Guaranteed Trade-Offs in Dynamic Information Flow Tracking Games

M. Weininger[1], K. Grover[1], S. Misra[2], J. Křetínský[1]

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ConVeY Retreat 2021

Outline

Motivating Example

Advanced Persistent Threats: An example

- In 2013, attack on Target Corporation's network.

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APTs: Gain illegitimate access to a system and remain there for a long time.

What can be done?

- Try to stop them from entering in the system.

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- Try to stop them from entering in the system.
- Can we do something more?
- Add another layer of security to find the attacker if it's already in the system.

Problem formulation

Dynamic Information Flow Tracking

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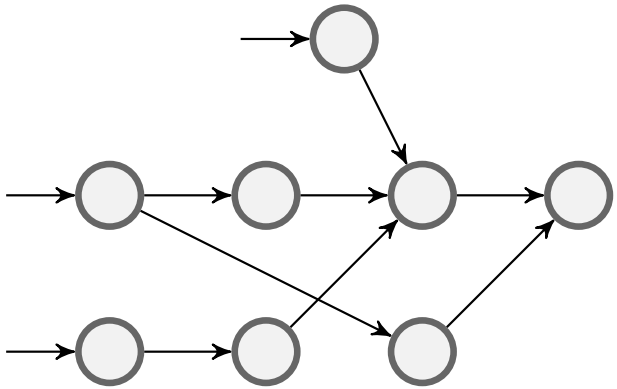

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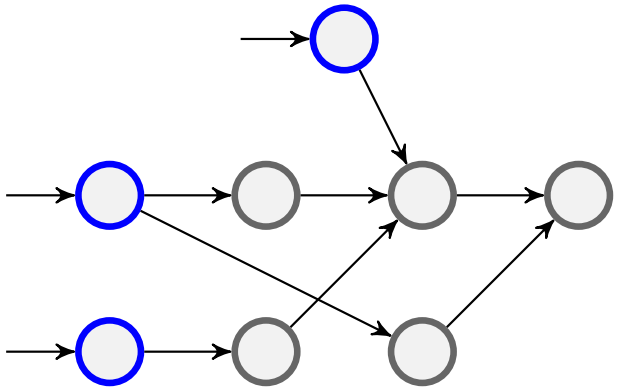

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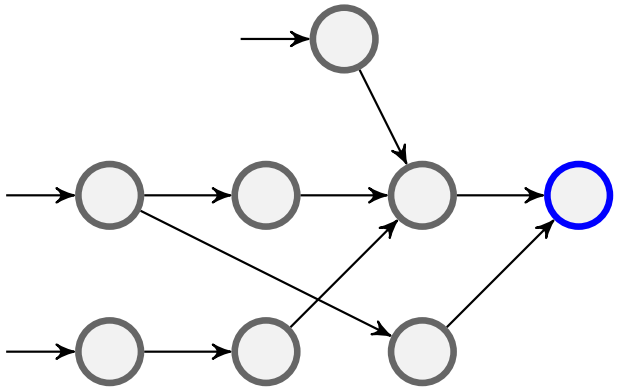
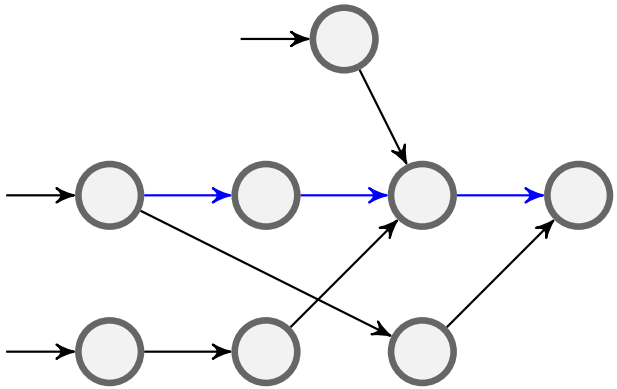


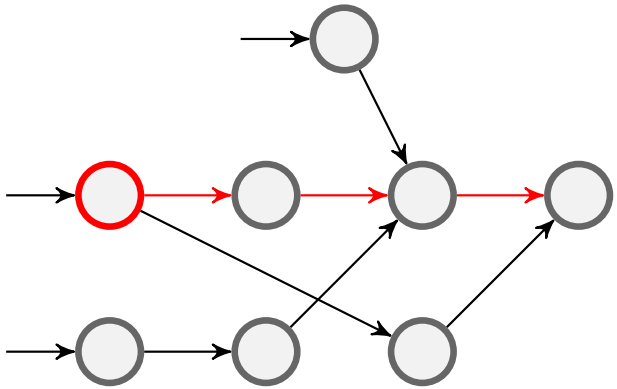
Dynamic Information Flow Tracking

- Try to find information flows which are APTs.



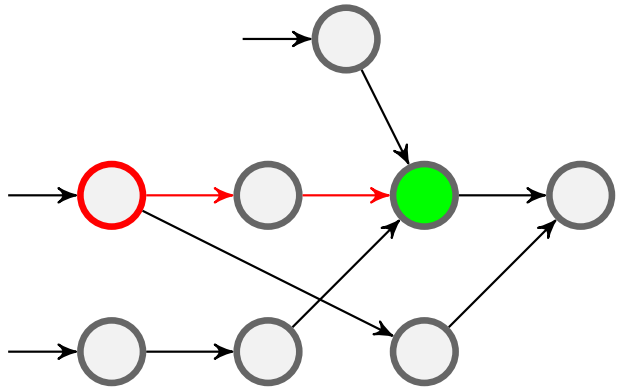
Dynamic Information Flow Tracking

- It operates by tagging "suspicious" data i/o channels.



