

# STACKELBERG EQUILIBRIUM APPROXIMATION IN GENERAL-SUM EXTENSIVE-FORM GAMES WITH DOUBLE-ORACLE SAMPLING METHOD

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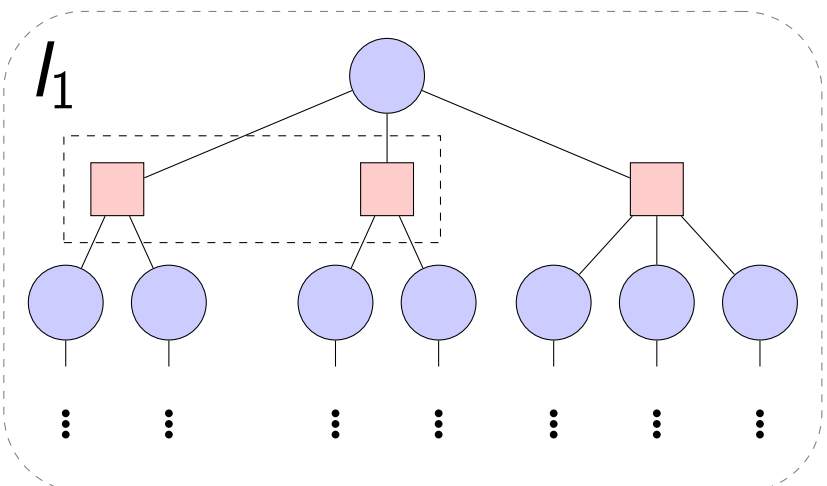
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★ O2UCT • Extensive Form Game • Good scalability • General sum • Anytime method ★

