Learning a Social Network by Influencing Opinions

Dmitry Chistikov, Luisa Estrada,
Mike Paterson and Paolo Turrini

INFLUENCING OPINION DYNAMICS

Suppose you are a campaigner who wants to promote a new ...

law product technology initiative

on a social network where each member has an initial opinion about it (◯,⬤)

- ✓ You can persuade some members to support your campaign.
- ✓ You know how "people talk" across the social network.

Want to target the members with the strongest influence.

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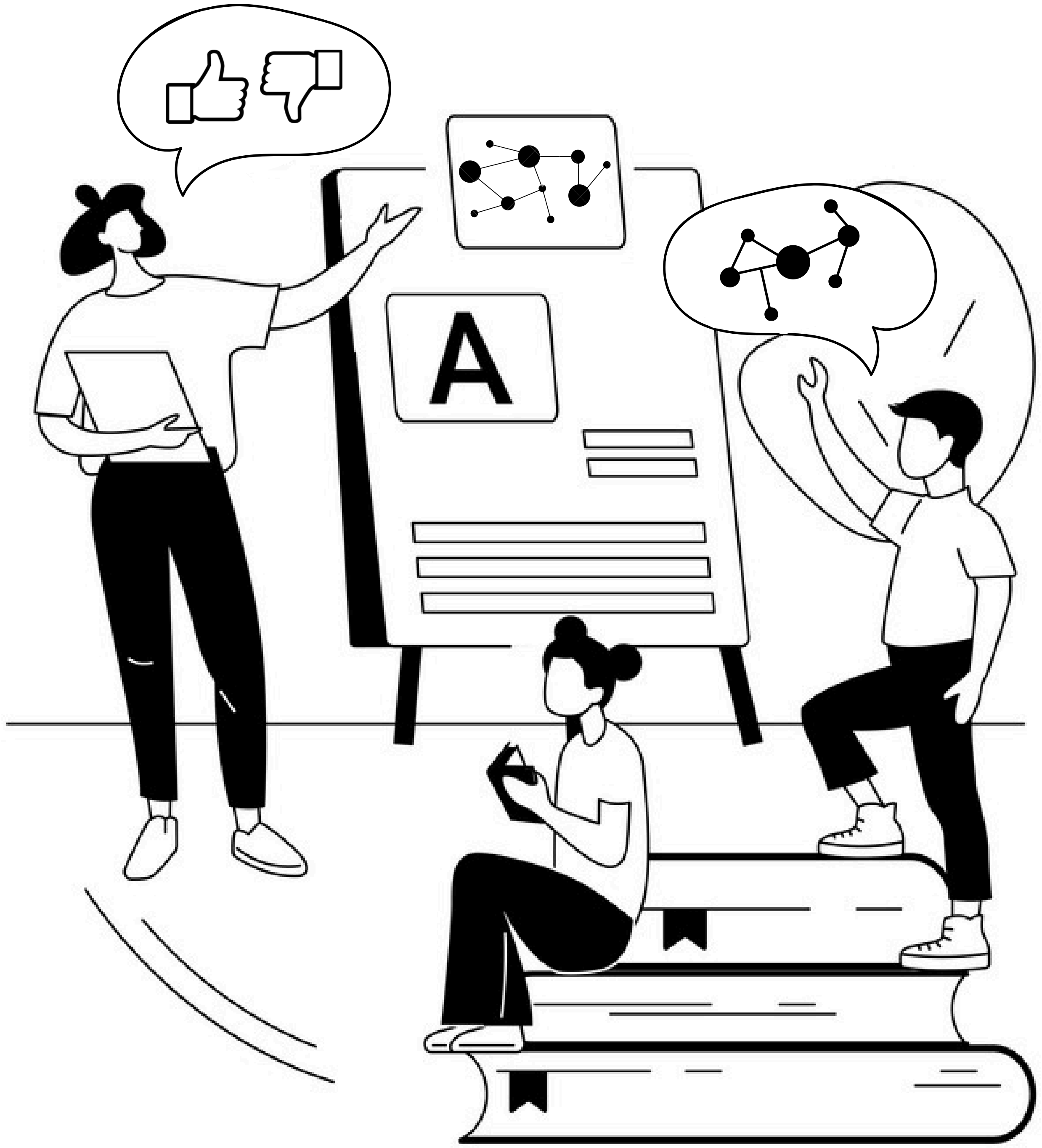
✓ You can persuade some members to support your campaign.

✓ You know **how** "people talk" across the social network.

≠ Knowing **who talks to whom.**

Want to target the members with the strongest influence.

PROBLEM SETUP



A social network.

Influence maximisation.

Opinion diffusion.

Opinion convergence.

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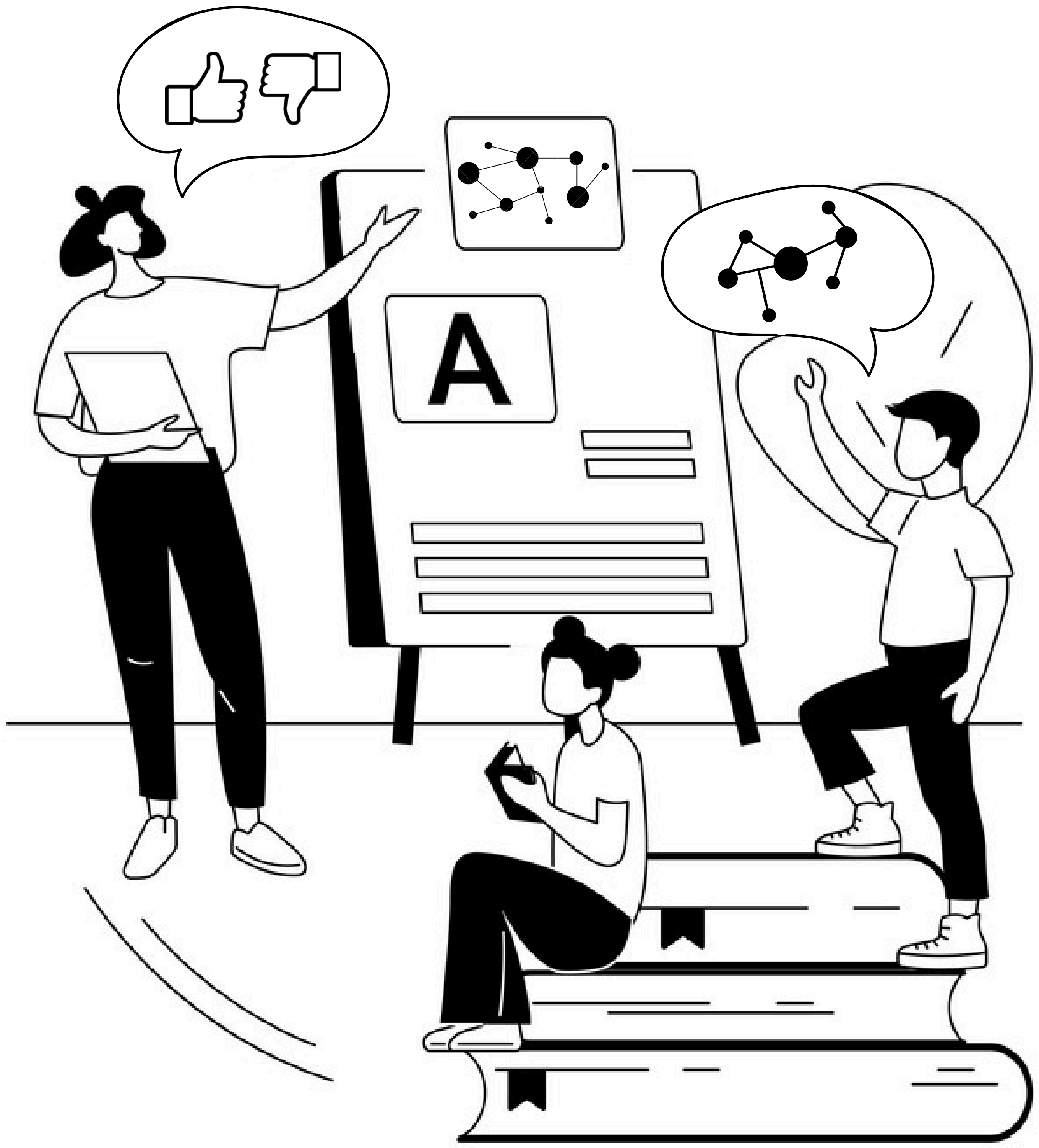

