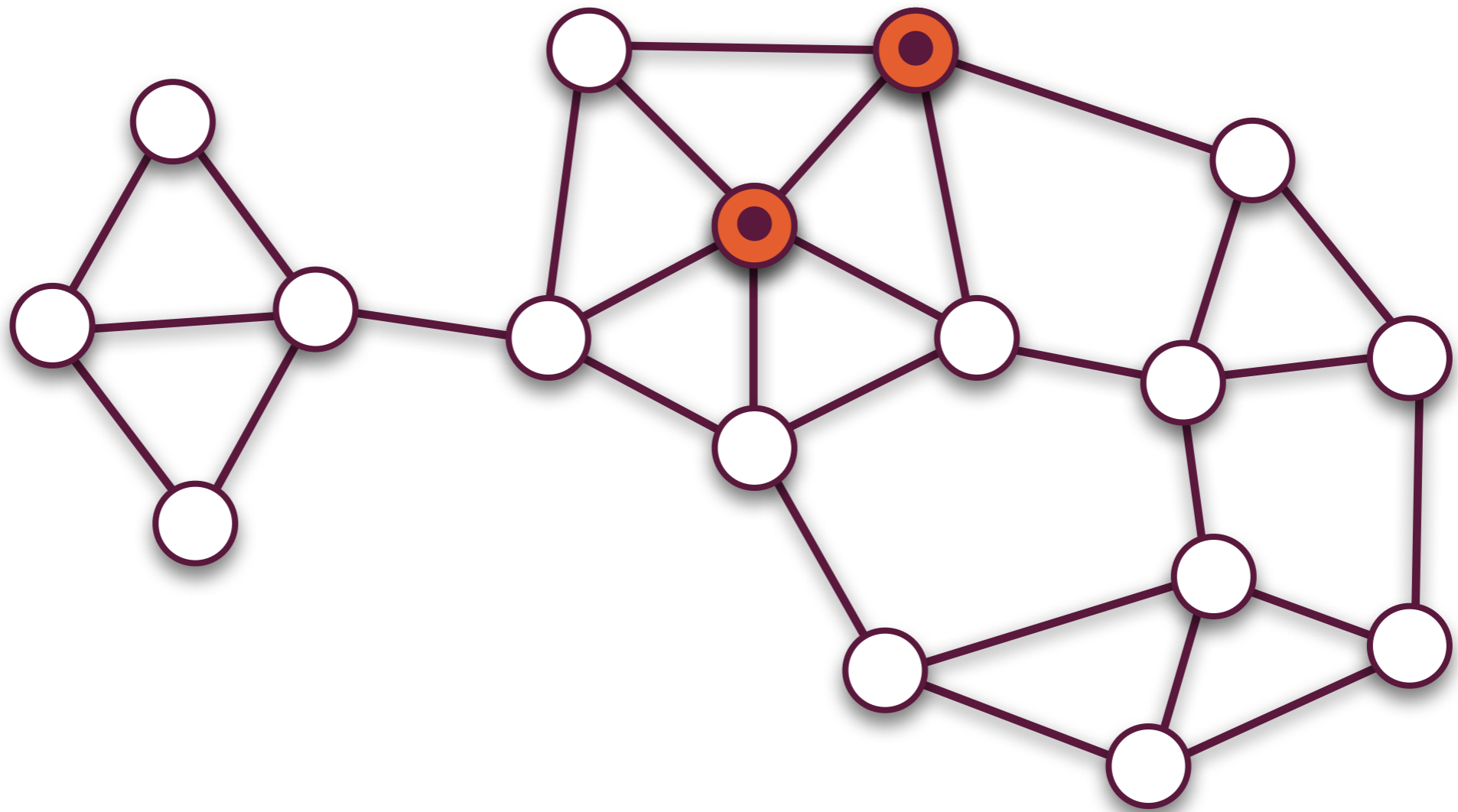
Independent-cascade model [Kempe03....]

- at time t : a node u adopts
- at time $t+1$: a neighbor v adopts with prob p_{uv}
- one-time opportunity