## Game

### Stackelberg equilibrium

Imperfect information

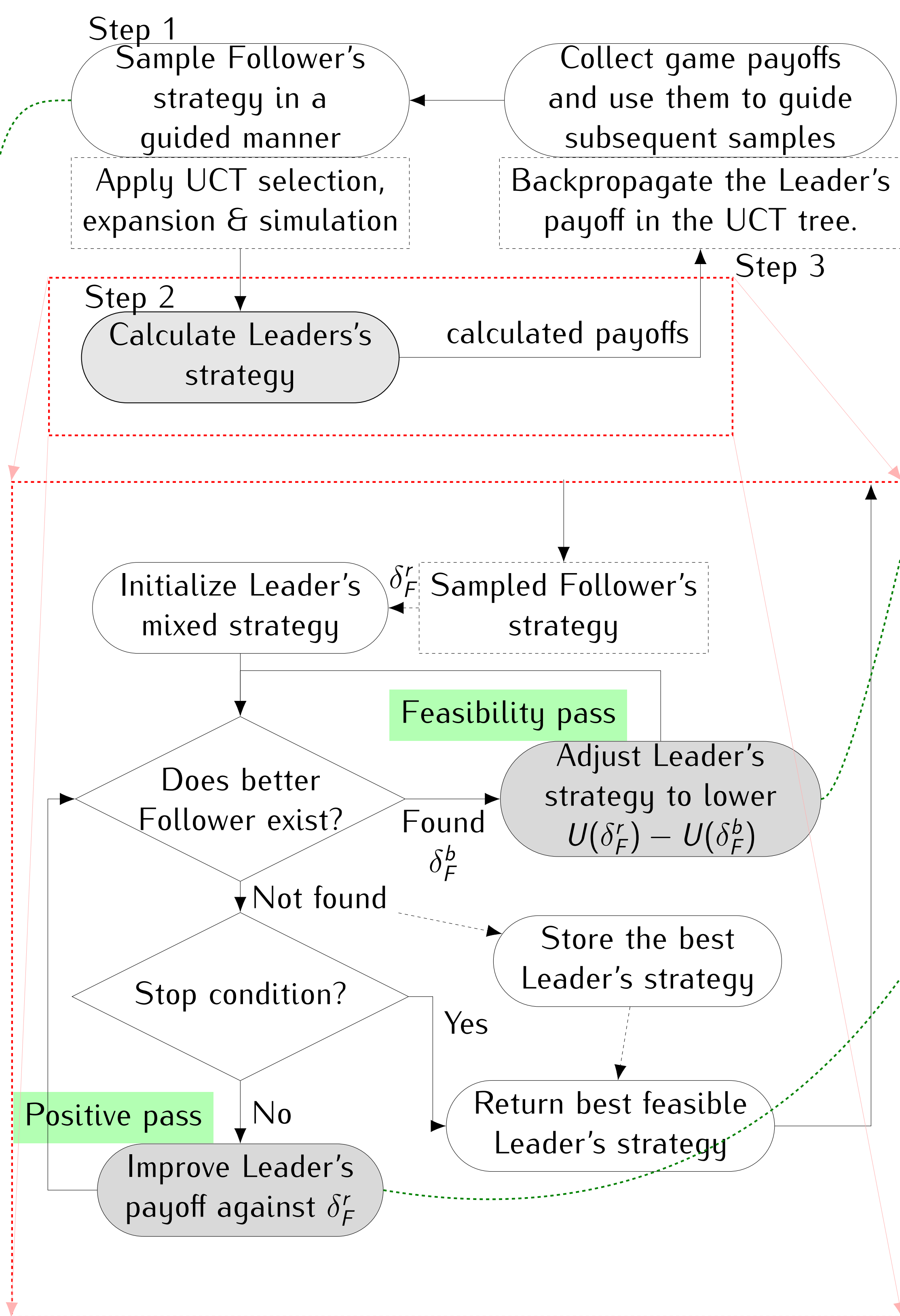


Extensive form

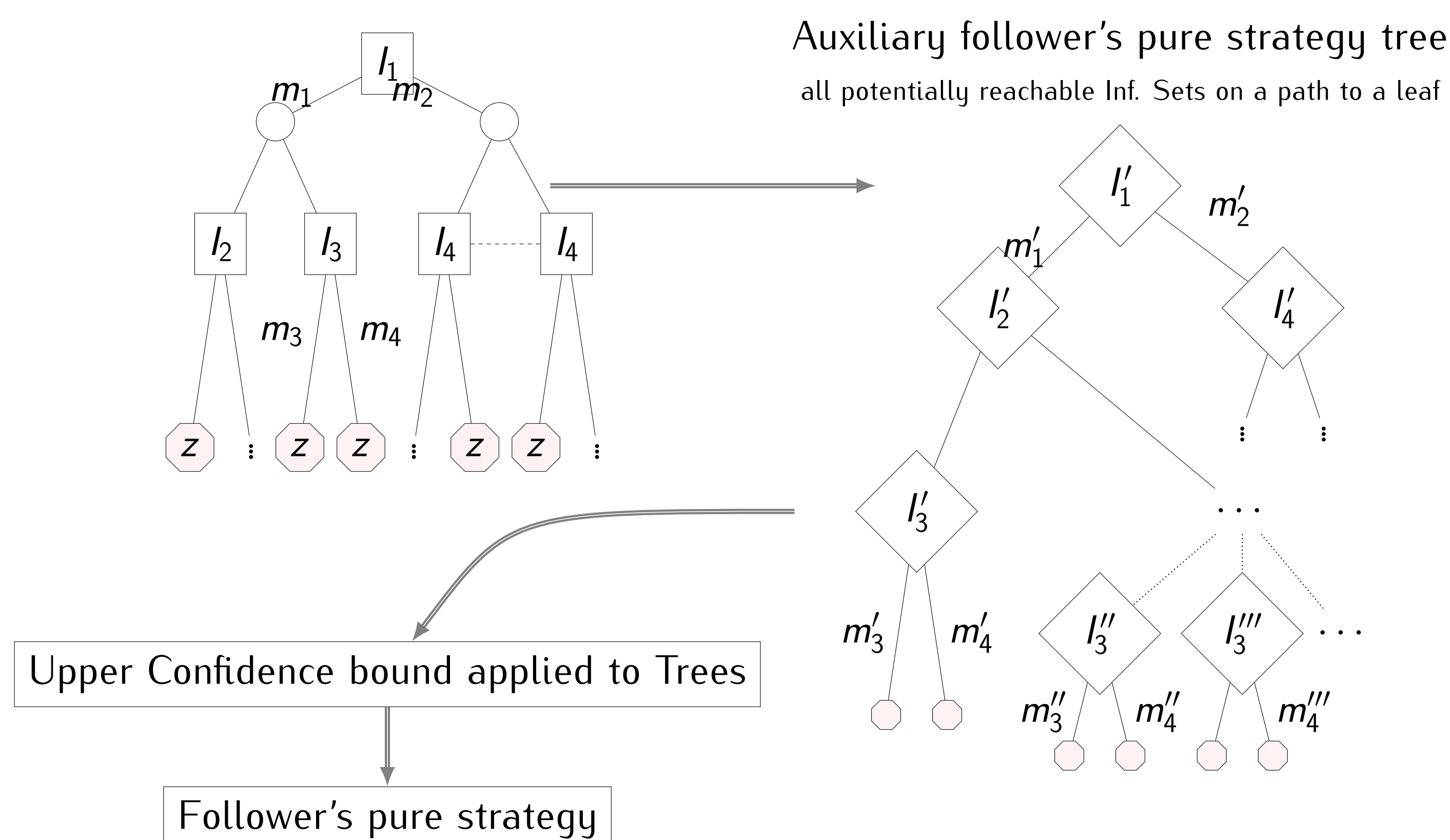
$$U_F = 0.4, U_L = -0.1$$

General sum

## O2UCT overview



## Follower's strategy sampling



## Strategy updates

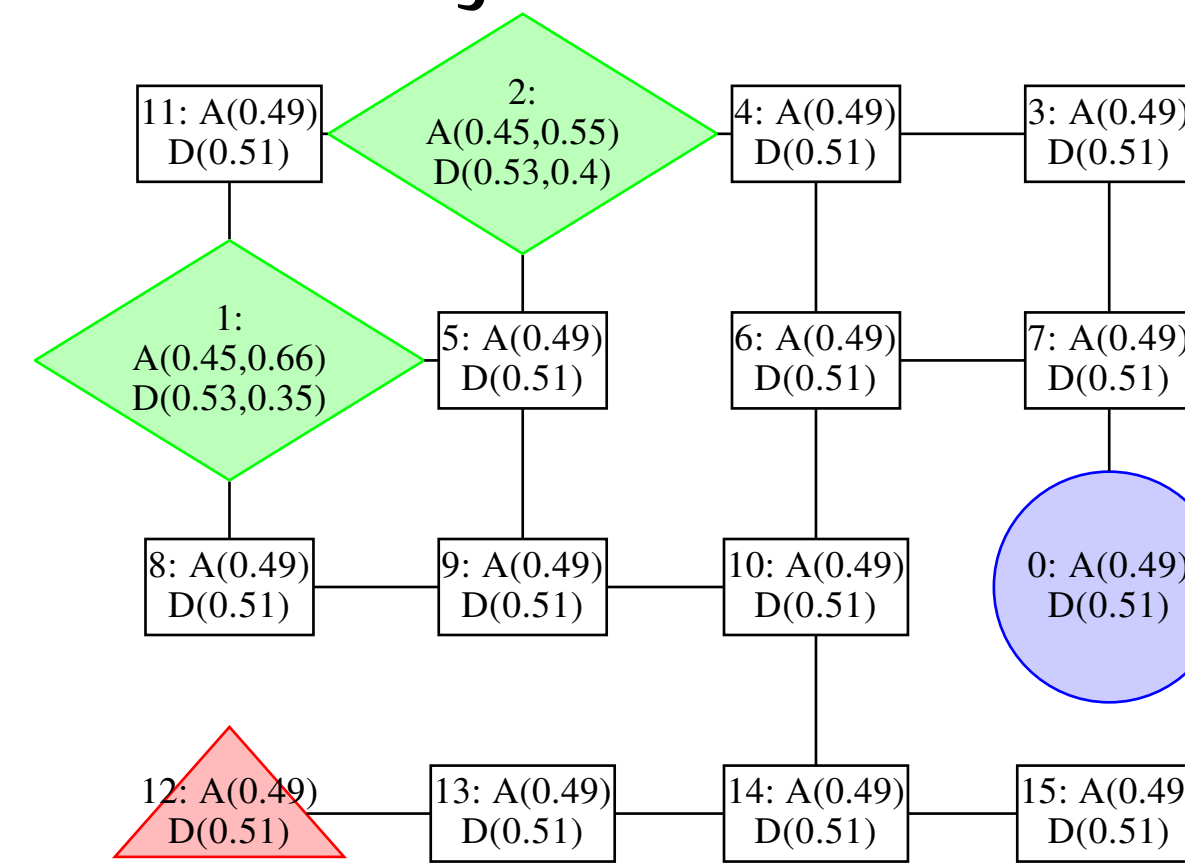
Algorithm 1: Node adjustment with momentum

**Data:**  $prob \in [0, 1]^M$  – a vector of probabilities,  $mom \in \mathbb{R}^M$  – a momentum vector,  $w \in \mathbb{R}$  – a momentum normalization factor,  $as \in \mathbb{R}^M$  – an assessments vector. All vectors contain values for the  $i$ -th move at their  $i$ -th position.