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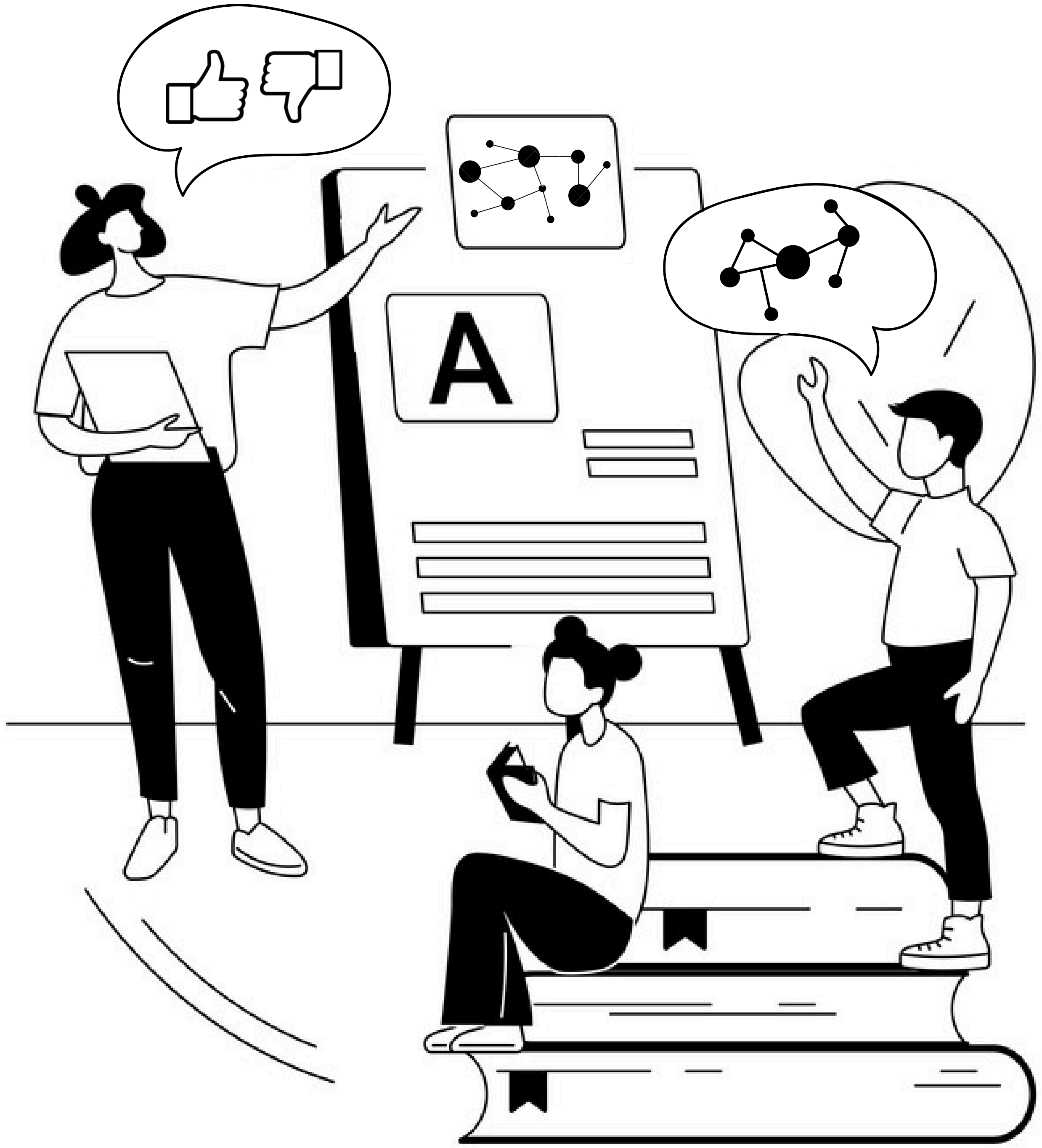


A social network. ≪ Influence maximisation. Opinion diffusion. Opinion convergence.

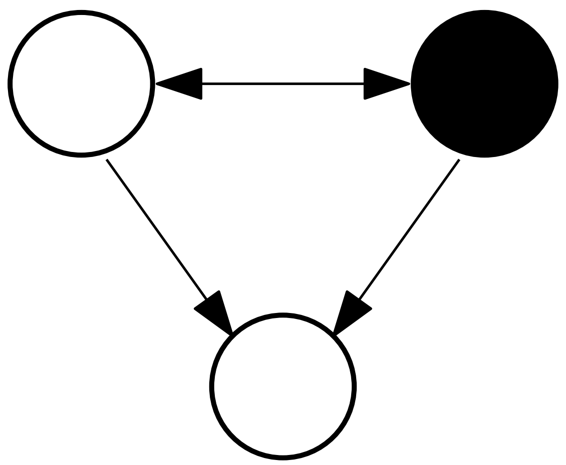
Game rules

- ✗ **Connections between agents are hidden.**
- ✓ Allow the campaigner to intervene on the agents' opinions and observe the result.
- ✓ Stop once there is only one feasible network.
- ✓ Opinions diffuse following majority dynamics.

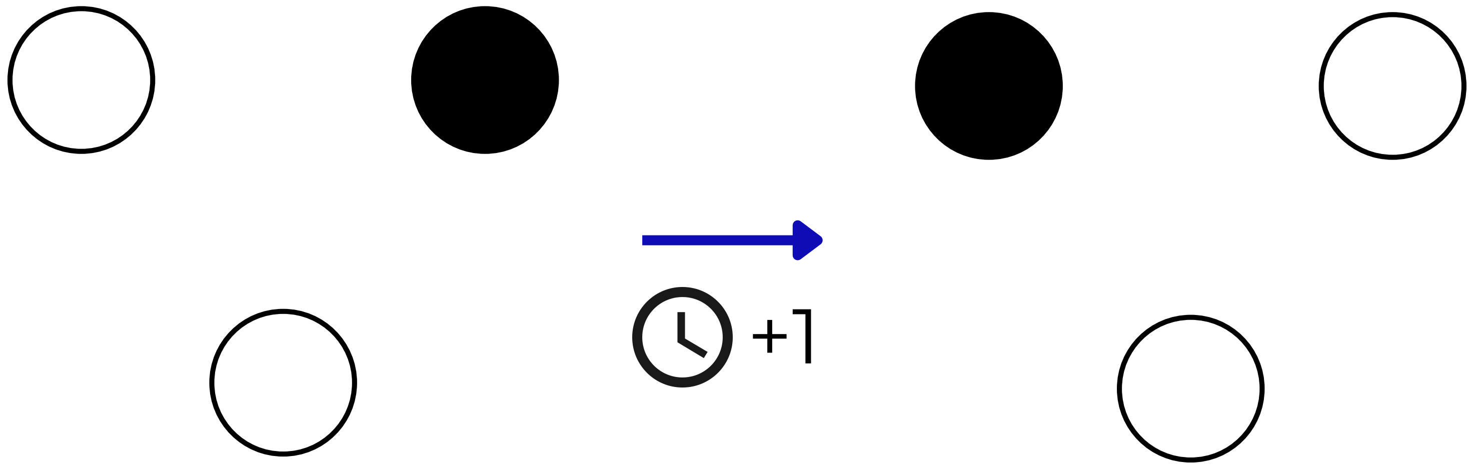
PROBLEM SETUP: AN EXAMPLE

Task: To learn the underlying network.

Budget: Observations and interventions



Underlying network



Campaigner's view

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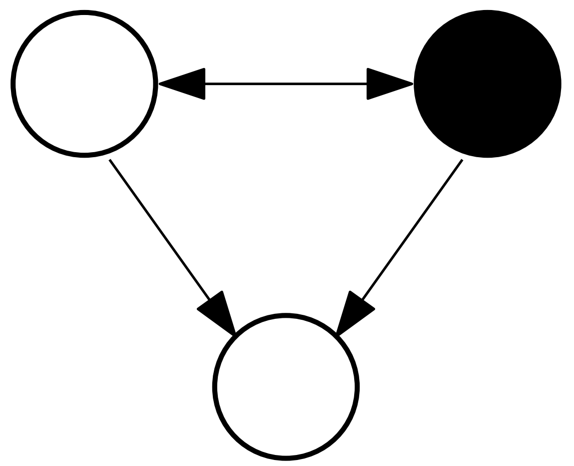