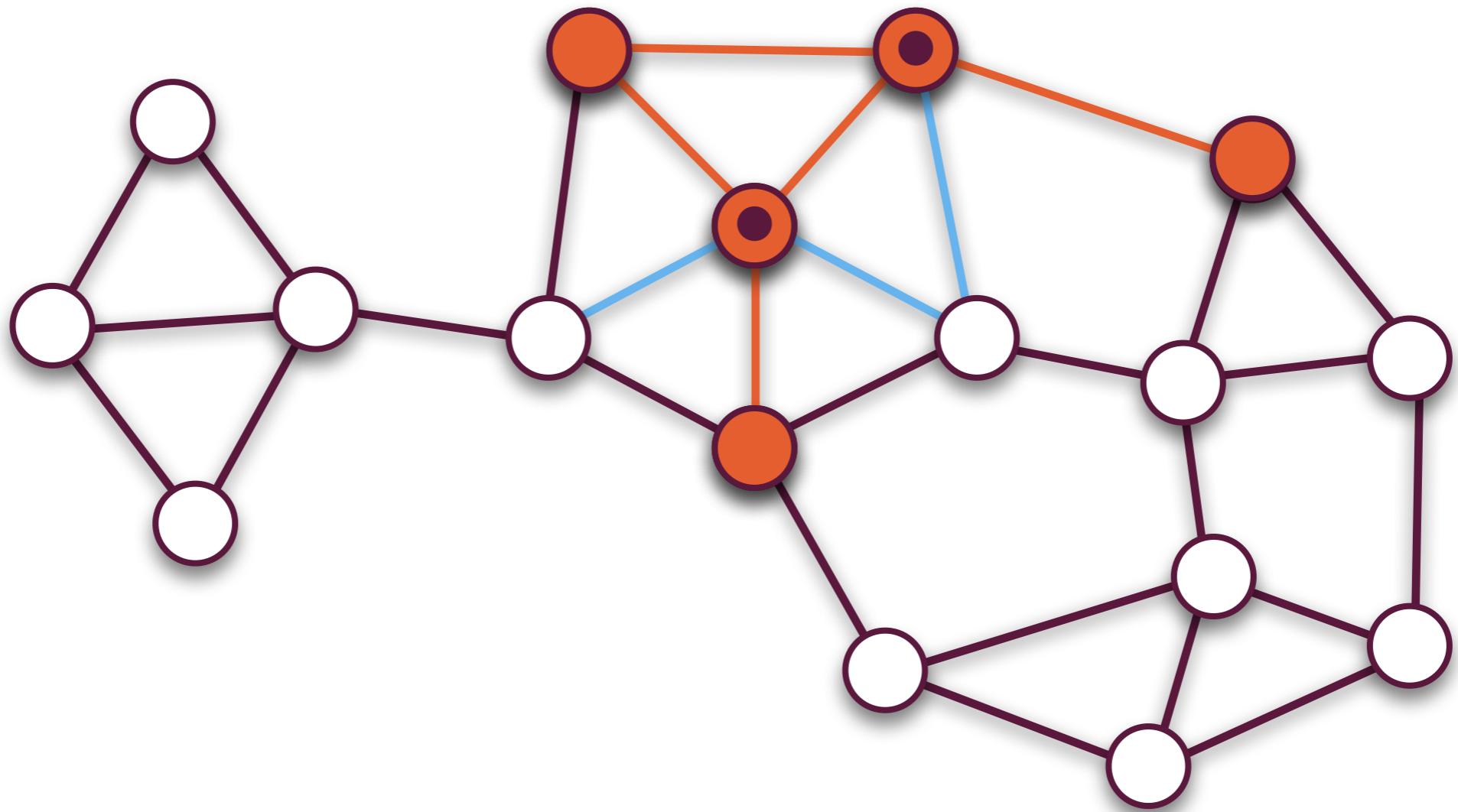




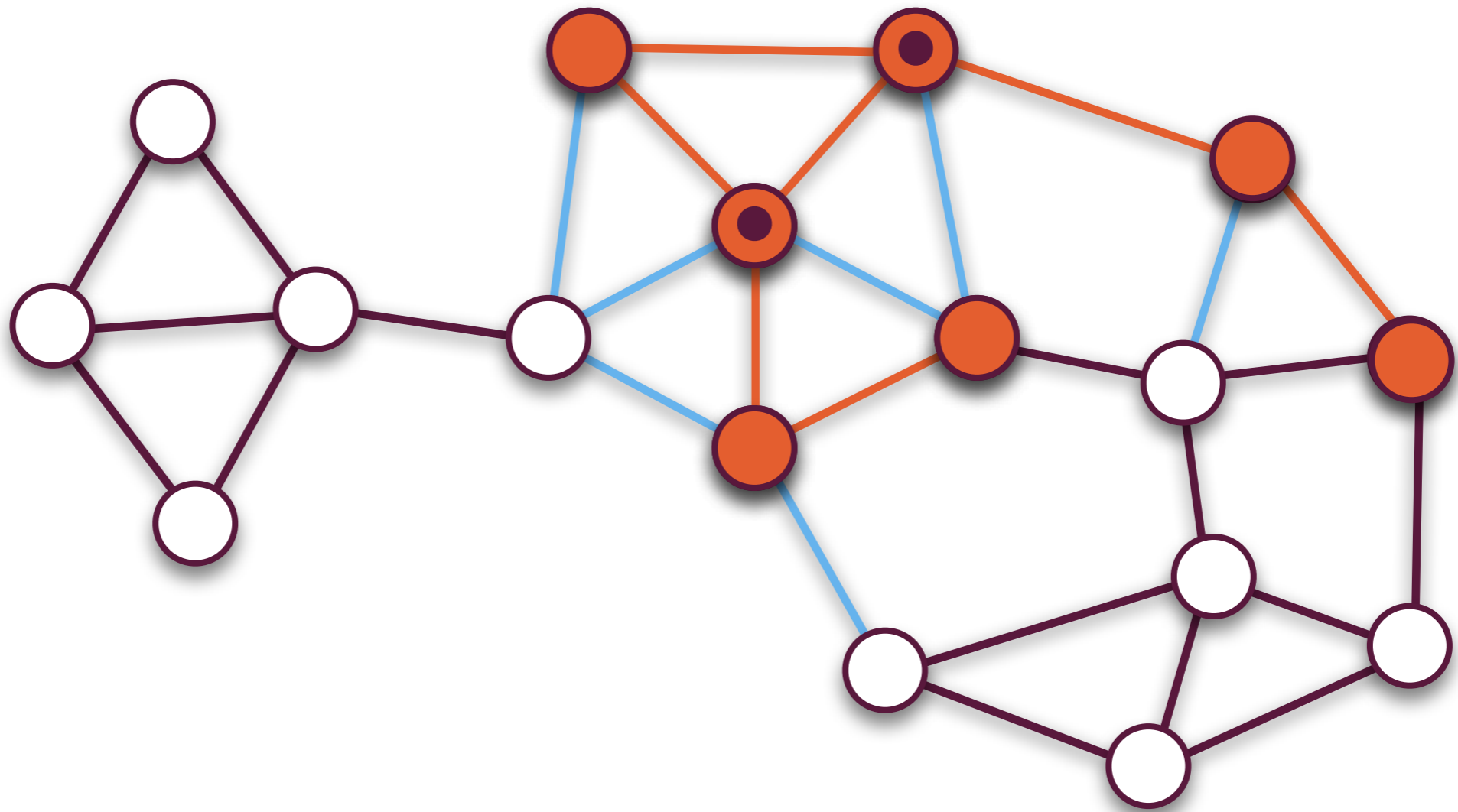
independent-cascade model



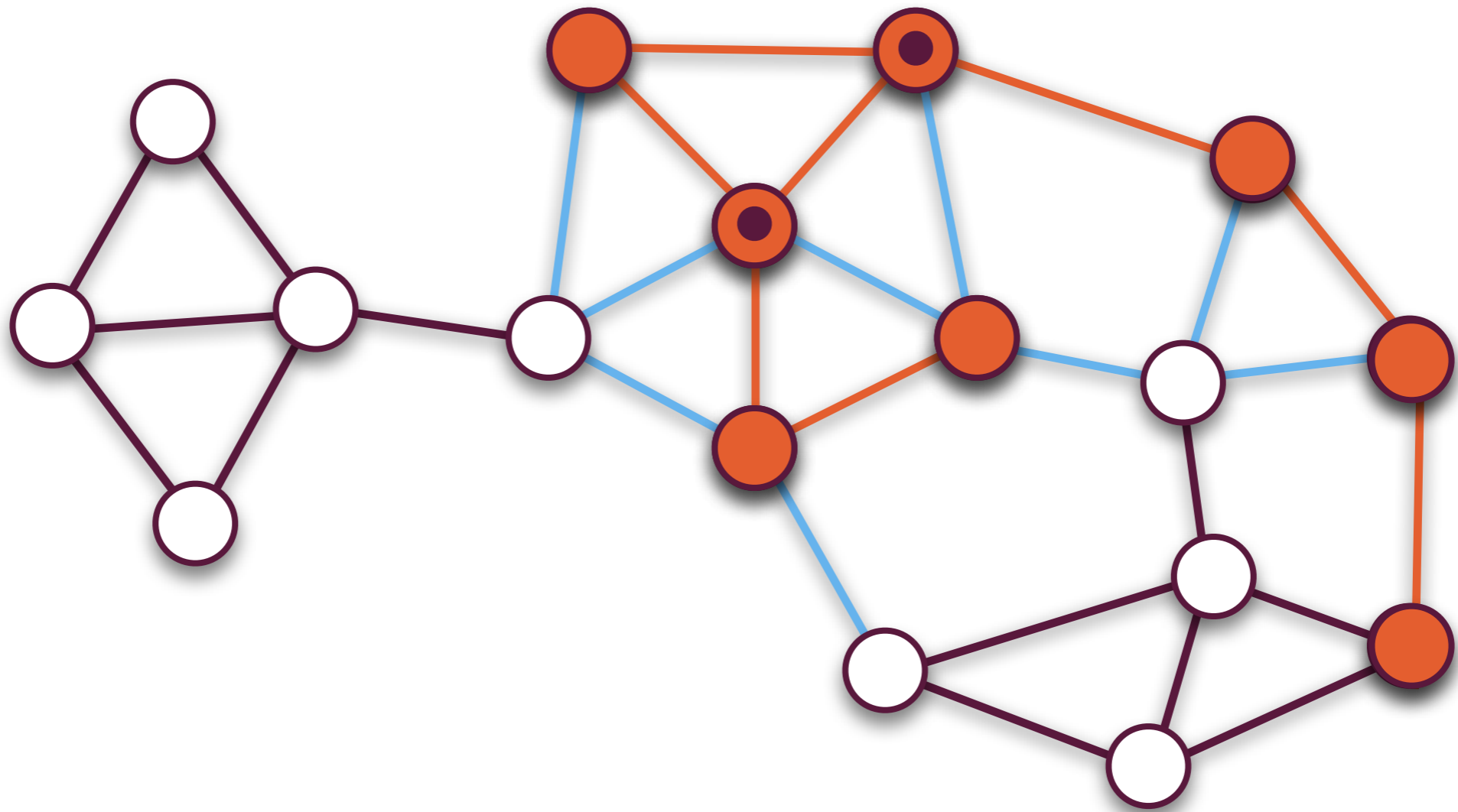
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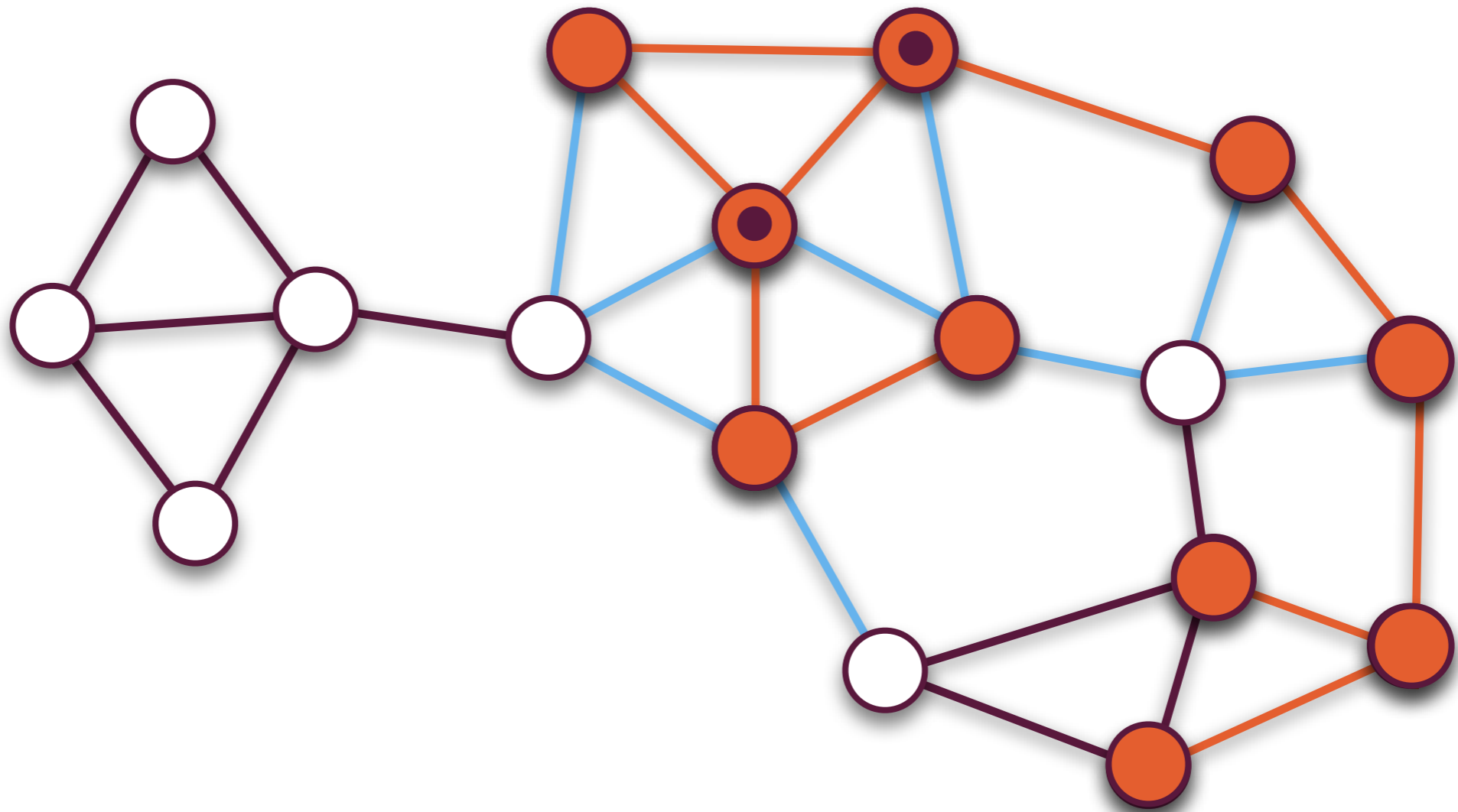
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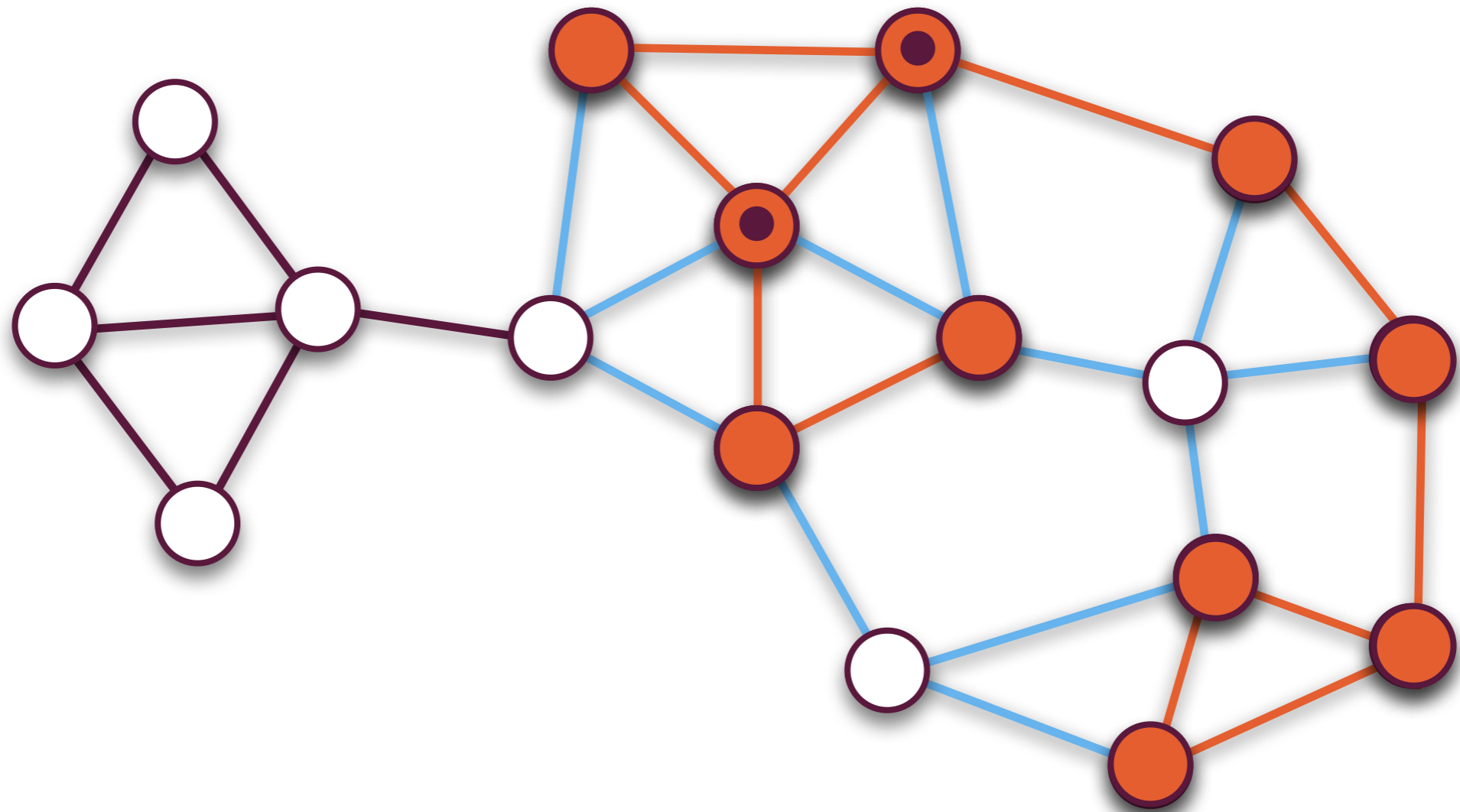
