

# MIXED STRATEGY EXTRACTION FROM UCT TREE IN SECURITY GAMES

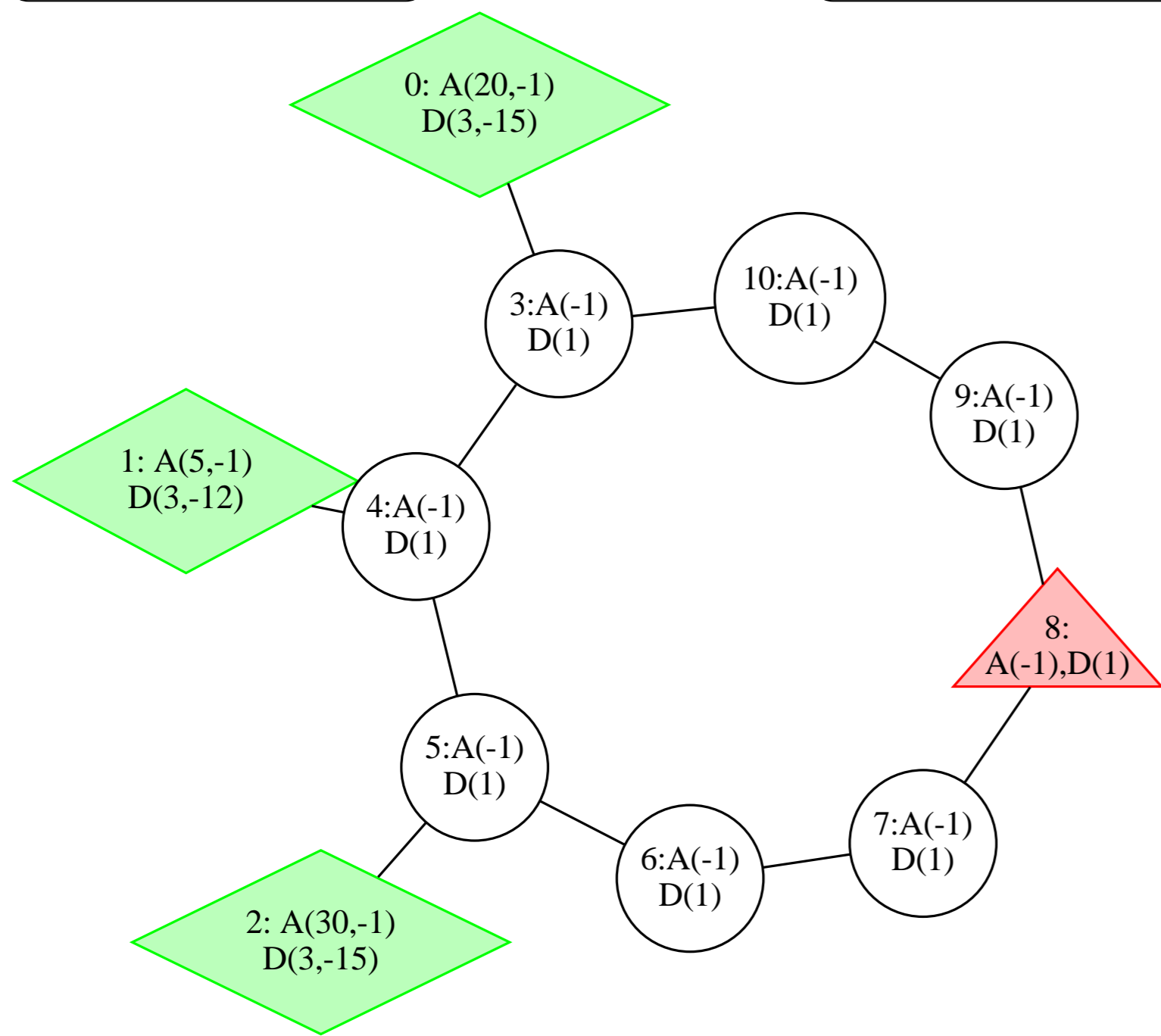
Jan Karwowski<sup>1</sup> and Jacek Mańdziuk<sup>1,2</sup>

<sup>1</sup>Faculty of Mathematics and Information Science, Warsaw University of Technology, Warsaw, Poland

<sup>2</sup>School of Computer Science and Engineering, Nanyang Technological University, Singapore