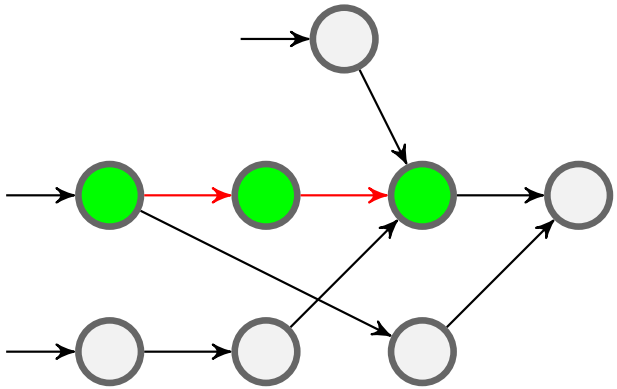
Dynamic Information Flow Tracking

- Perform security analysis on a node (a stochastic process).



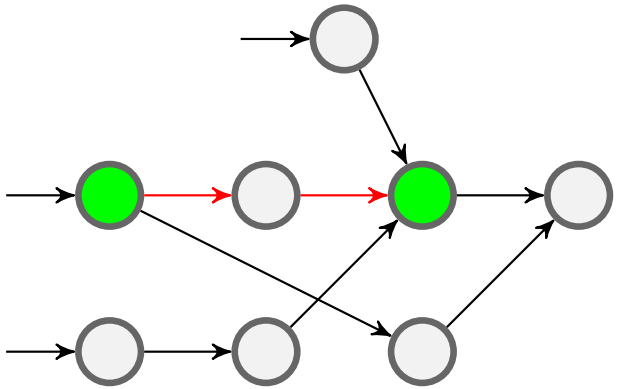
Dynamic Information Flow Tracking

- Tracking and analyzing information flow induces a memory and performance **cost** on the system.



Dynamic Information Flow Tracking

- It is critical to optimally select where to perform the security analysis.



APT vs DIFT: A game

Model the interaction as a stochastic game on the information flow graph. [1]

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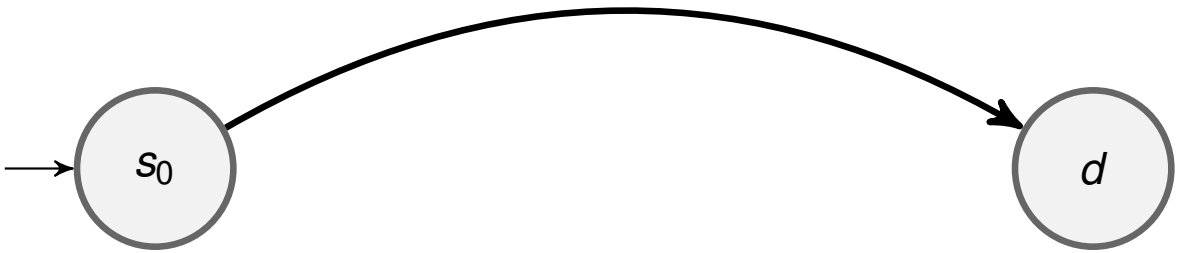

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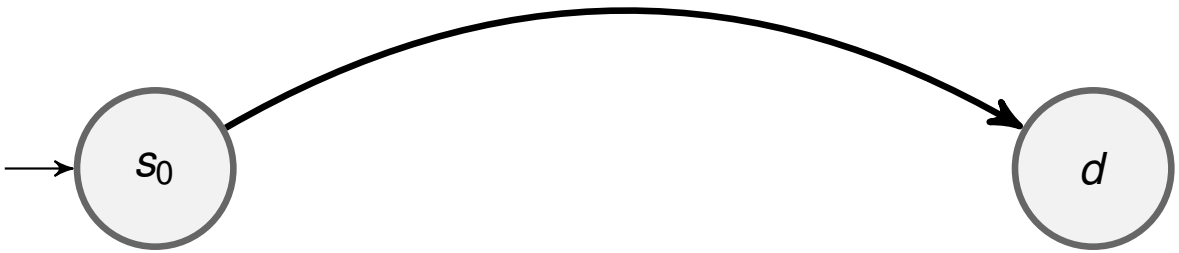