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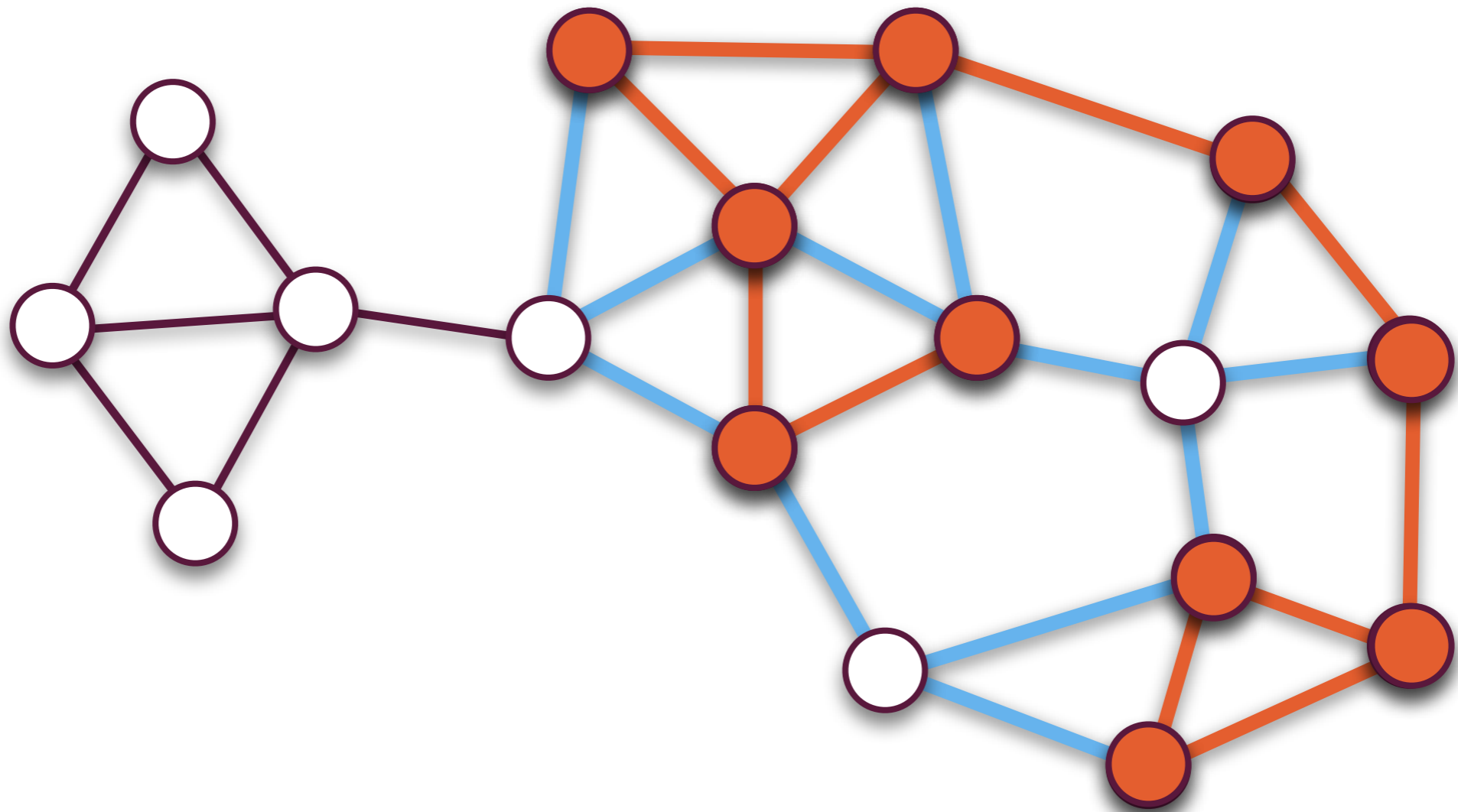


independent-cascade model



independent-cascade model

Products/actions propagate in a **binary**
fashion



independent-cascade model

But not everything is black and white...