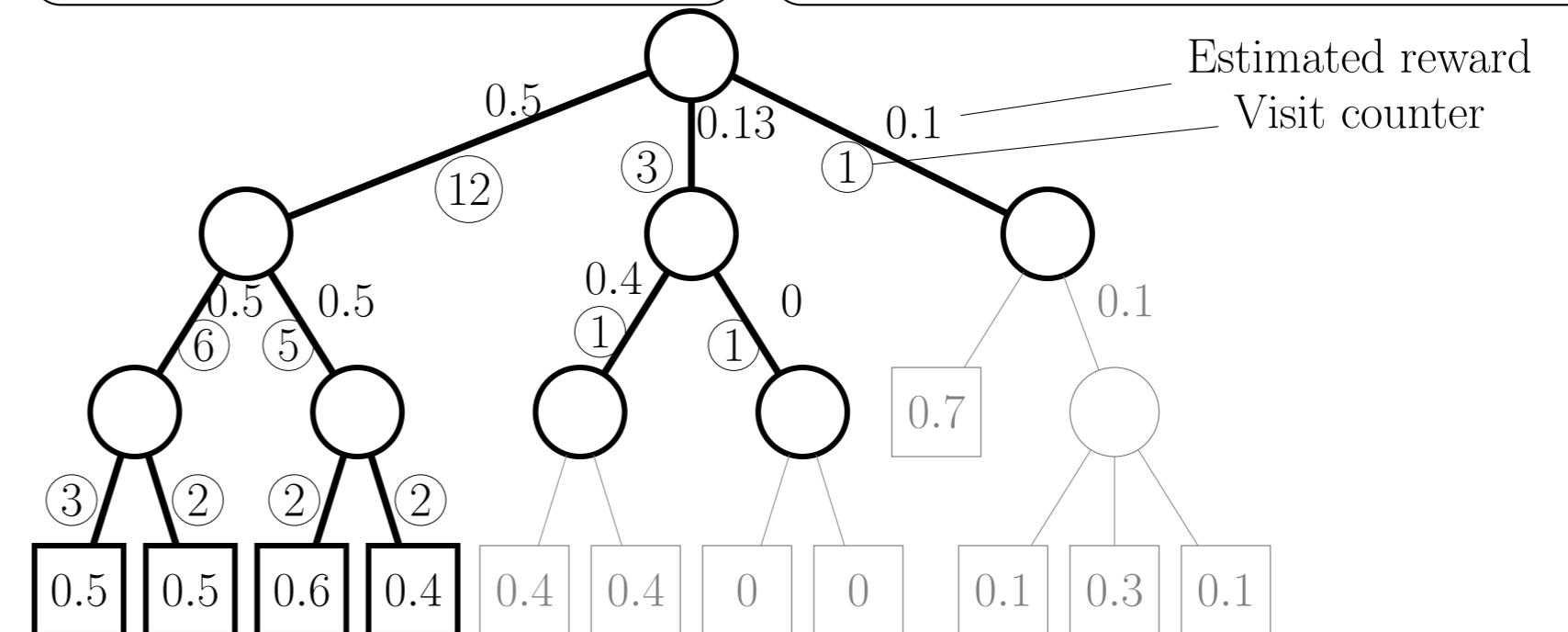
## Patrolling games on graphs

Security-games inspired  
Imperfect information  
Pursuit-evasion  
Stackelberg Equilibrium  
Multi-act games