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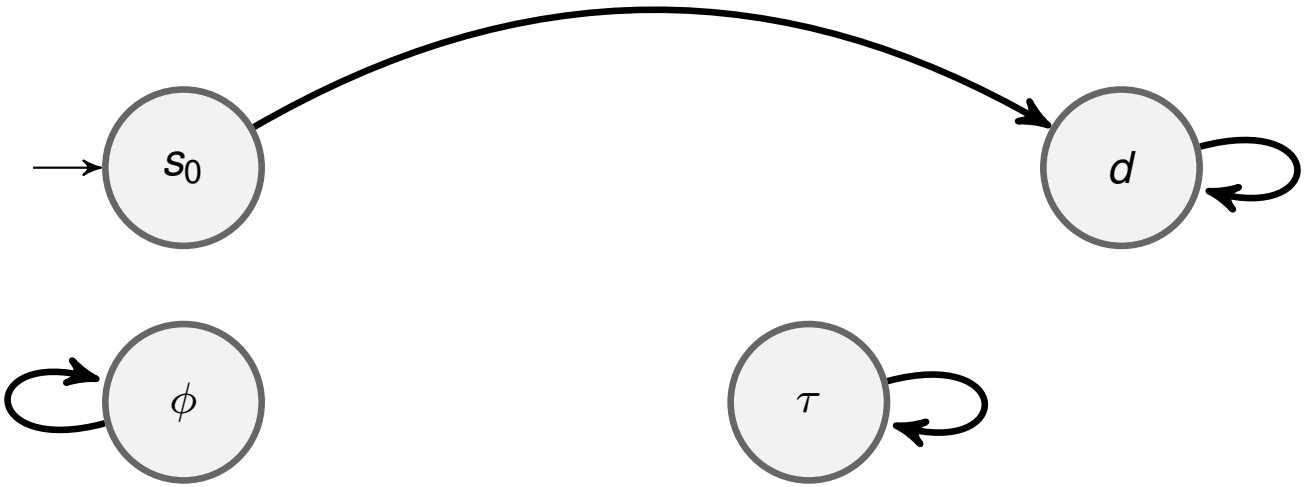

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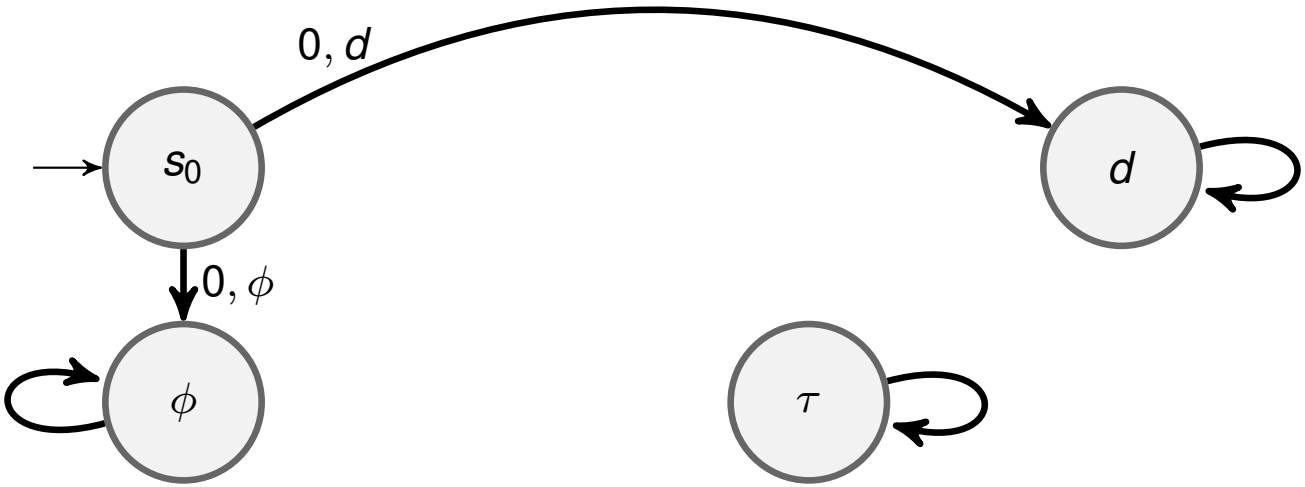

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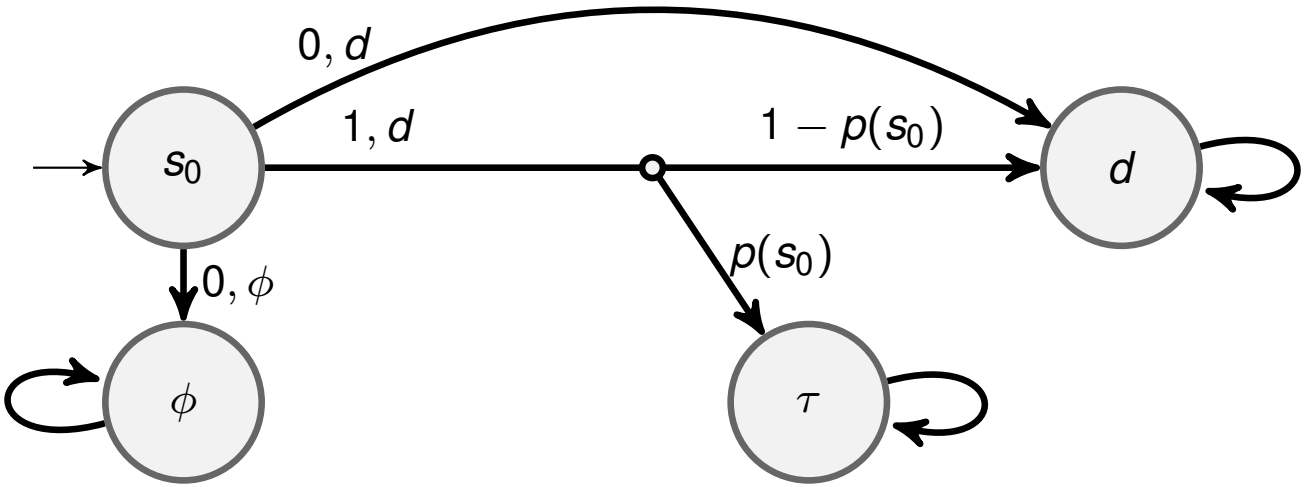