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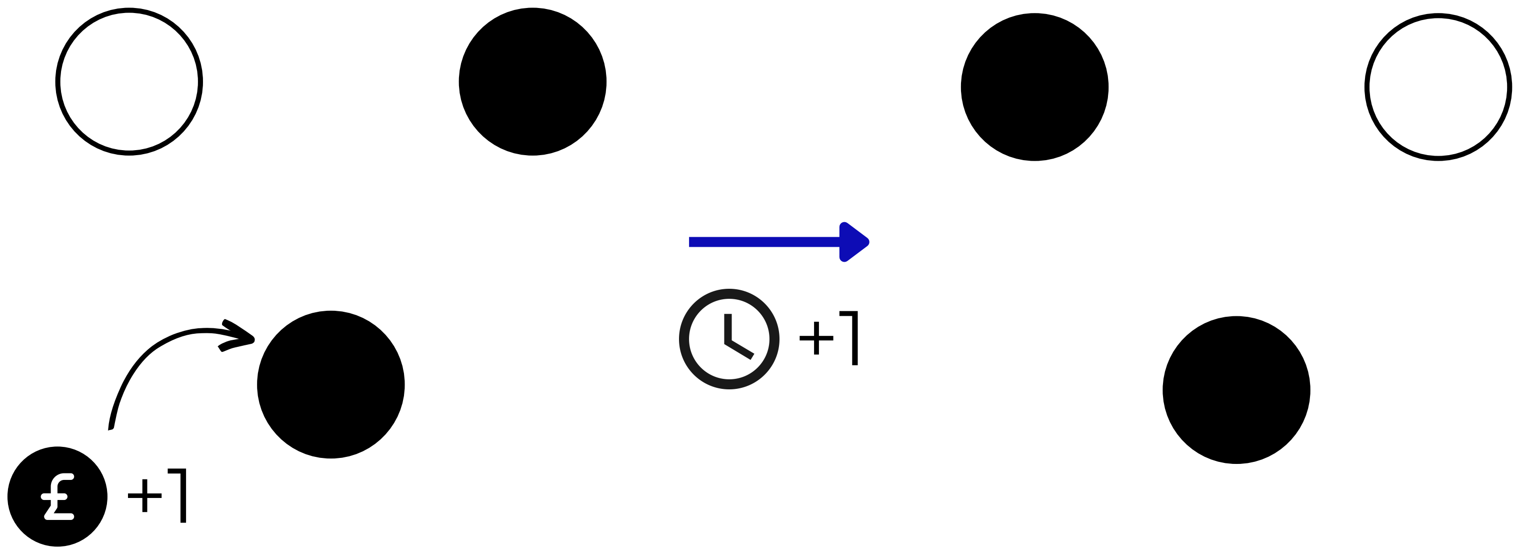

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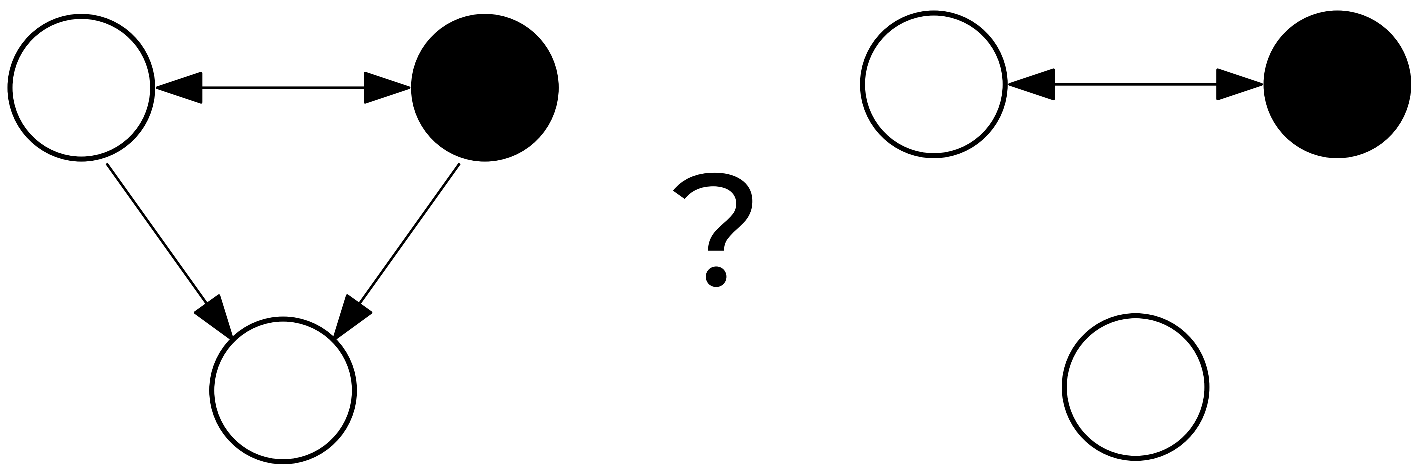
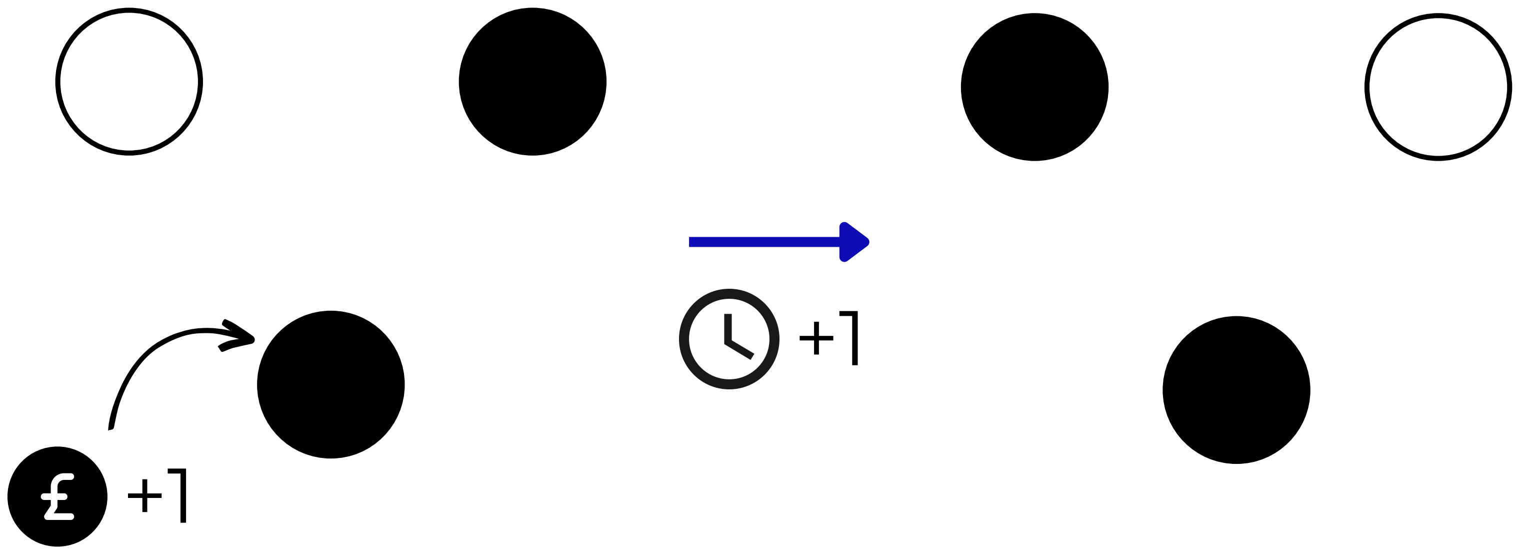