prevent global warming

prevent global warming



prevent global warming

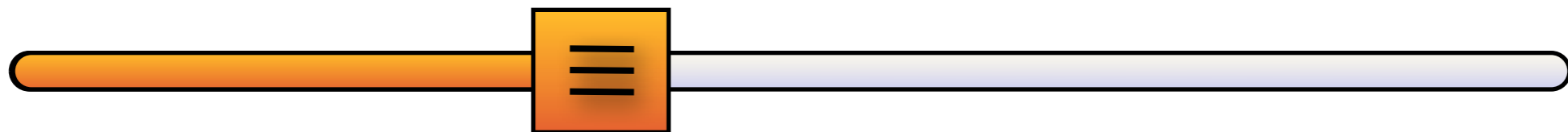


reduce military spending

prevent global warming



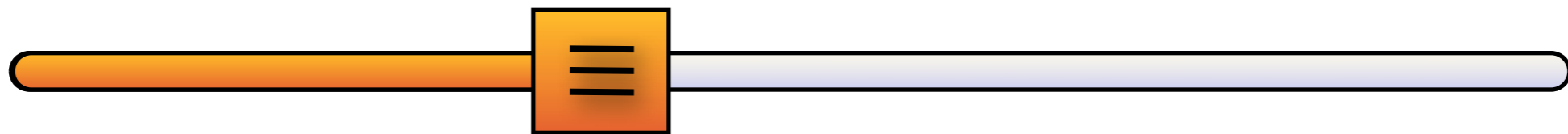
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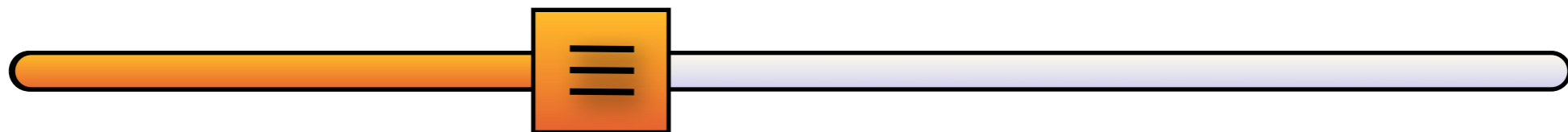


fight poverty

prevent global warming



reduce military spending



fight poverty



DON'T BUY THIS JACKET



COMMON THREADS INITIATIVE

REDUCE

WE make useful gear that lasts a long time
YOU don't buy what you don't need

REPAIR

WE help you repair your Patagonia gear
YOU pledge to fix what's broken

REUSE

WE help find a home for Patagonia gear
you no longer need
YOU sell or pass it on*

RECYCLE

WE will take back your Patagonia gear
that is worn out
YOU pledge to keep your stuff out of
the landfill and incinerator



REIMAGINE

TOGETHER we reimagine a world where we take
only what nature can replace

patagonia[®]
patagonia.com

- **opinions** assume a **continuous** range of values
- **constantly evolving and being refined**

Our problem

- In a setting of constantly changing opinions
- select k initial nodes to convince 100% about your idea
- to maximize the overall *positive opinion* of the crowd on this idea

Rest of the talk

- How people form opinions
- How to select k nodes (efficiently)
- Experiments

Forming opinions

- opinion modeled as a value in $[0, 1]$
- person i has
 - predisposition S_i
 - expressed opinion Z_i
 - **personal cost** expressing conflict

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$$c(z_i) = (z_i - s_i)^2 + \sum_{j \in N(i)} w_{ij} (z_i - z_j)^2$$



your loyalty to
Red Sox ?



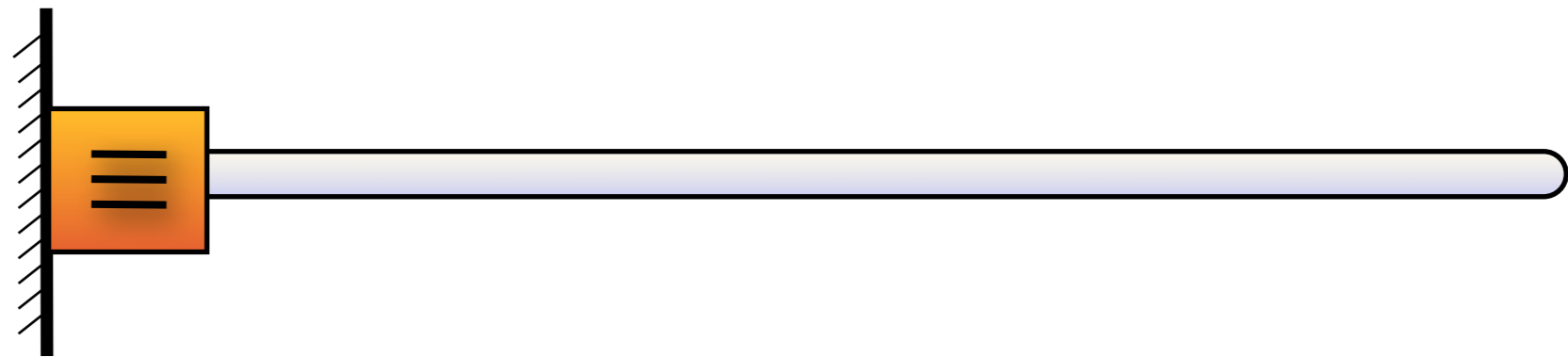


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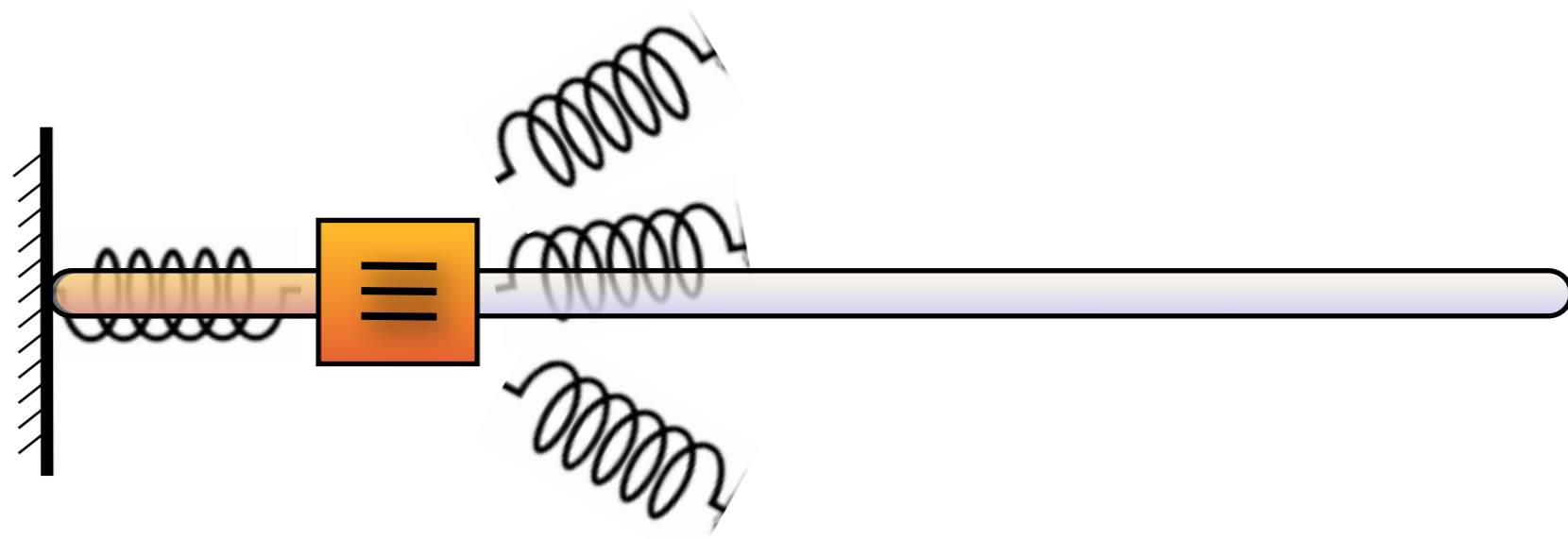


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Forming opinions

- **egoistic** agents **minimizing** their costs

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Forming opinions

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$$C(z_i) = (z_i - s_i)^2 + \sum_{j \in N(i)} w_{ij} (z_i - z_j)^2$$

gives

$$z_i = \frac{s_i + \sum_{j \in N(i)} w_{ij} z_j}{1 + \sum_{j \in N(i)} w_{ij}}$$