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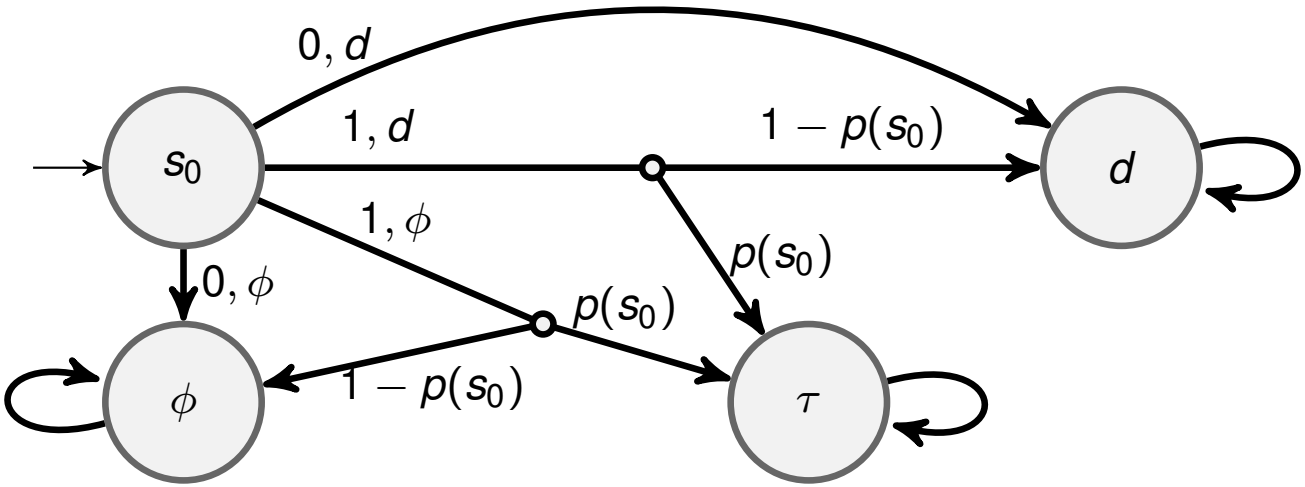

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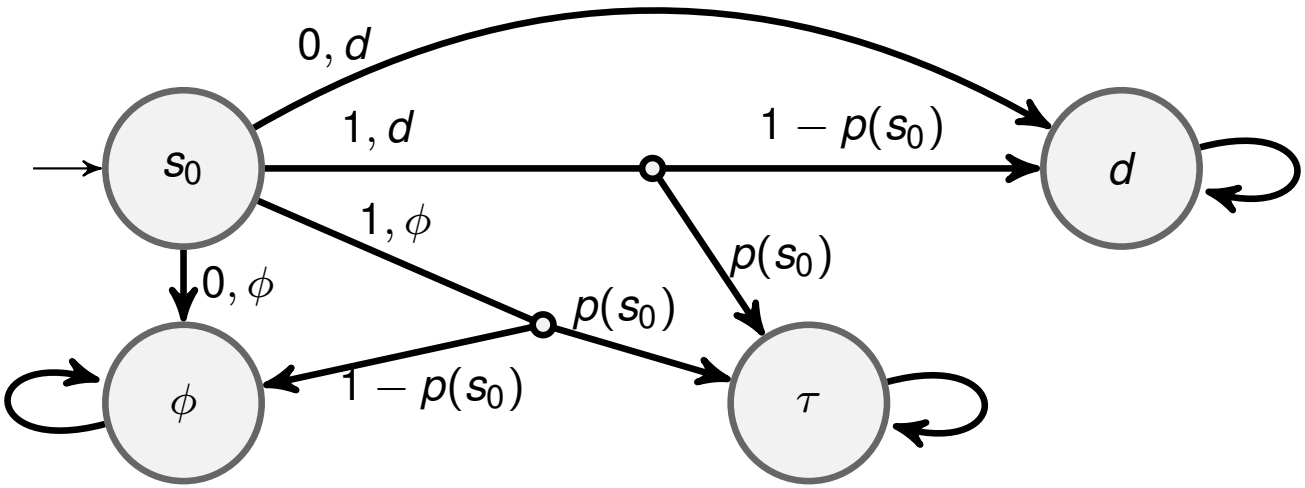

$p(s_0)$ is unknown.