- 1  $mom \leftarrow mom + as$ ;
- 2  $w \leftarrow w + L_1(as)$ ;
- 3  $prob \leftarrow \max\{prob + mom/w, 0\}$  // independent max at each position
- 4  $prob \leftarrow \text{normalizeOrEqualprob}$  // Normalize vector values so their sum is 1 or, as a fallback, assign equal probability at each position in case all positions equal 0

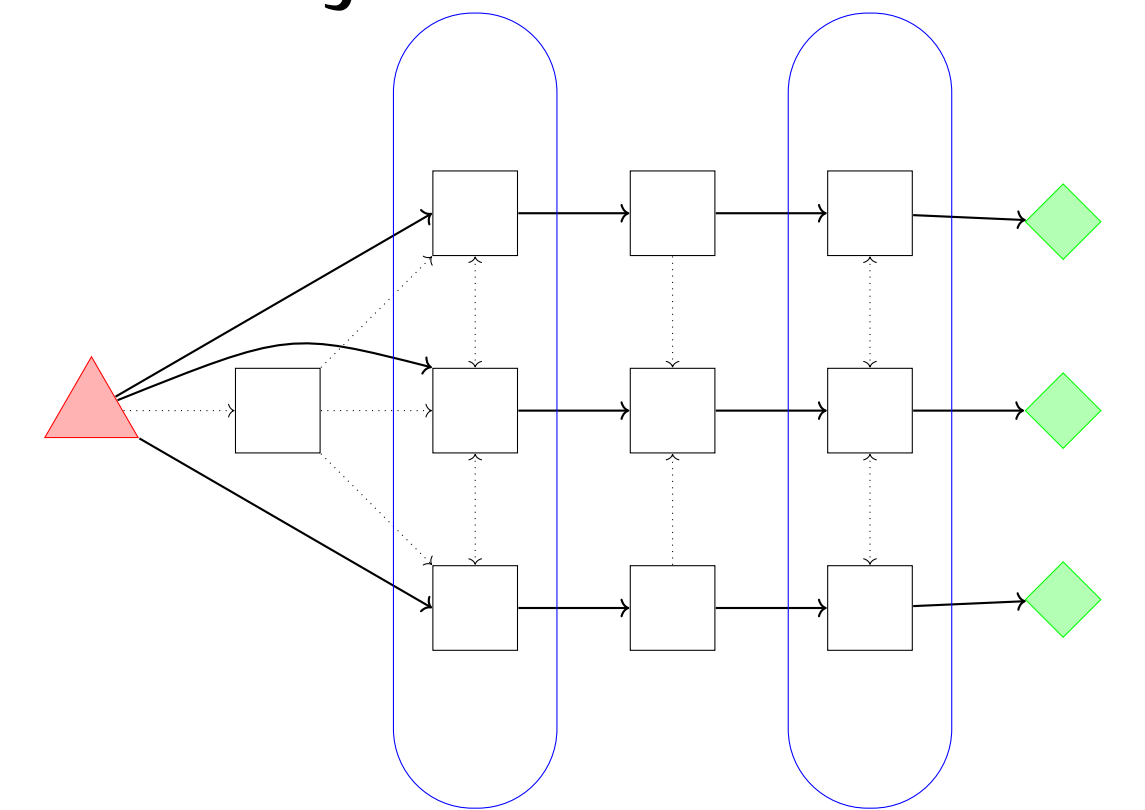
## Benchmark games

### Warehouse games



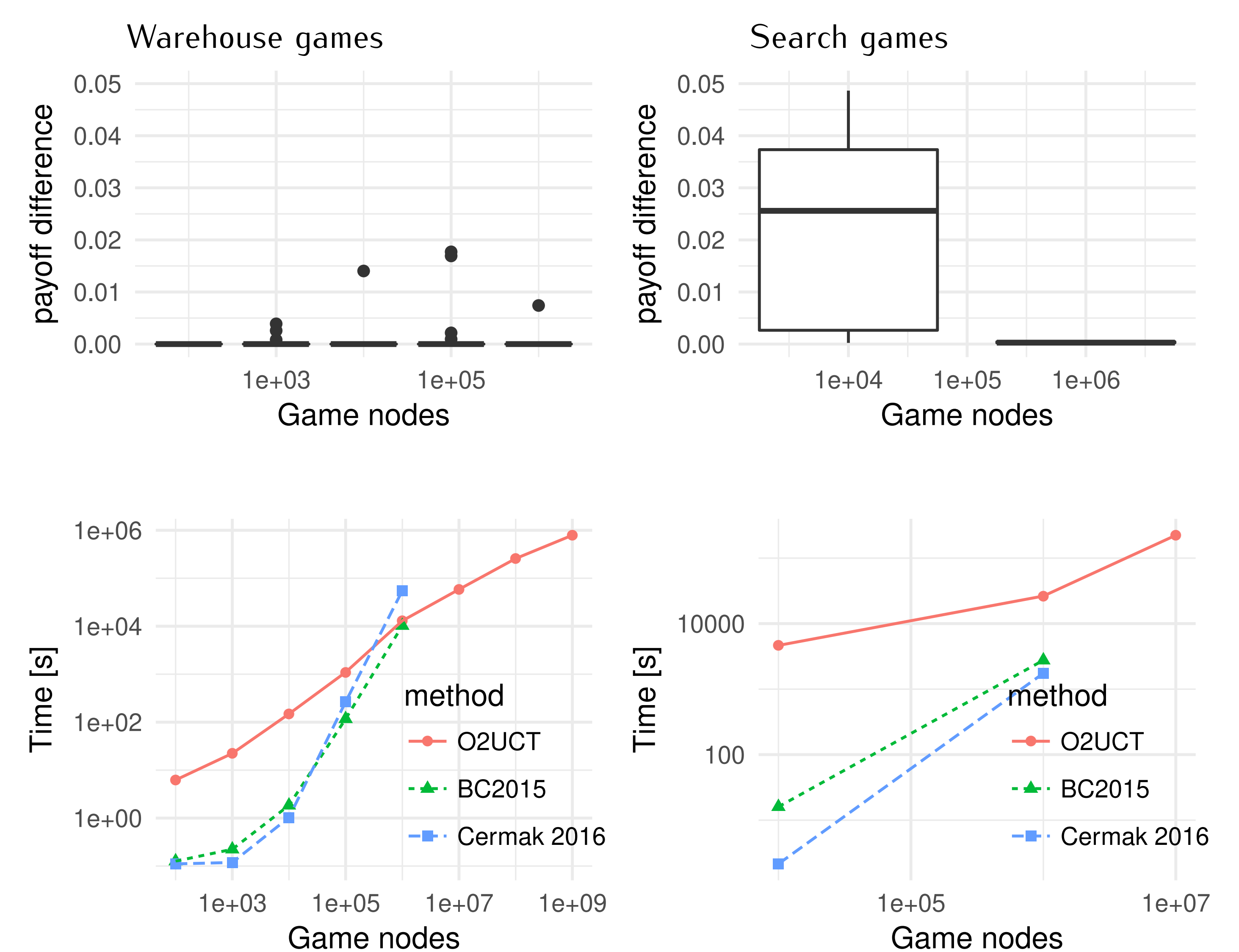
Jan Karwowski and Jacek Mańdziuk. "A Monte Carlo Tree Search approach to finding efficient patrolling schemes on graphs". In: *European Journal of Operational Research* (2019). ISSN: 0377-2217. URL: <http://dx.doi.org/10.1016/j.ejor.2019.02.017>

### Search games



Branislav Bosansky and Jiri Cermak. "Sequence-Form Algorithm for Computing Stackelberg Equilibria in Extensive-Form Games". In: *Proceedings of the Twenty-Ninth AAAI Conference on Artificial Intelligence*. Austin: AAAI Press, 2015, pp. 805–811. ISBN: 978-1-57735-698-1. URL: <http://www.aaai.org/ocs/index.php/AAAI/AAAI15/paper/view/9610>

## Results



## Conclusions

- Better scalability than exact methods
- Small payoff difference from exact methods
- Low memory requirements
- Generic method

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