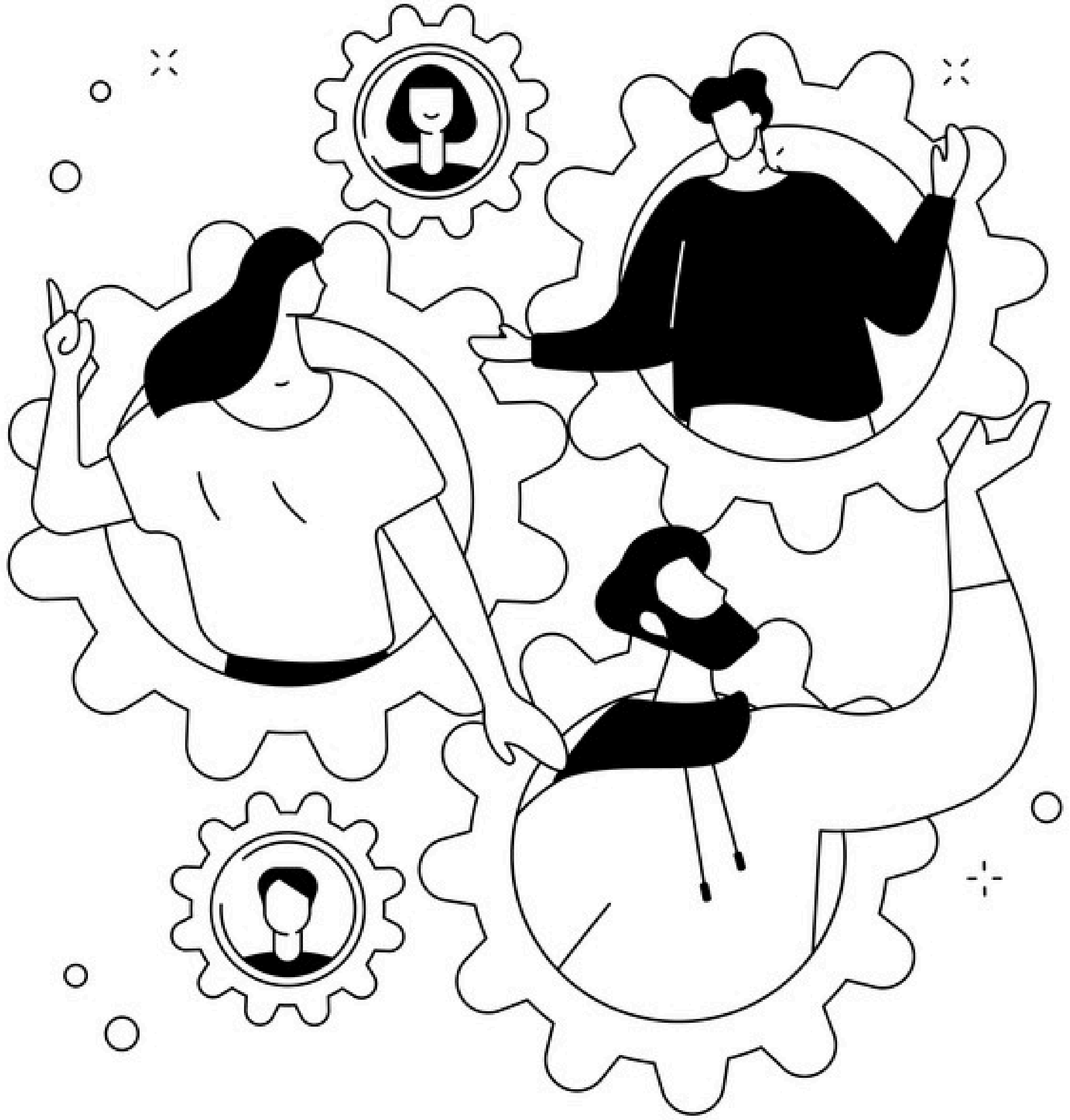
Hidden Underlying network



Campaigner's view

OUR MAIN RESULTS

Learning task	Observation budget	Intervention budget
Identify an even clique	$\mathcal{O}(n)$	$\mathcal{O}(n)$
Identify an odd clique	$\mathcal{O}(n)$	$\mathcal{O}(n^2)$
Learn any network $G \in \mathcal{H}$	$\mathcal{O}(n^2)$	$\mathcal{O}(n^3)$



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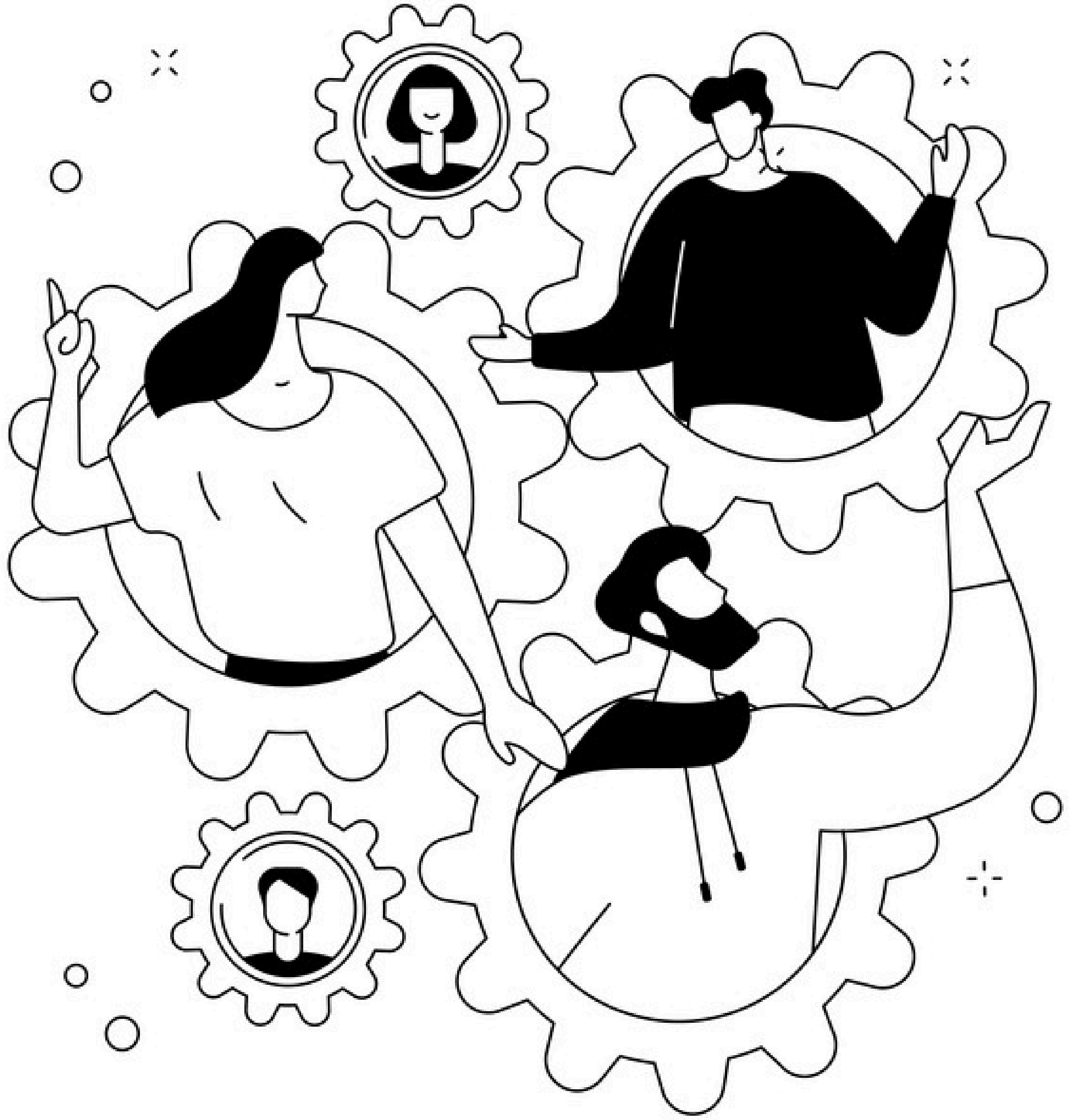

GENERAL CASE

How can we identify **any** network?

Theorem:

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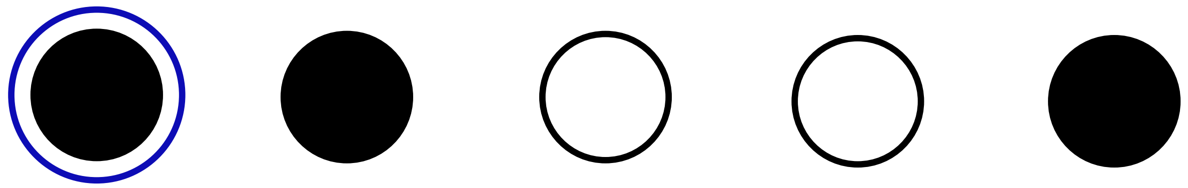
Proof (sketch)

Stage 1: Find the pivot



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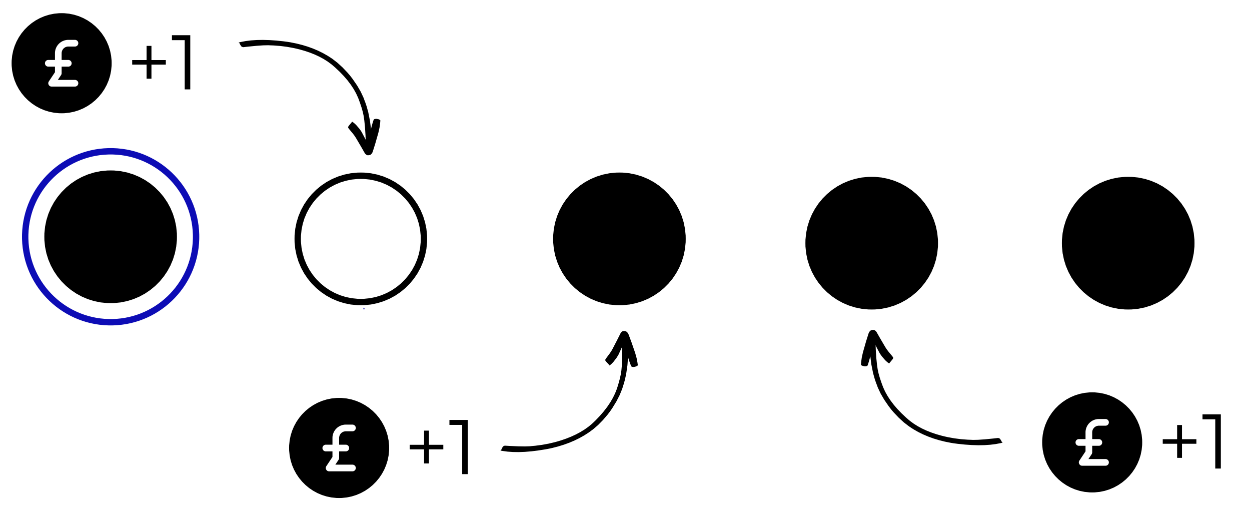