Nash equilibrium vs. social optimal

- Nash optimum : z_i that optimizes

$$c(z_i) = (z_i - s_i)^2 + \sum_{j \in N(i)} w_{ij} (z_i - z_j)^2$$

- social optimum : y_i that optimizes

$$c(\mathbf{y}) = \sum_{i \in V} c(y_i)$$

Nash equilibrium vs. social optimal

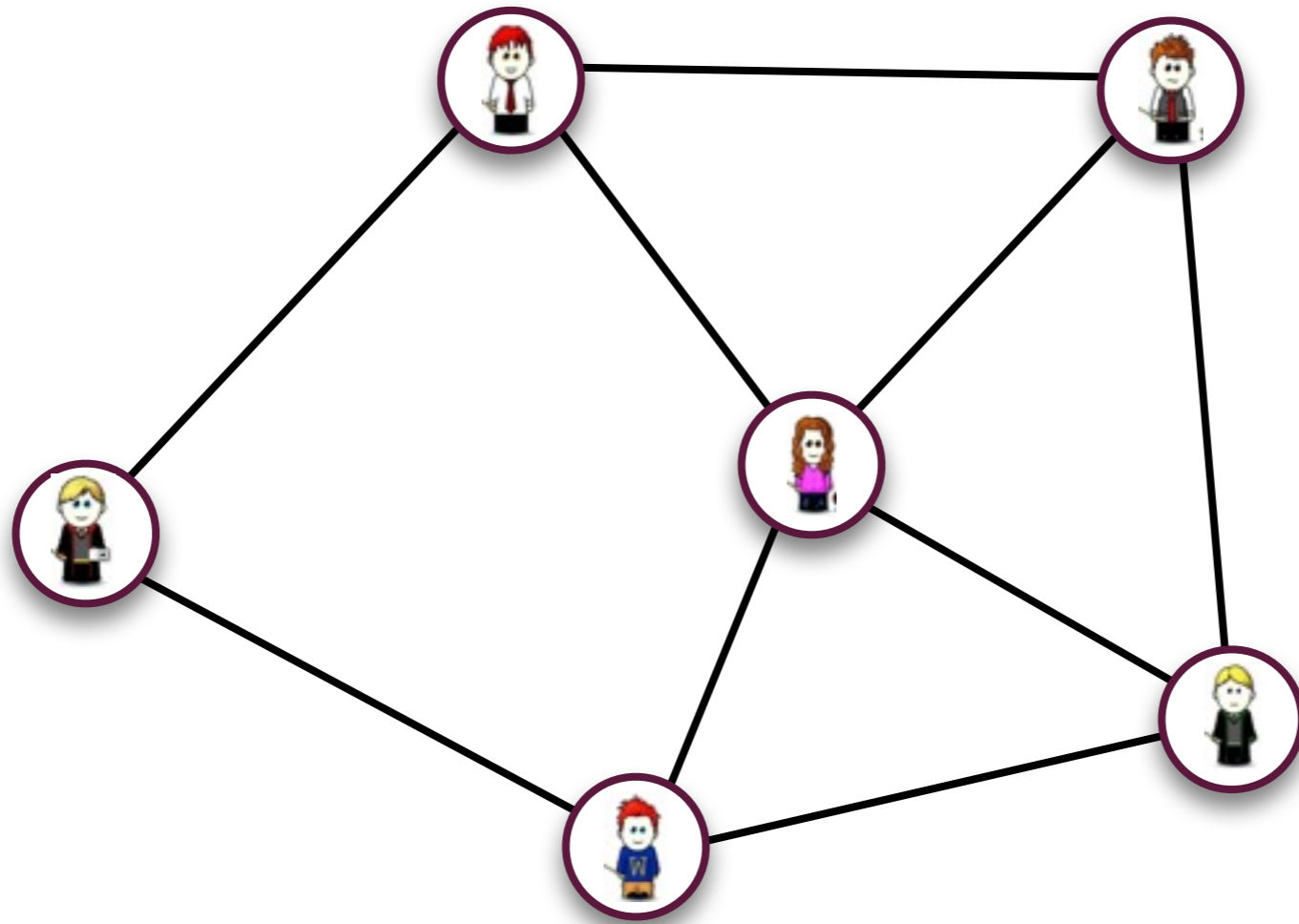
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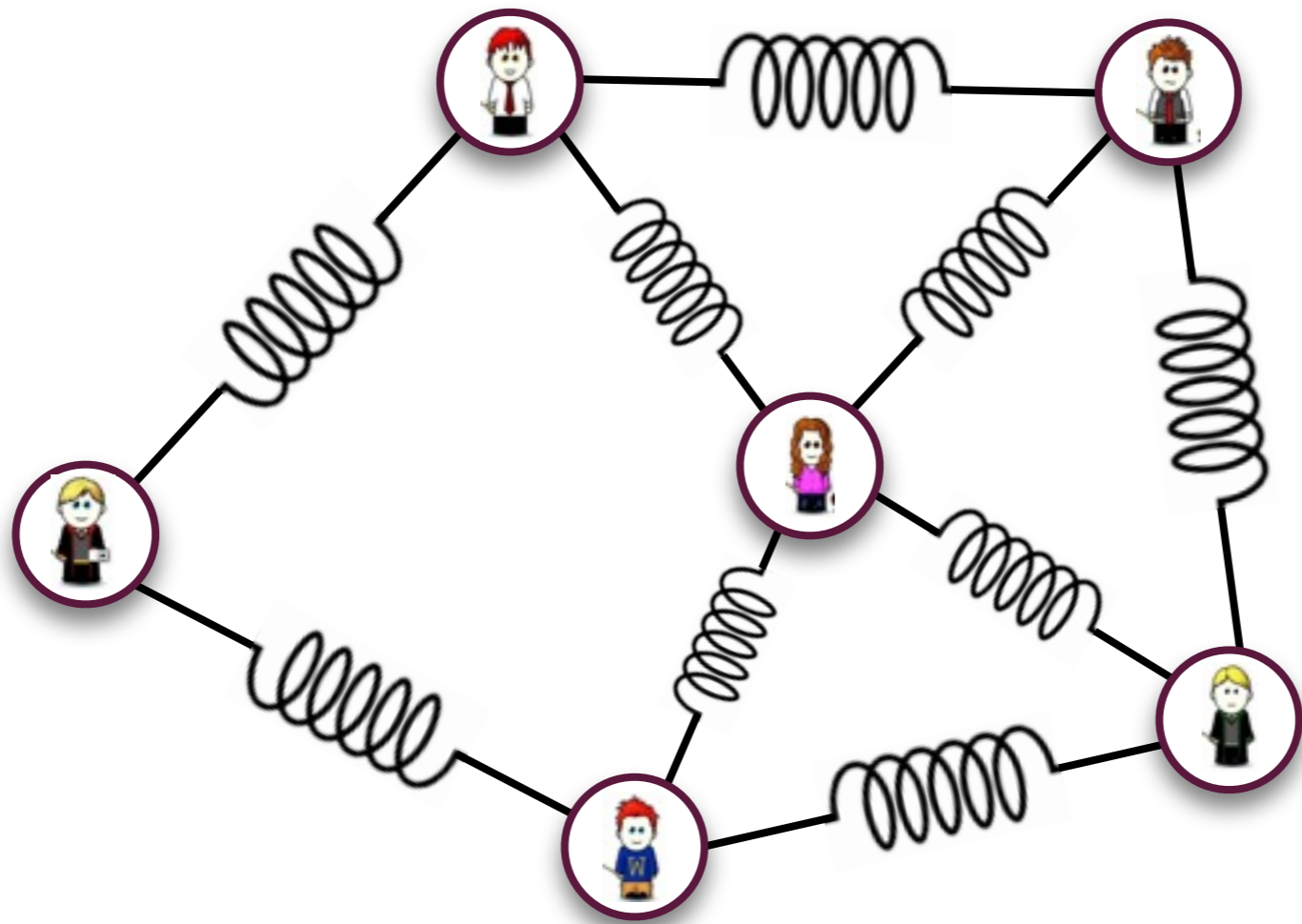
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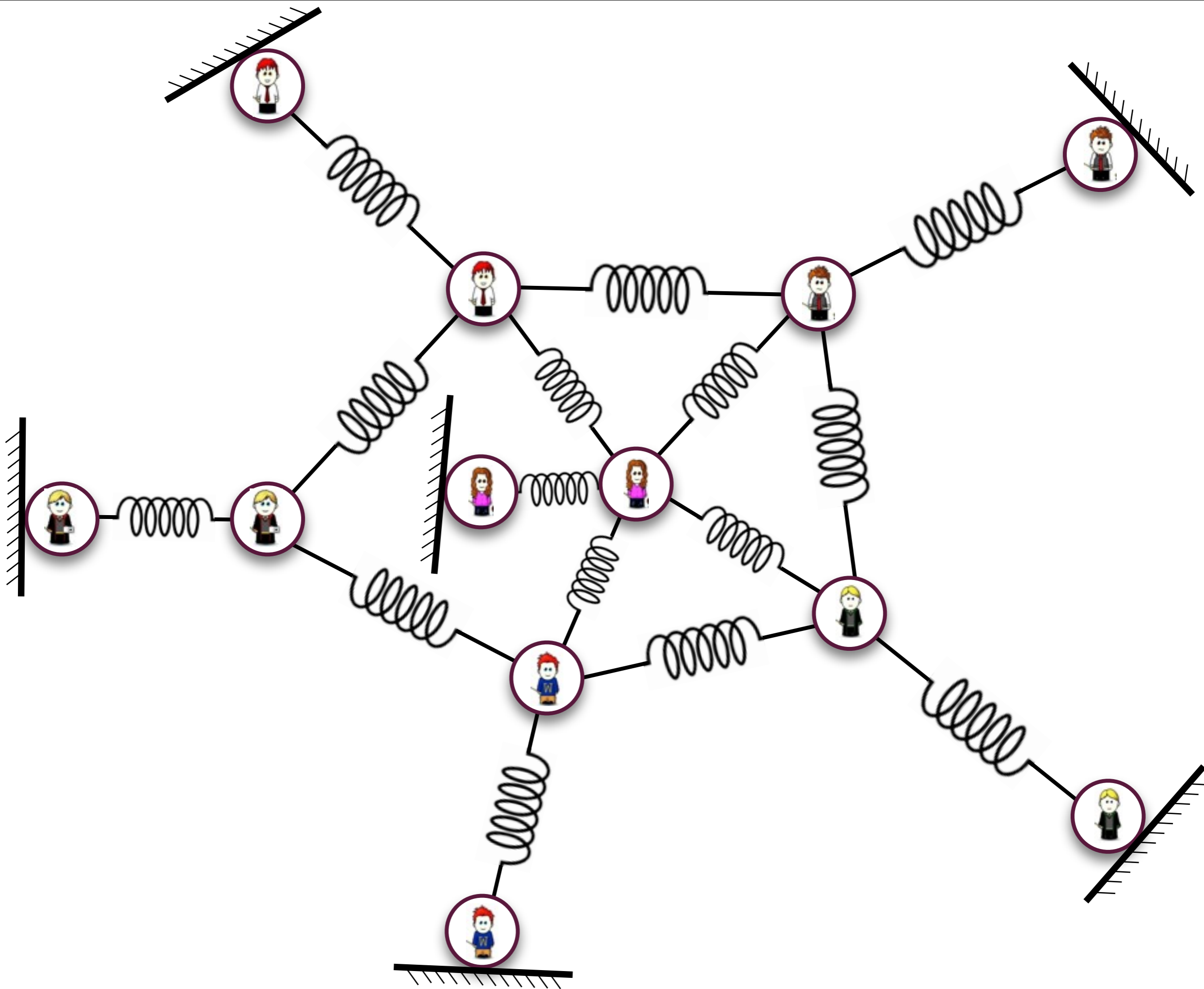
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$$\text{price of anarchy} = \frac{9}{8}$$