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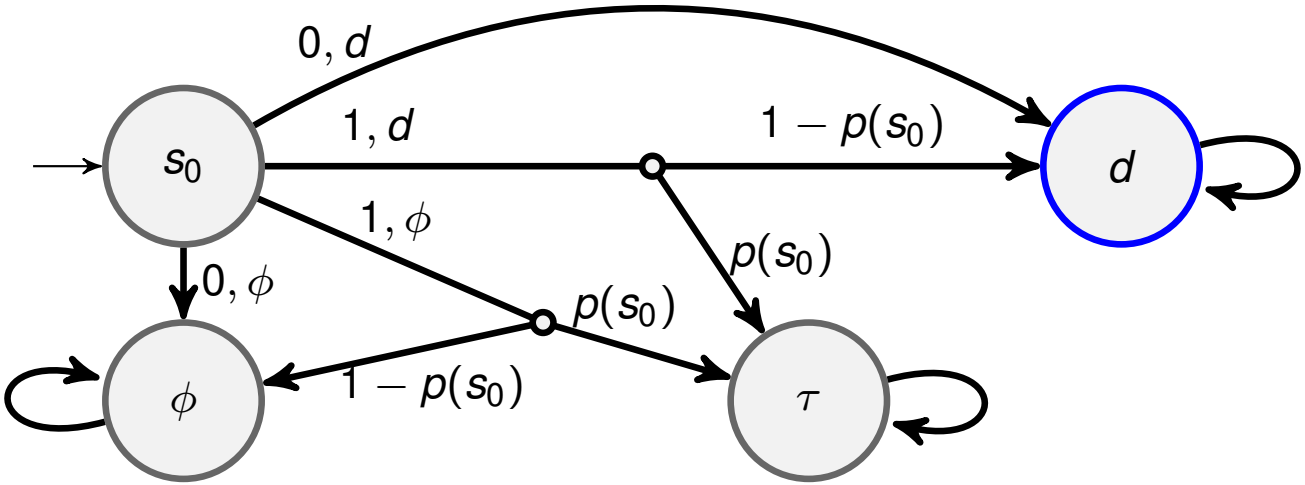
Objectives

- Minimize the probability of reaching the target.



Objectives

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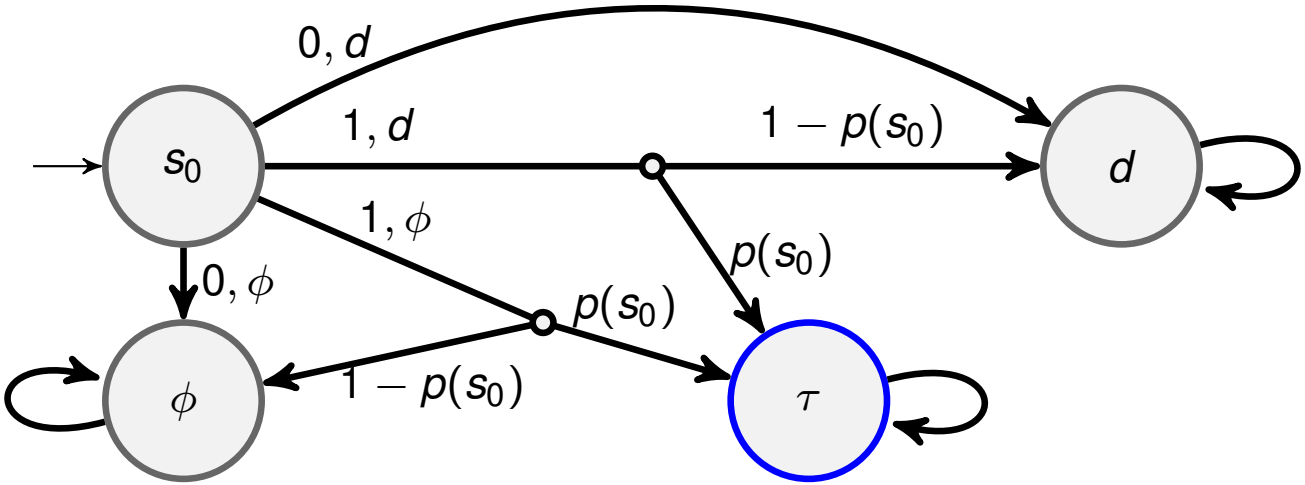

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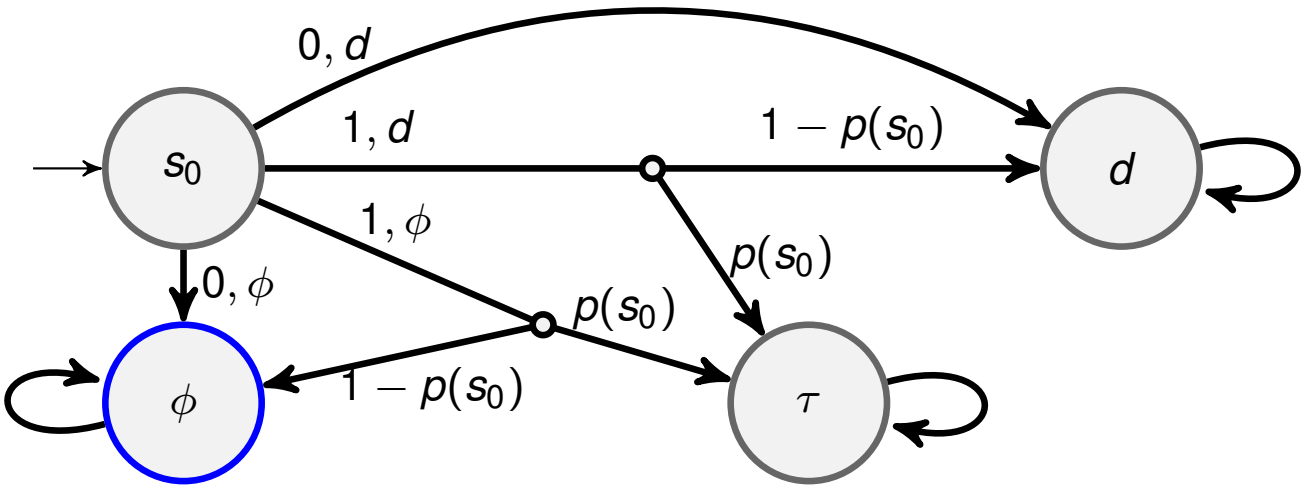