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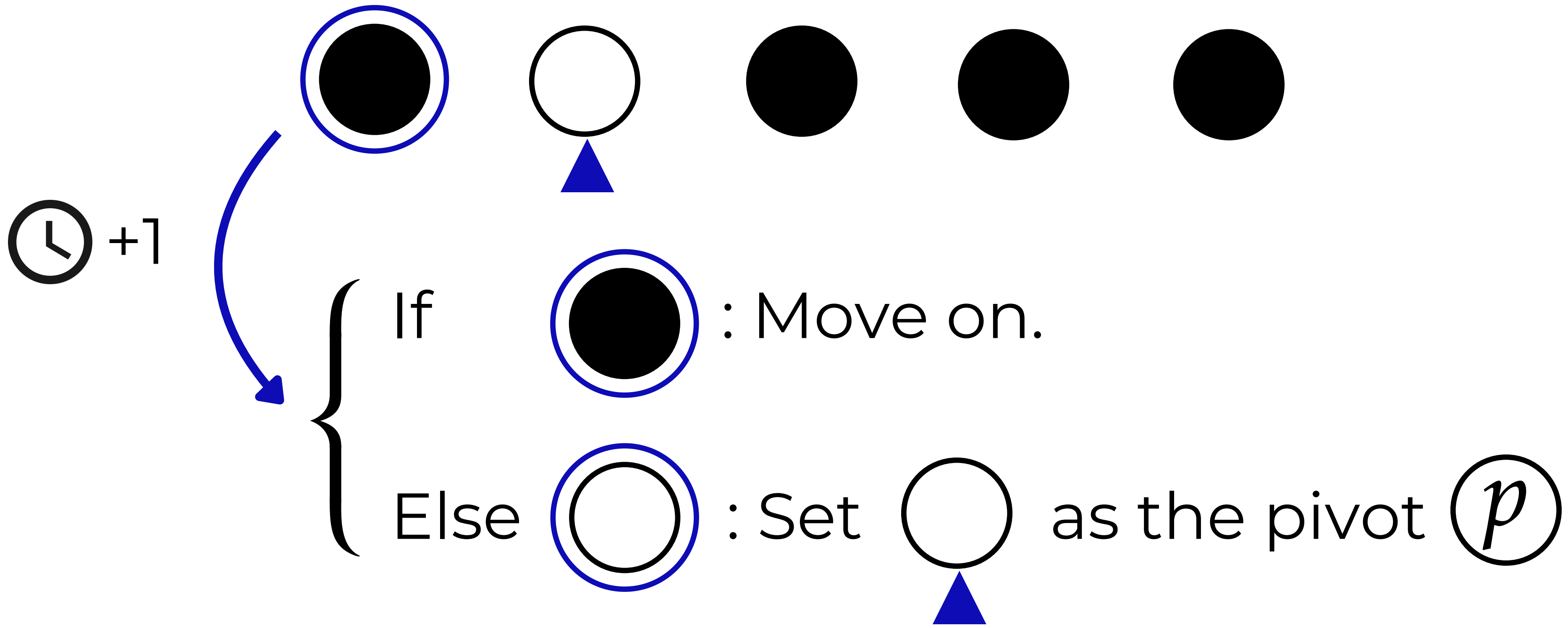

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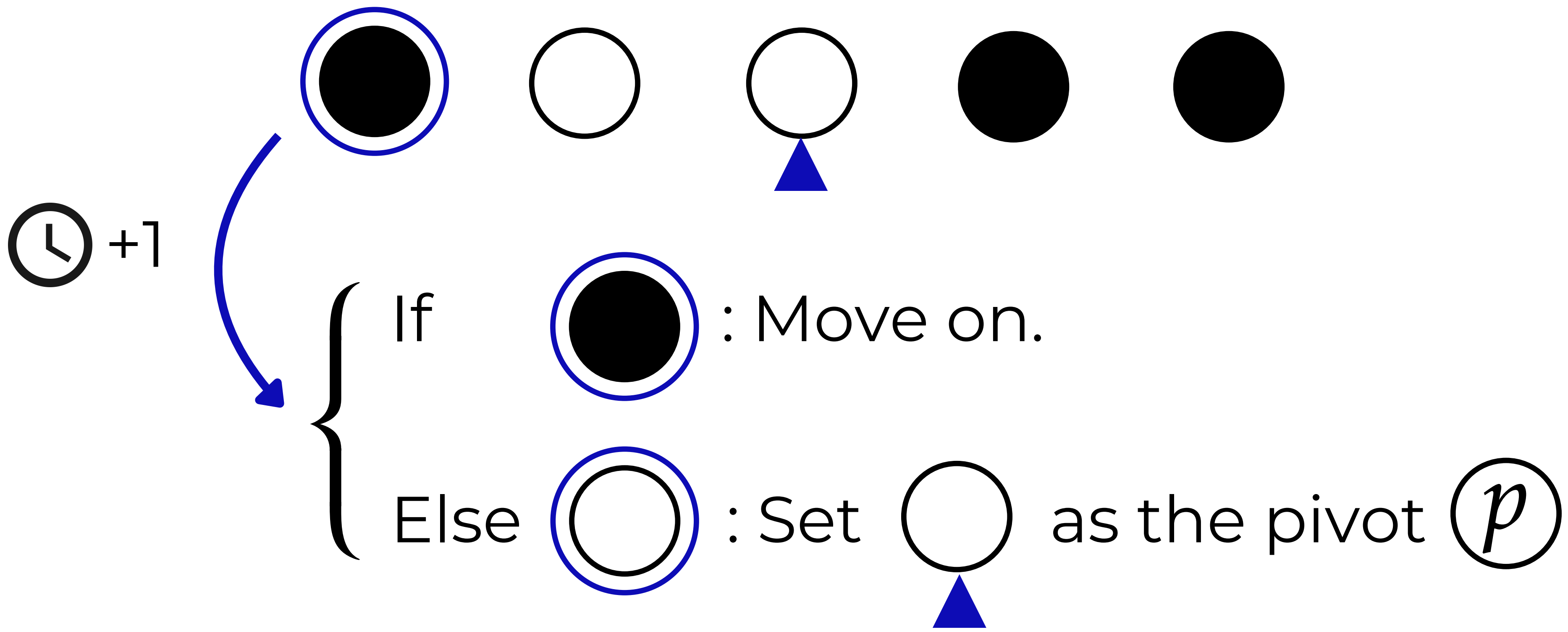

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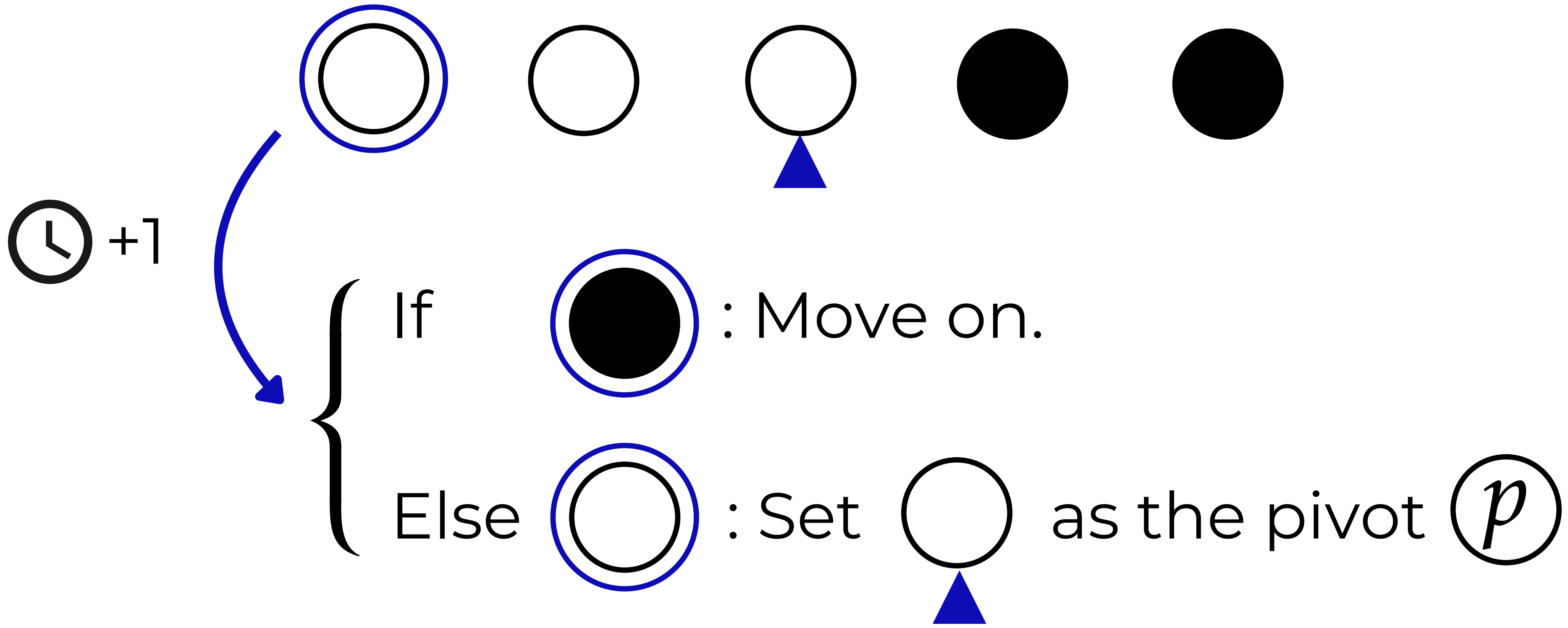