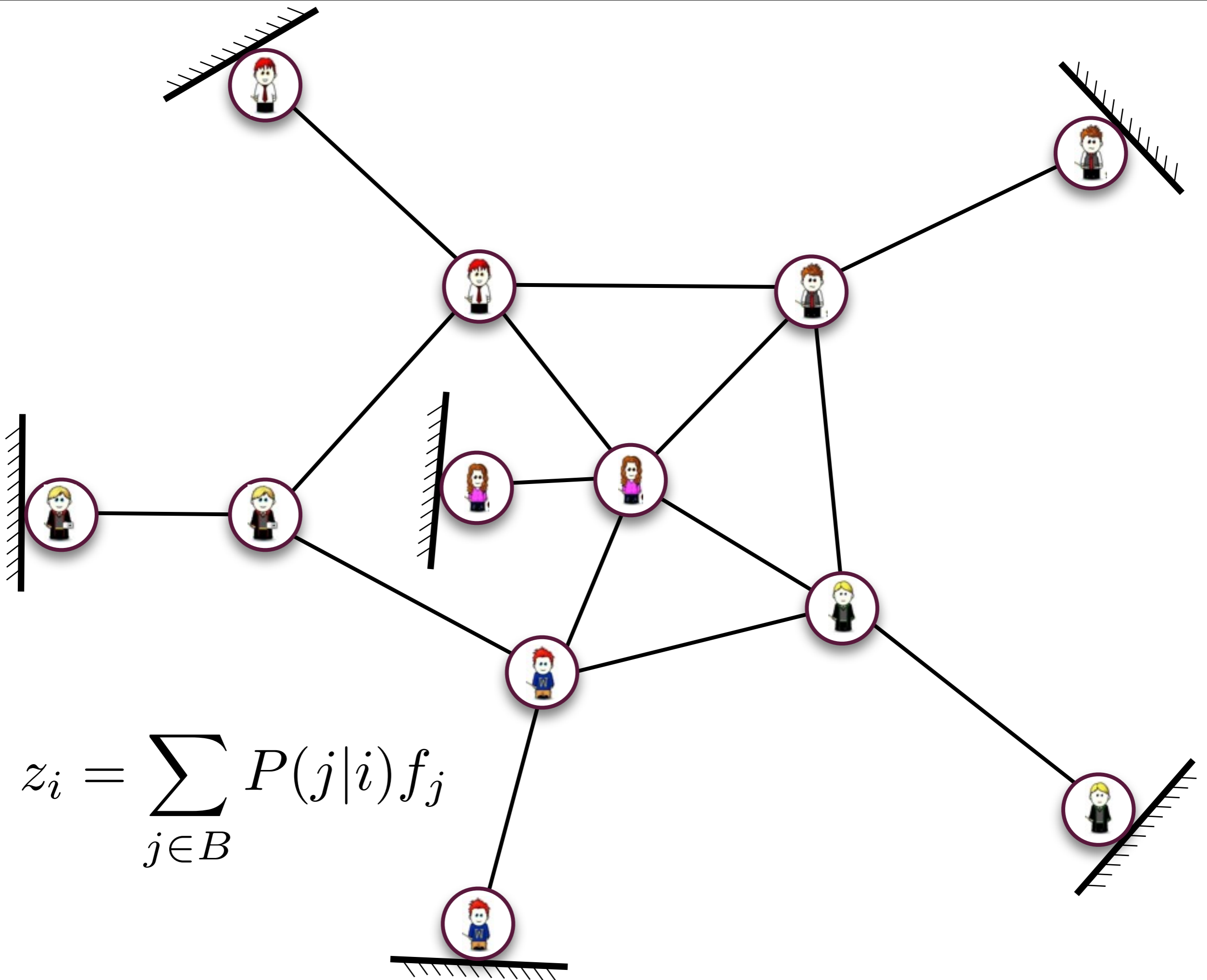






Interpretation of opinion Z_i

- value in the equilibrium state of the **spring model**
- value at absorption in an **absorbing random walk**



$$z_i = \sum_{j \in B} P(j|i) f_j$$

- find k users to set $z_i = 1$
- maximize the overall expressed opinion (or average opinion)