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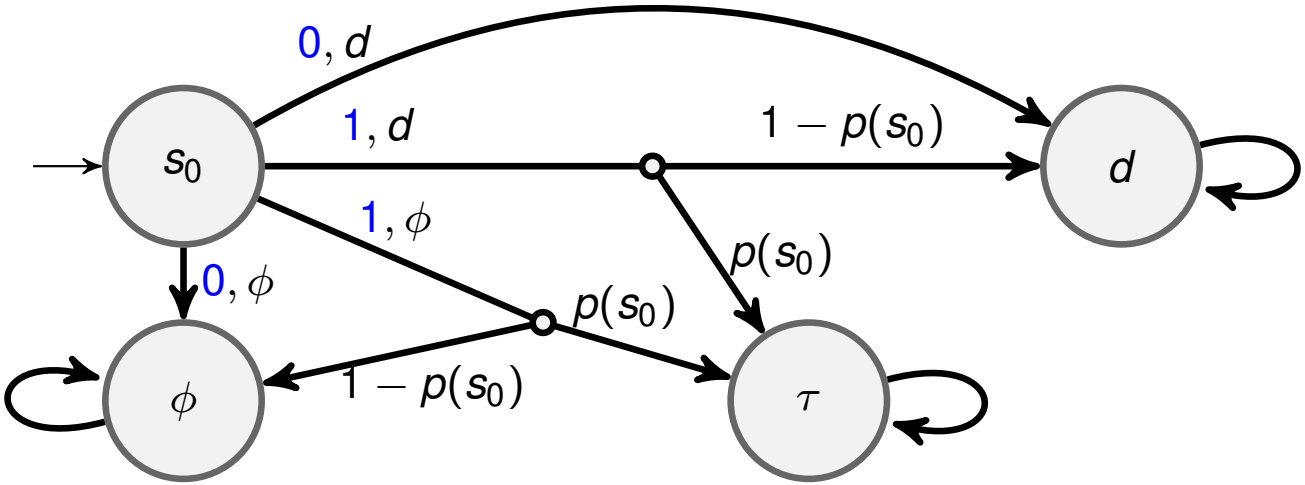

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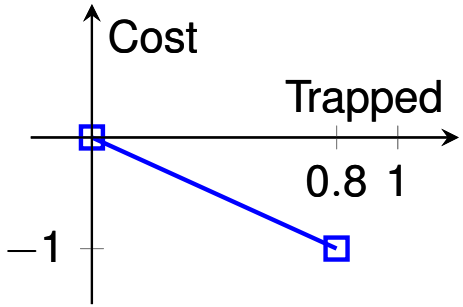

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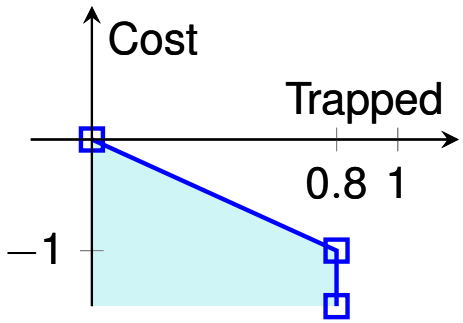

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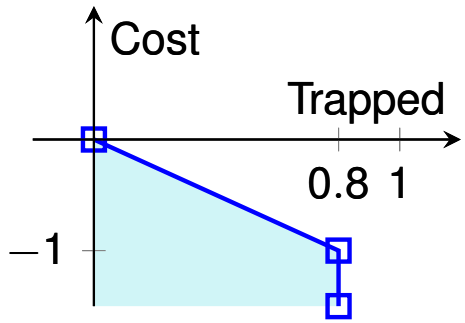

Prism can compute these **Pareto frontiers** for turn-based games with known probabilities.

Our Solution

Turn-based Game

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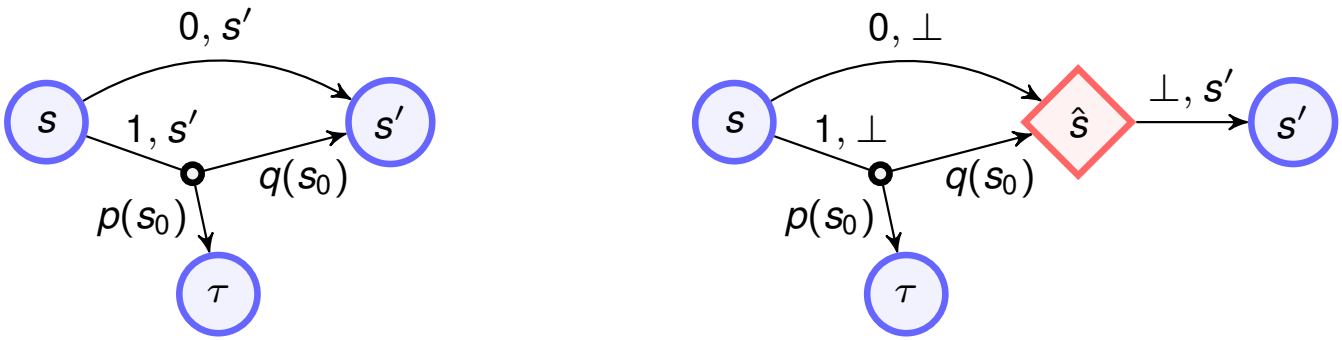