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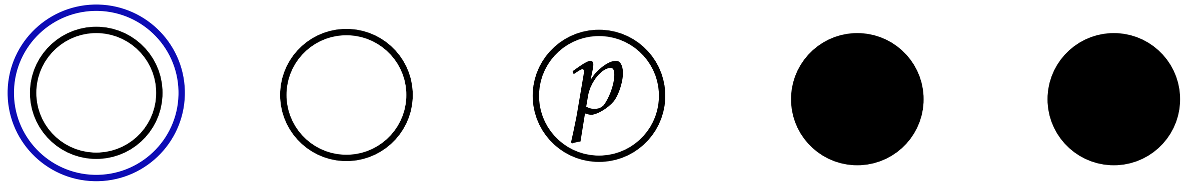

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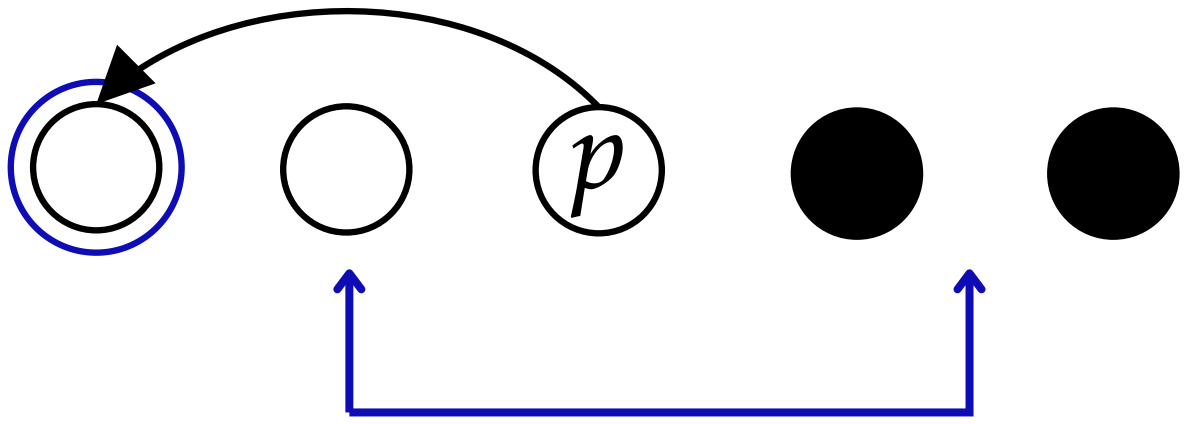

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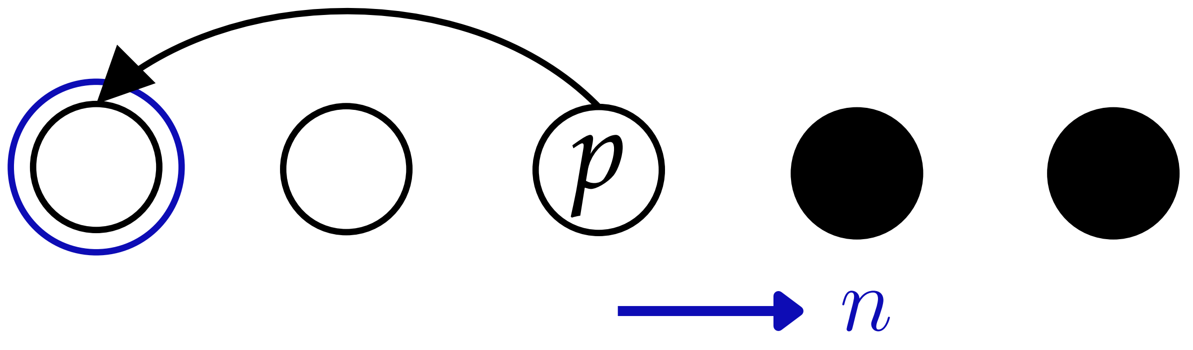

Budget:

$\leq n$

$\leq n^2$

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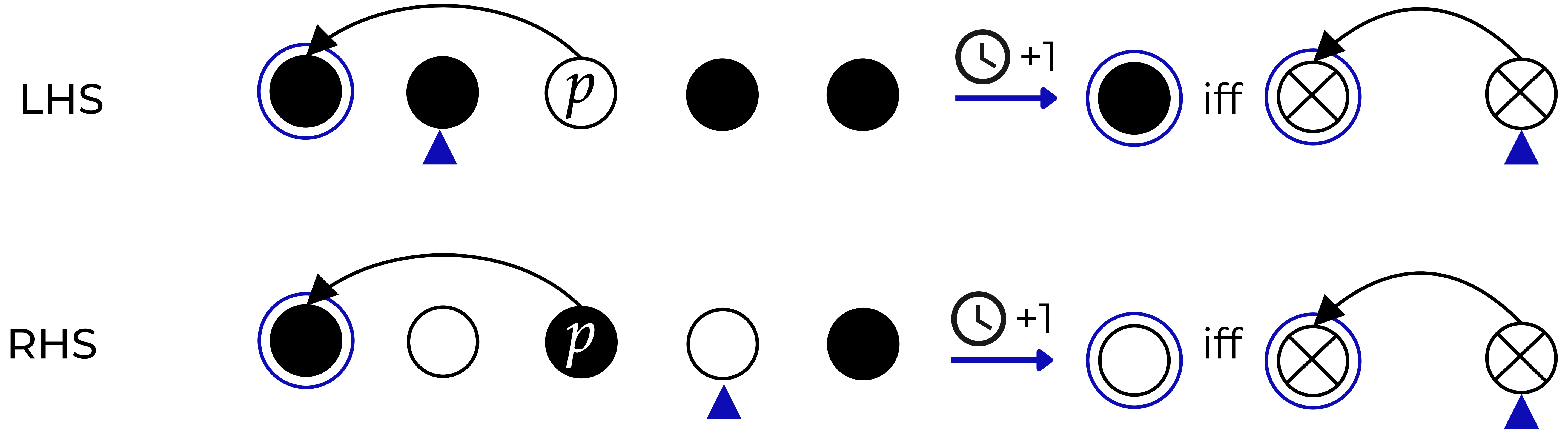
Stage 2: Find all other influencers

Budget:

🕒 $\leq n$

£ $\leq n^2$



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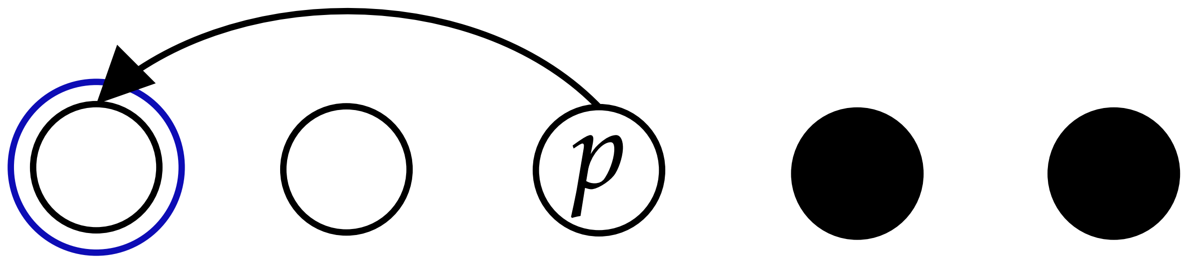

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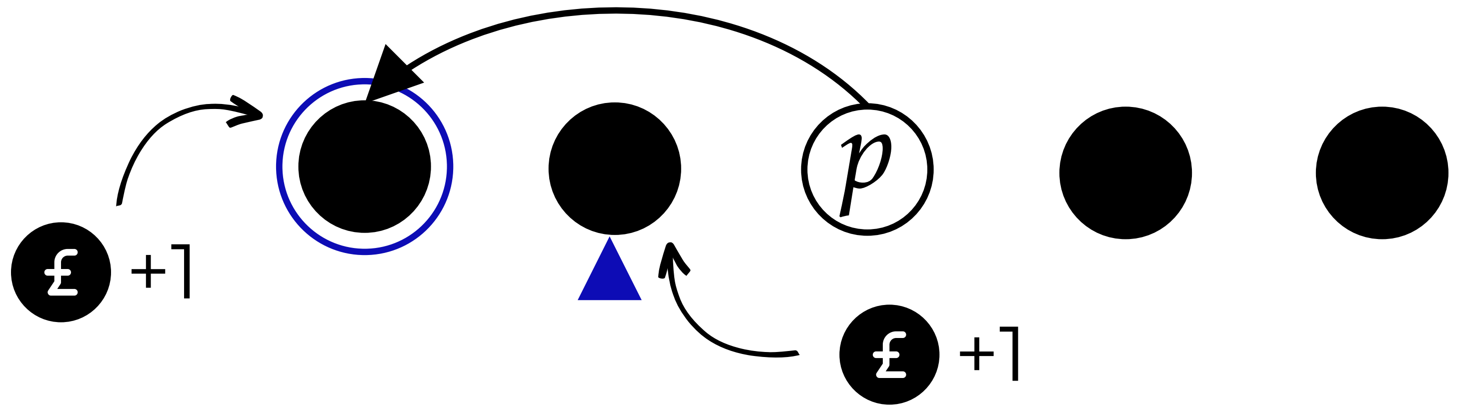
Budget:

$\leq n$

£ $\leq n^2 + n$



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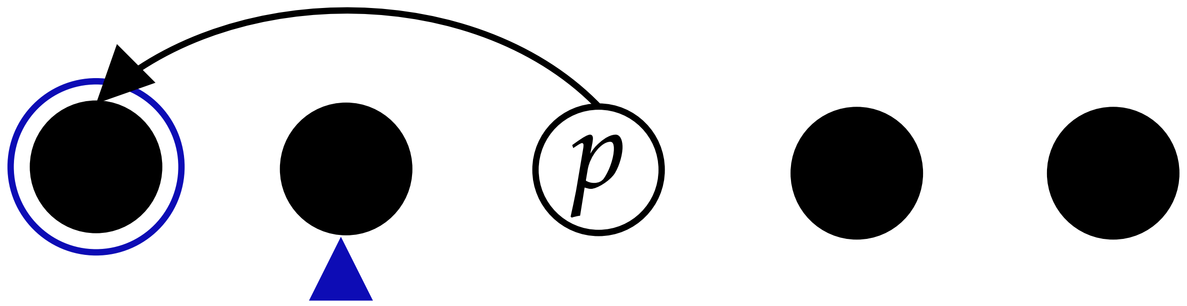

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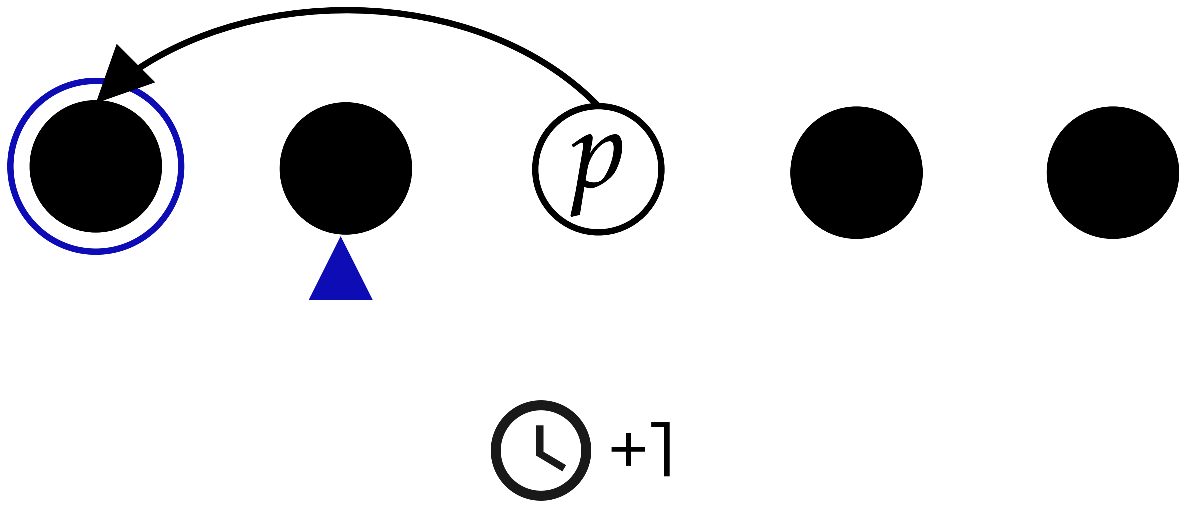

Budget:

$\leq n + 1$

$\leq n^2 + n$

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Budget:

 $\leq n + 1$

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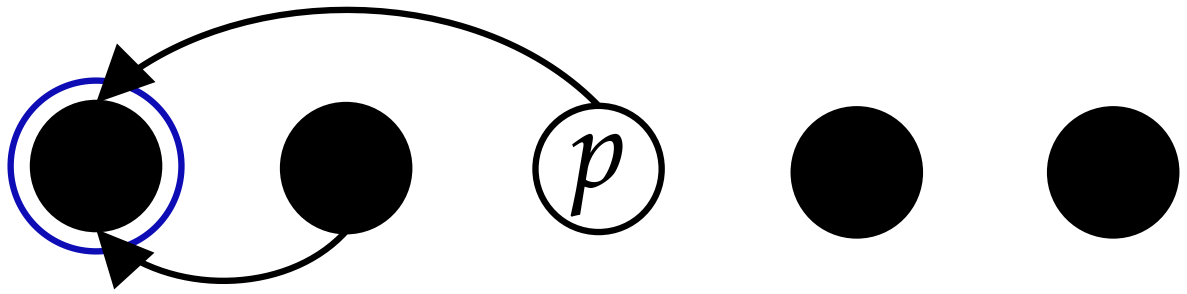

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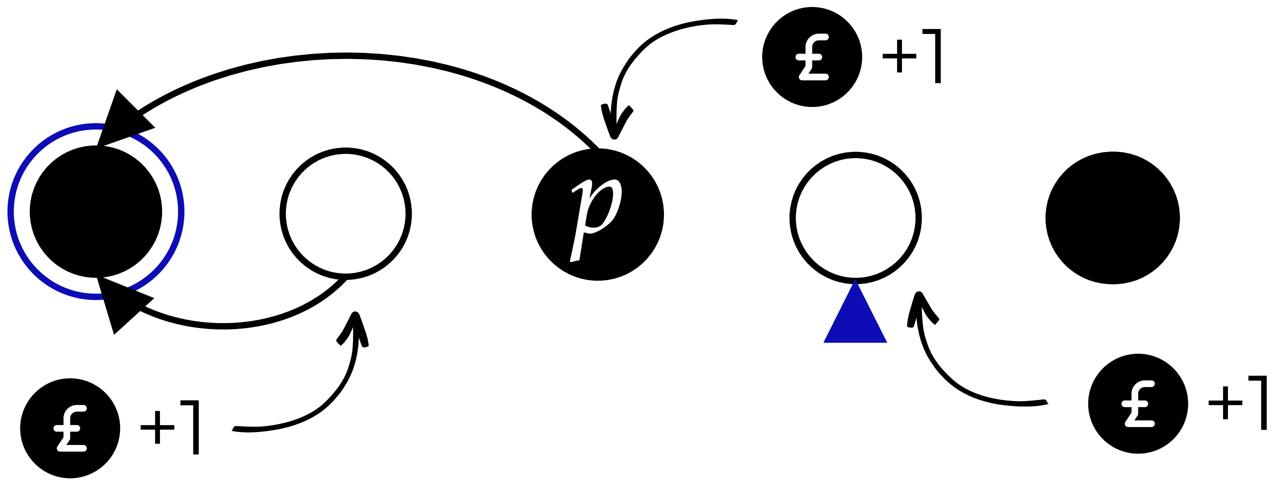

Budget:

(clock) $\leq n + 1$

(£) $\leq n^2 + 2n$

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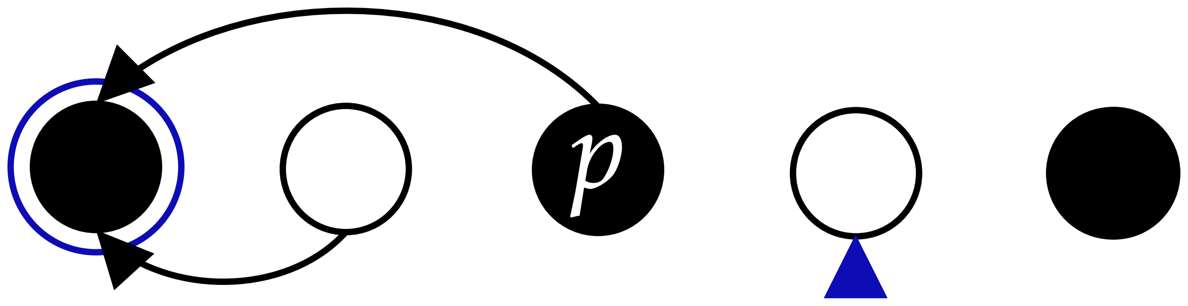

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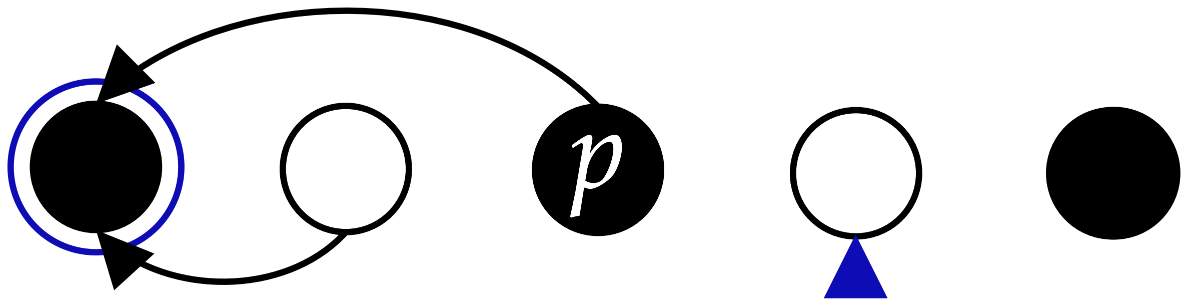