$$g(\mathbf{z}) = \sum_{i \in V} z_i$$

Characterization of the campaign problem

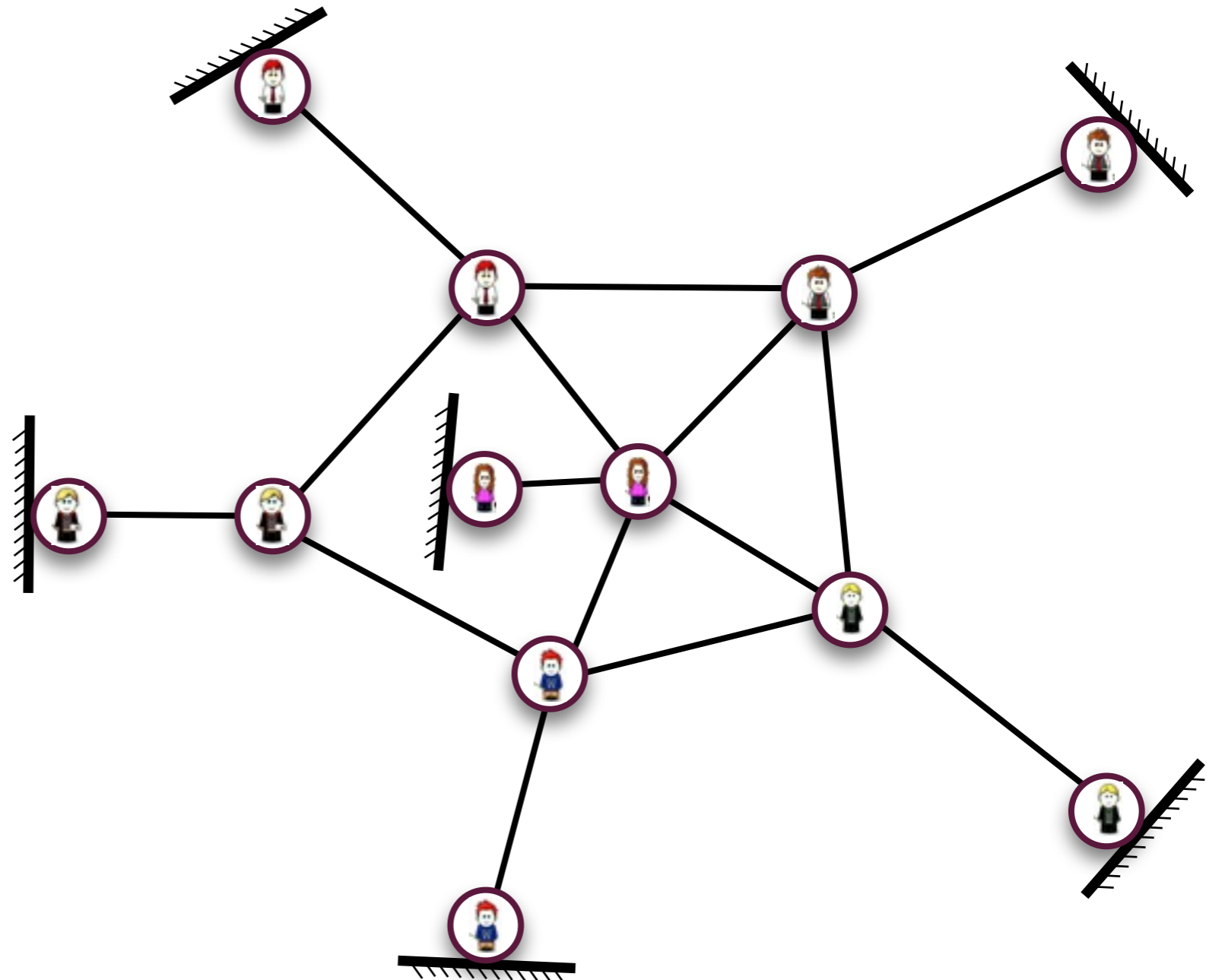
- NP-hard

- function $g(\mathbf{z}) = \sum_{i \in V} z_i$

is monotone and submodular

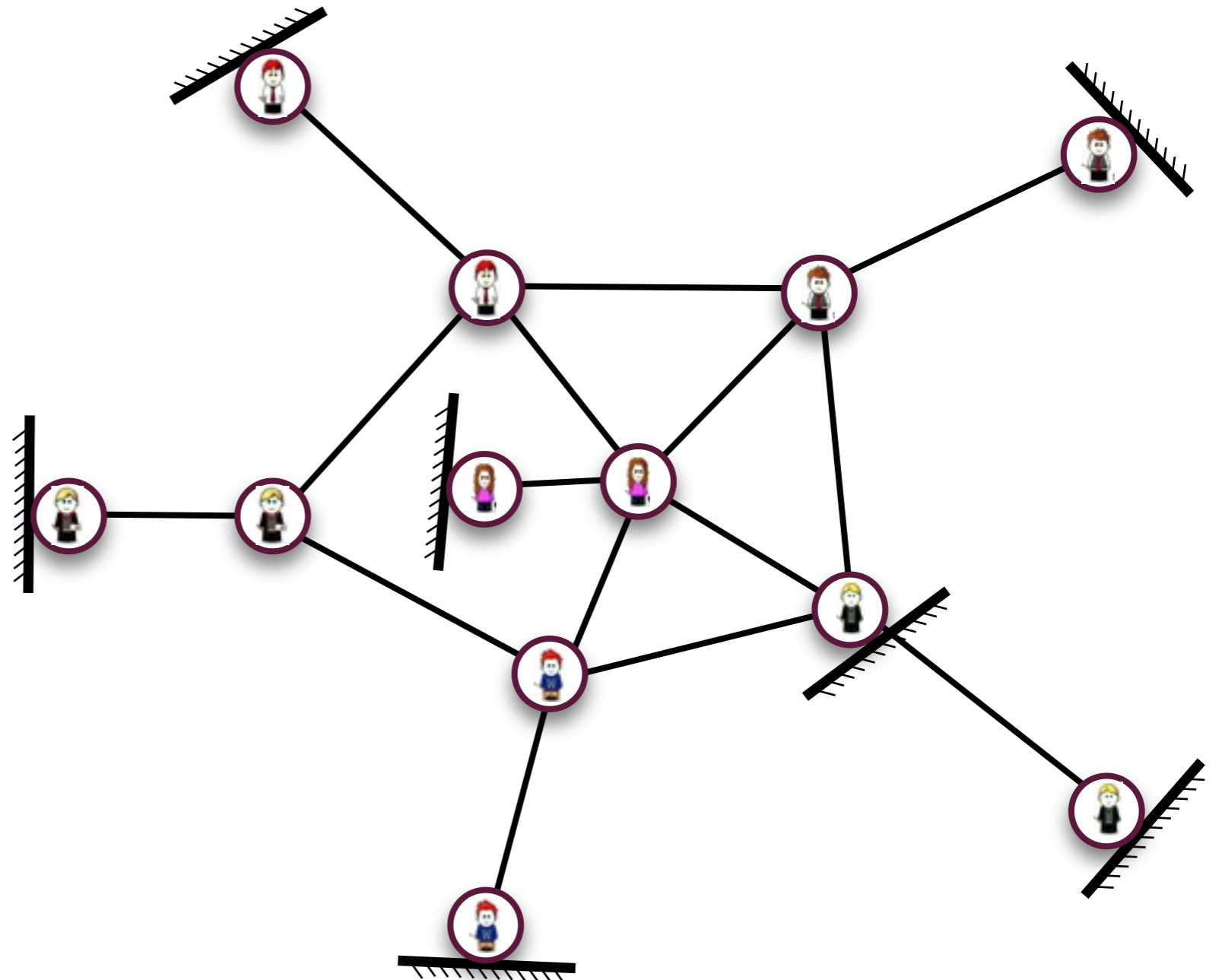
Example : monotonicity

- objective $g(\mathbf{z}) = \sum_{i \in V} z_i$
- where $z_i = \sum_{j \in B} P(j | i) f_j$



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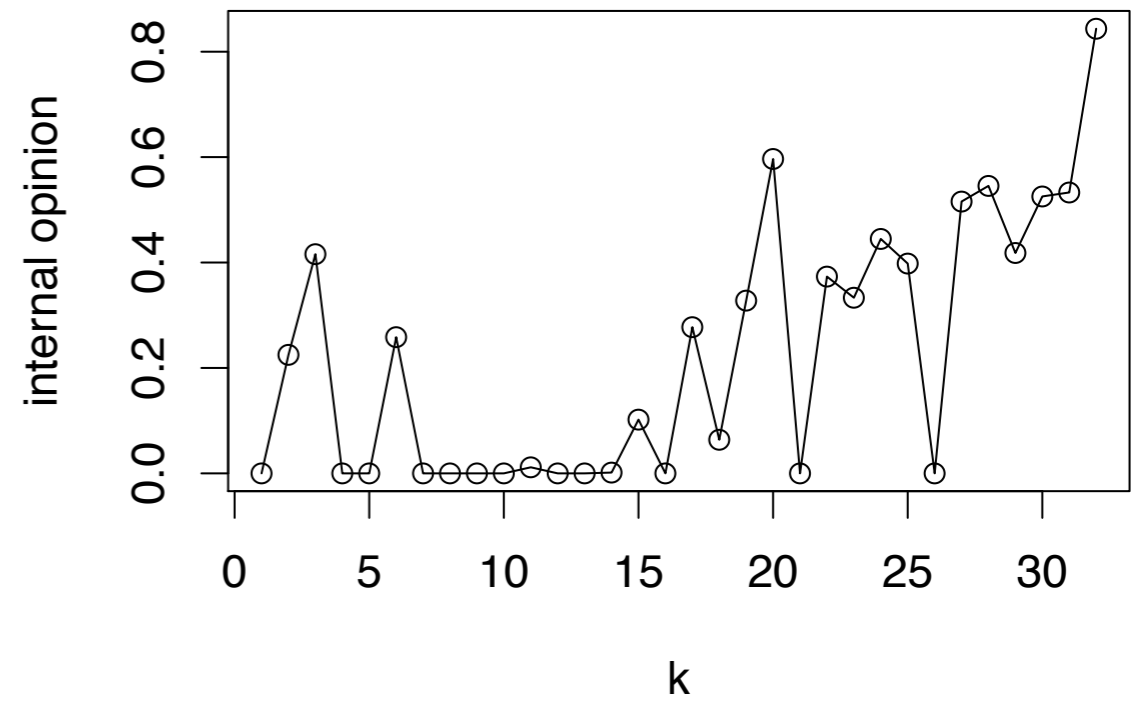
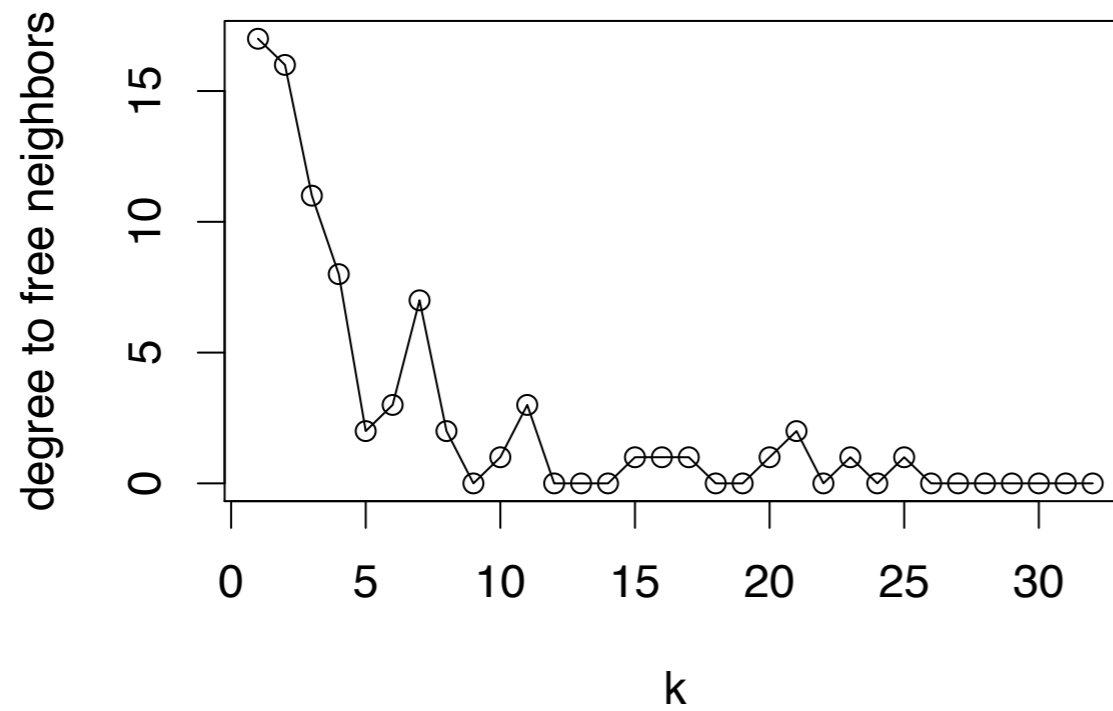
Algorithms