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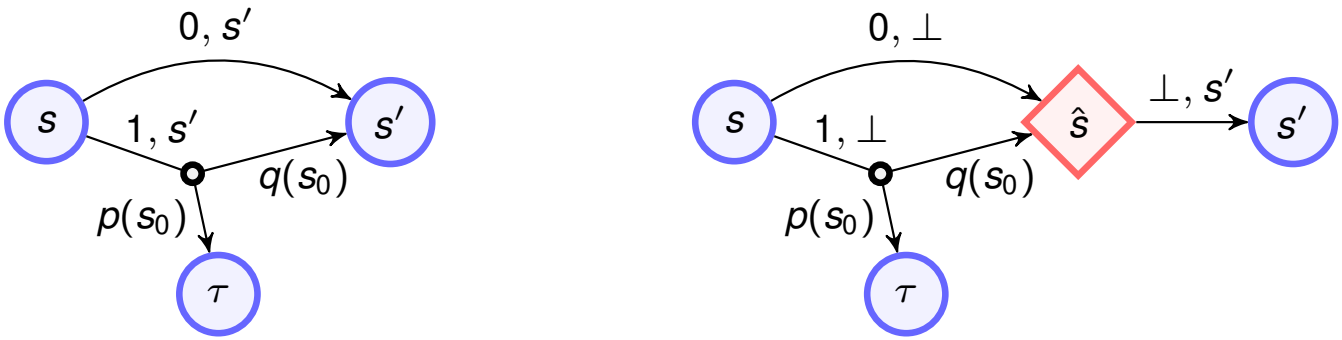

- Analyzing it becomes a lot easier now.

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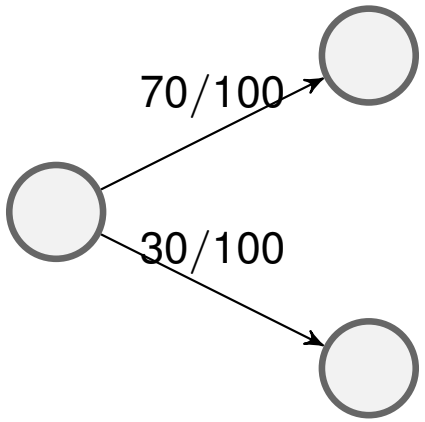

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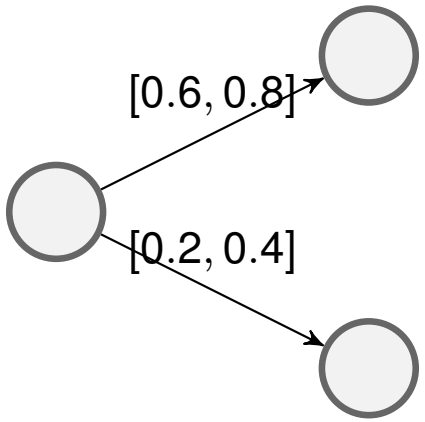
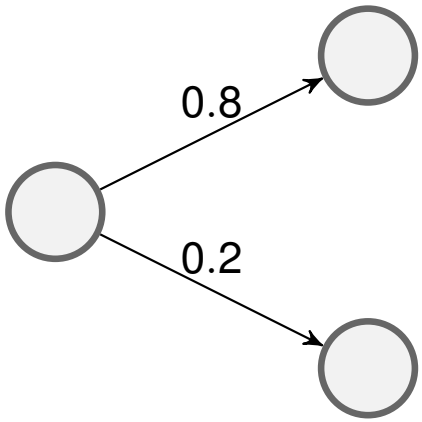
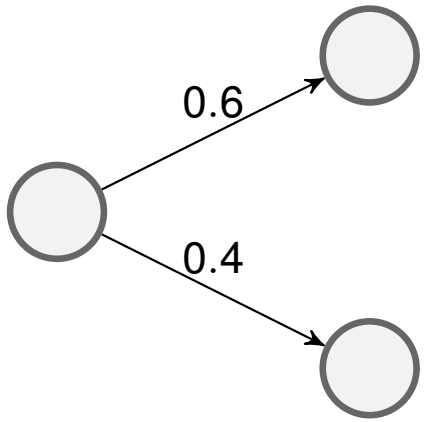


Where to get the probabilities?

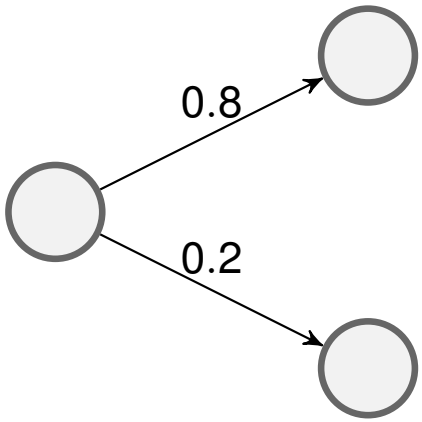
- We can construct best-case and worst-case games using these intervals.