+1

Budget:

$\leq n + 2$

$\leq n^2 + 2n$

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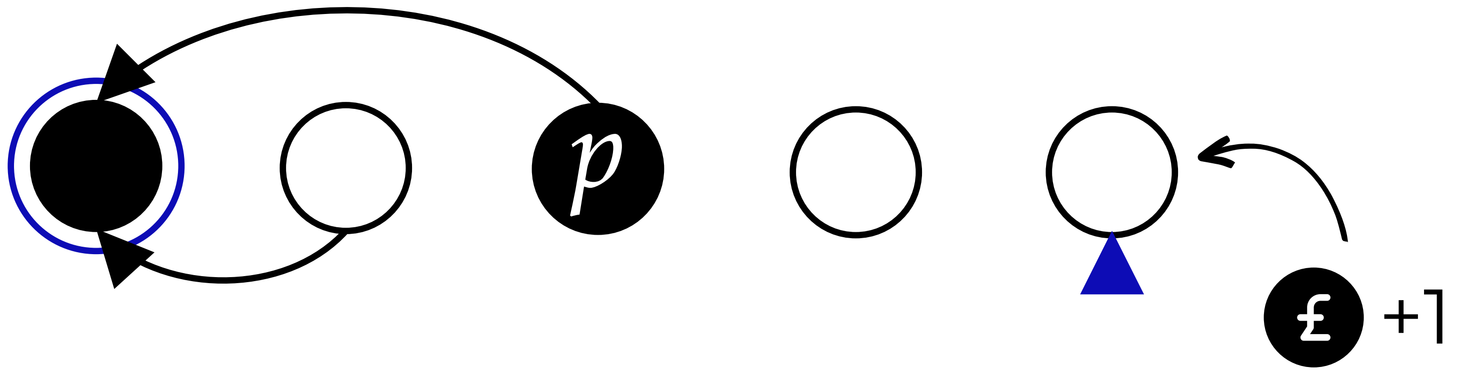
Budget:

🕓 $\leq n + 2$

£ $\leq n^2 + 3n$



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Proof (sketch)

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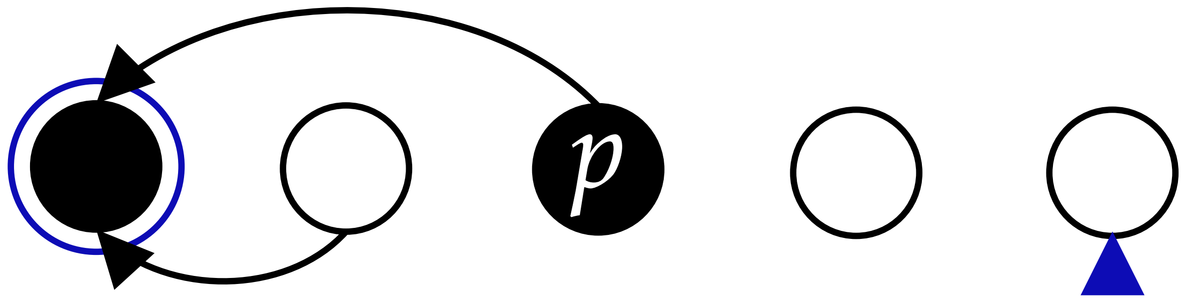
Budget:

🕓 $\leq n + 2$

£ $\leq n^2 + 3n$



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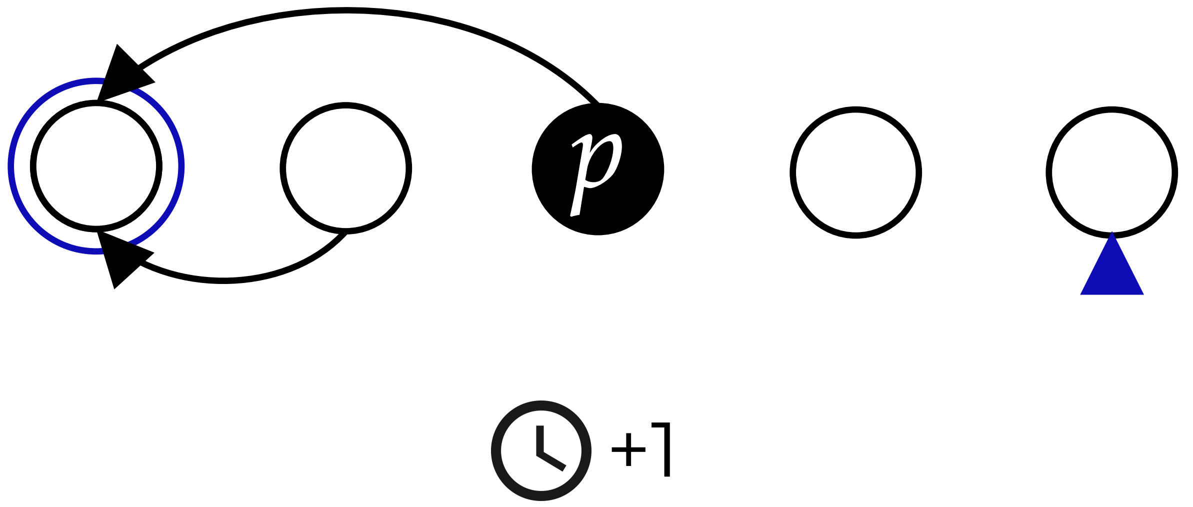
Proof (sketch)

Budget:

$\leq n + 3$

$\leq n^2 + 3n$

Stage 2: Find all other influencers



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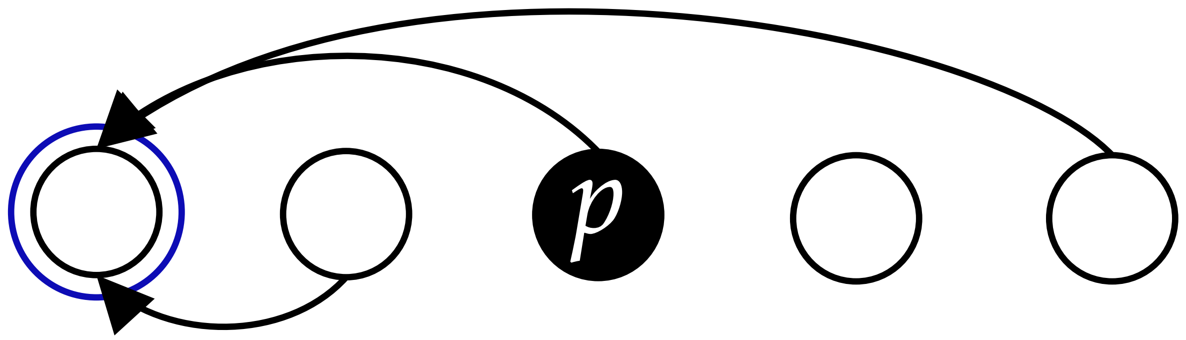

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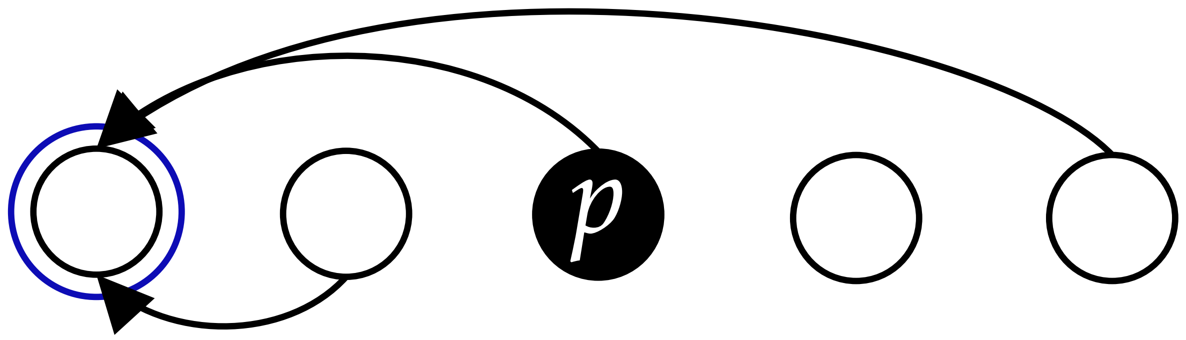
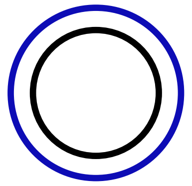


Budget:

🕓 $\leq n + (n-2)$

£ $\leq n^2 + (n-2)n$

Only consistent influencers for 

SOME FOOD FOR THOUGHT

- What would happen if we had a threshold other than the majority?
- Can we efficiently learn the correct network probably approximately (PAC)?
- What would happen if we add dynamic rules to our network?
  (eg. partner selection, rich get richer, ...)
- How can we scale our approach so it can handle inputs from real-world data?