- GREEDY (matrix inversion vs power iteration)

Algorithms

- **GREEDY (matrix inversion vs power iteration)**

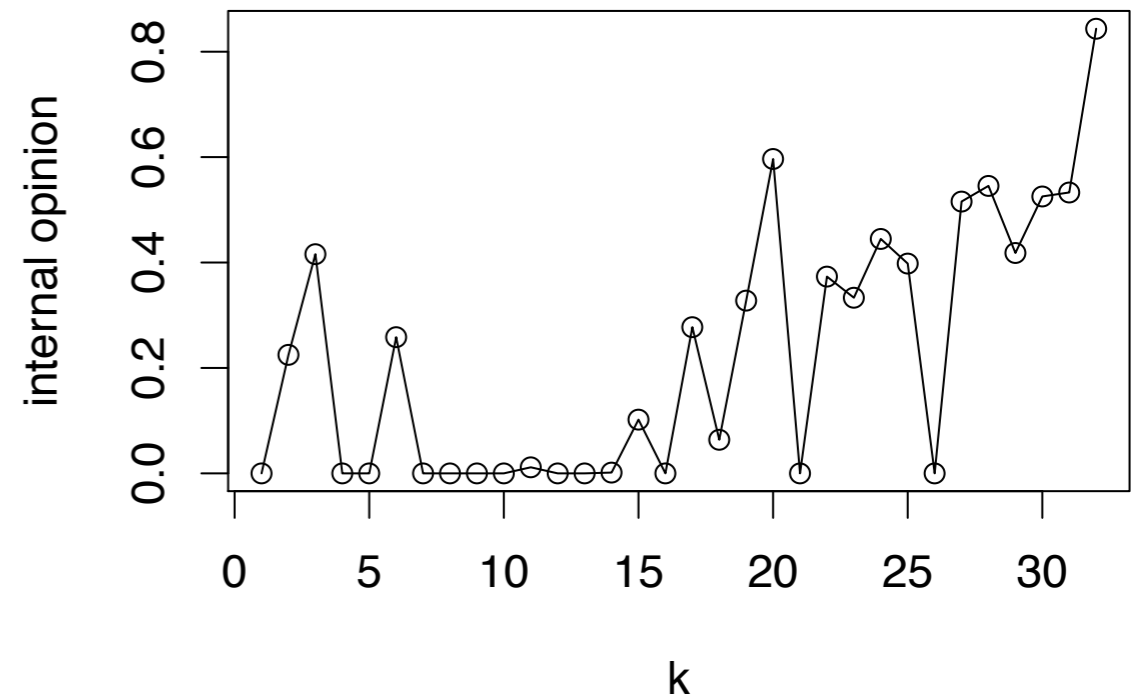
Karate club



Algorithms

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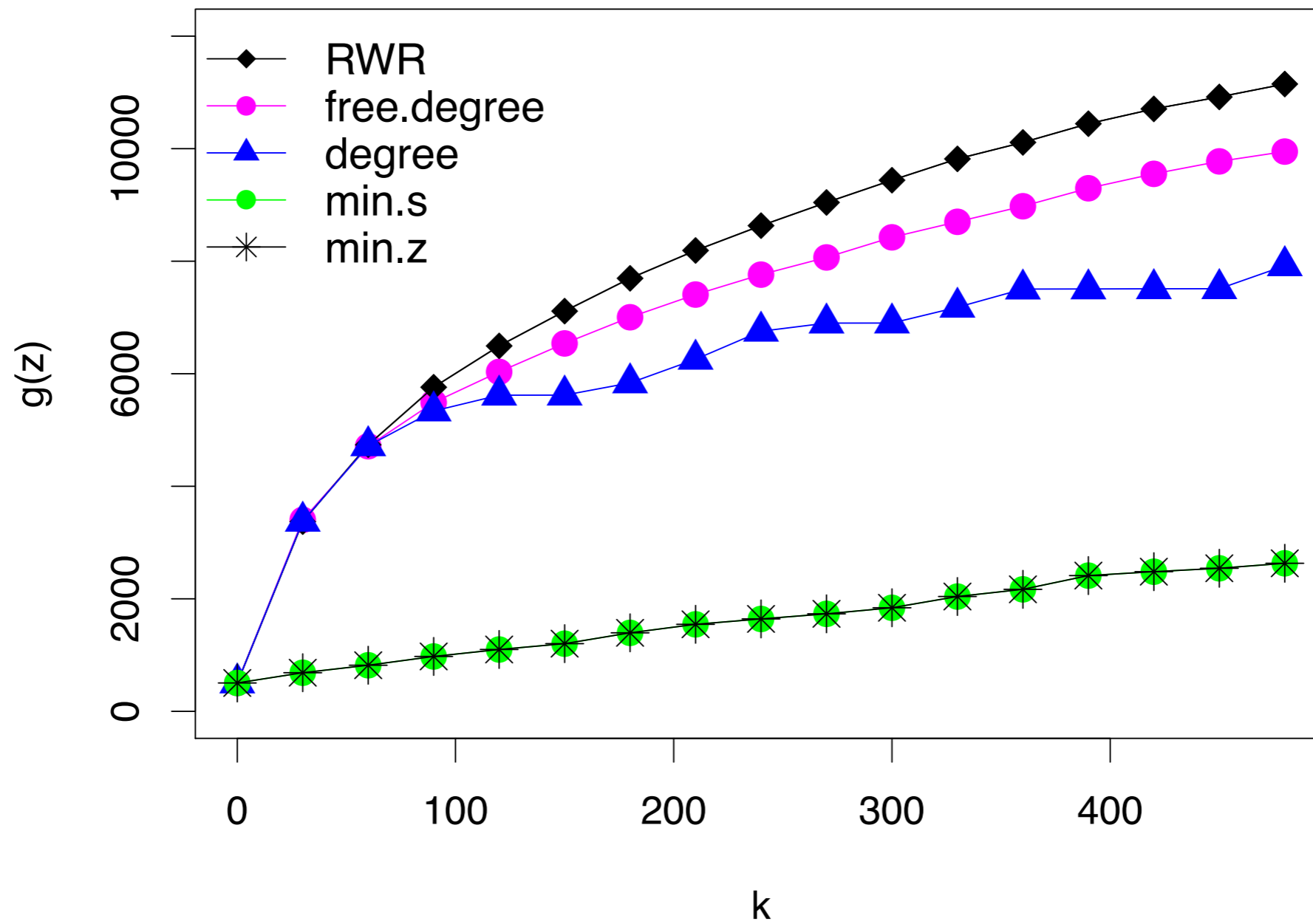
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- DEGREE
- MINS
- RWR

On a larger dataset

Bibsonomy -- data mining



Remarks

- **campaign** with setting $S_i = 1$ easy

Thank you!