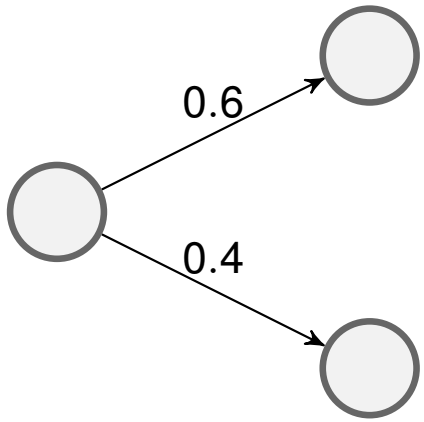




Where to get the probabilities?

- Generate Pareto frontiers for both games.





An overview

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- Compute probability intervals using simulations. [Pranav and Maxi ’19]
- Generate best and worst case games. [Maxi and Tobi ’19 + **Our contribution**]
- Compute Pareto frontiers for these games. [Kwiatkowska ’13]

Experiments

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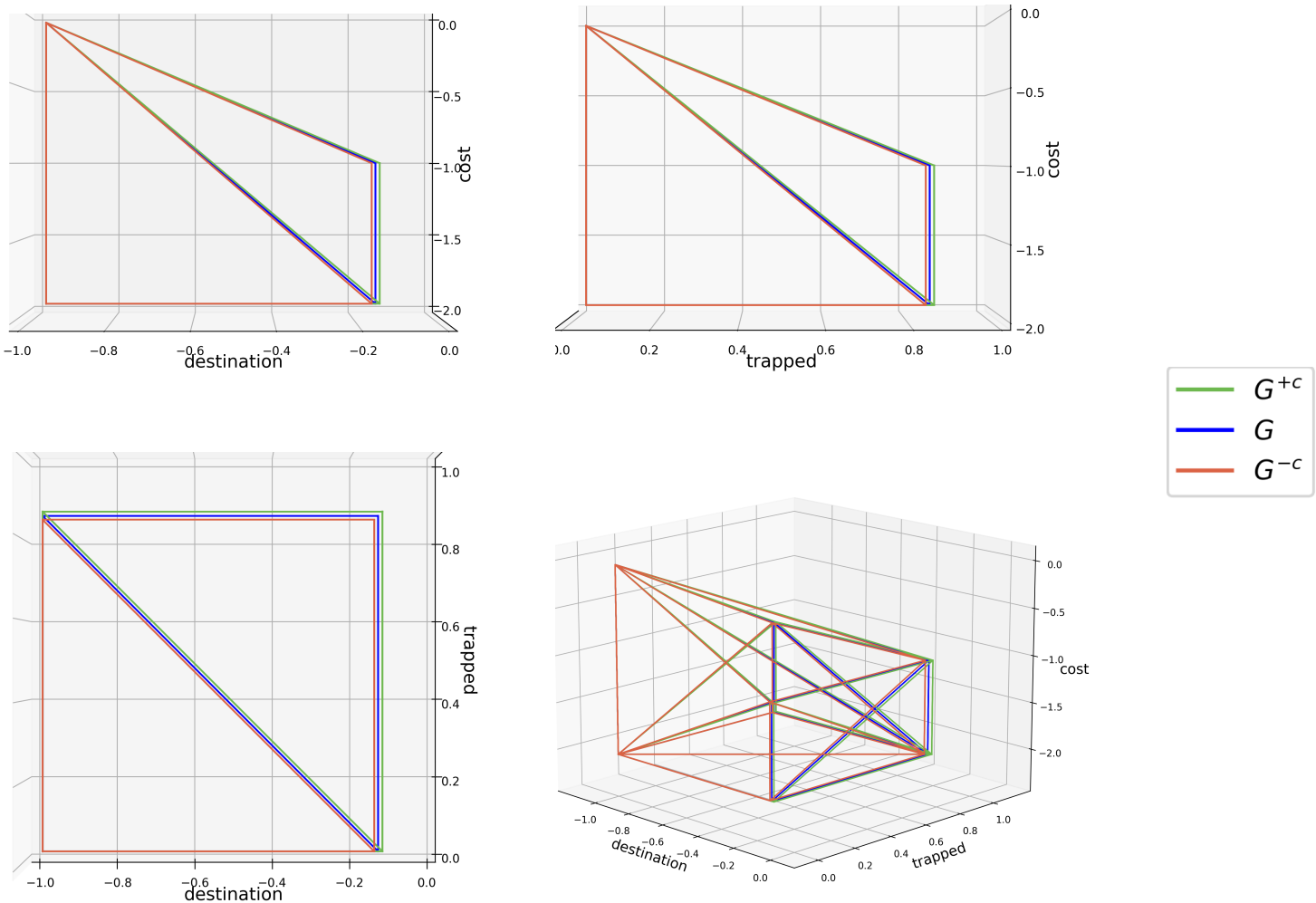

Figure: Achievable vectors of the NationState Attack case study.

Experiments

Example	Size	Cyclicity	Time taken (s)
Random	10	No	7.78
	100	No	11.90
Random	10	Yes	8.29
	100	Yes	17.63
ScreenGrab	9	No	7.95
NationState	30	Yes	8.40

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