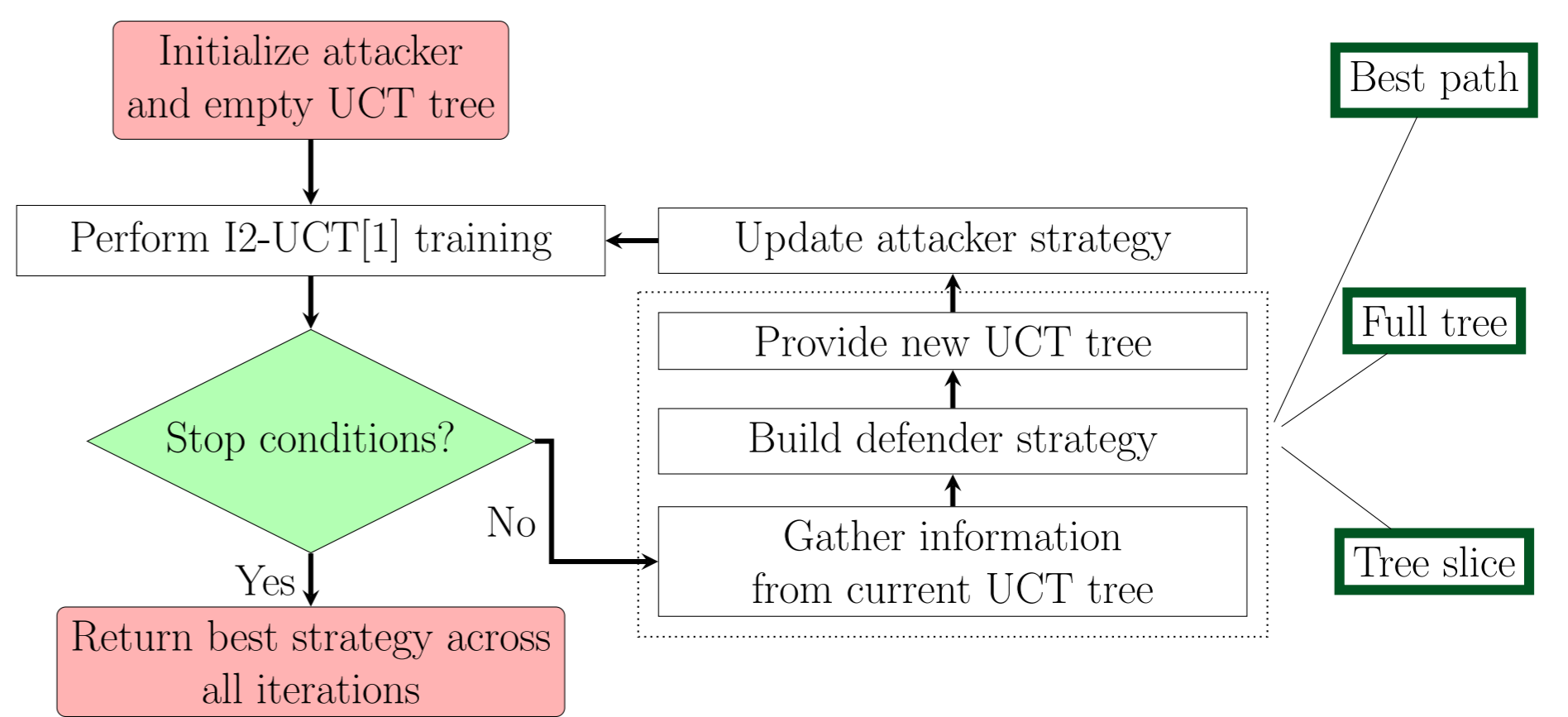


## UCT[2]

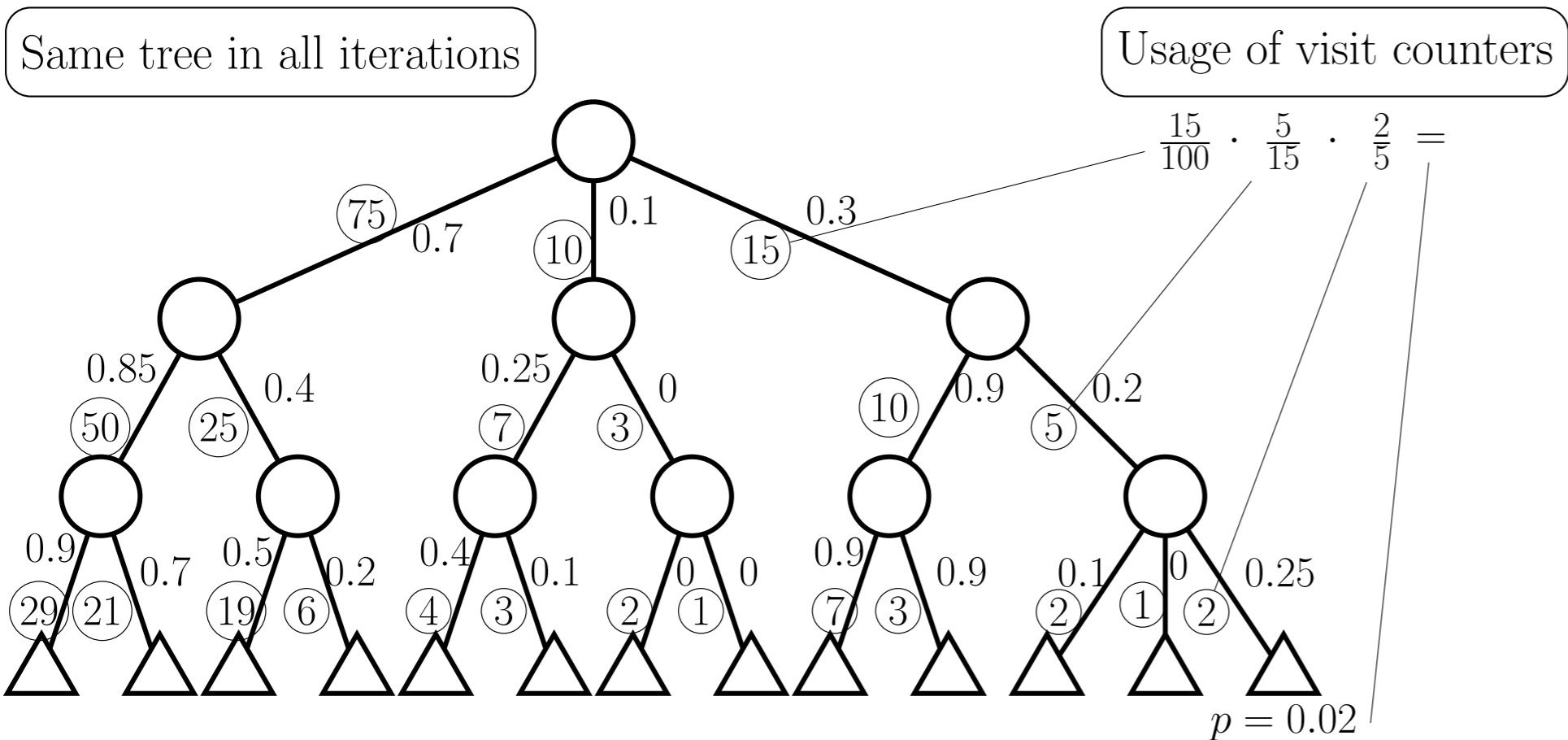
Monte-Carlo based  
Exploits known good solutions  
Visit counter and reward estimation for moves  
Uses game rules (no extensive form game)



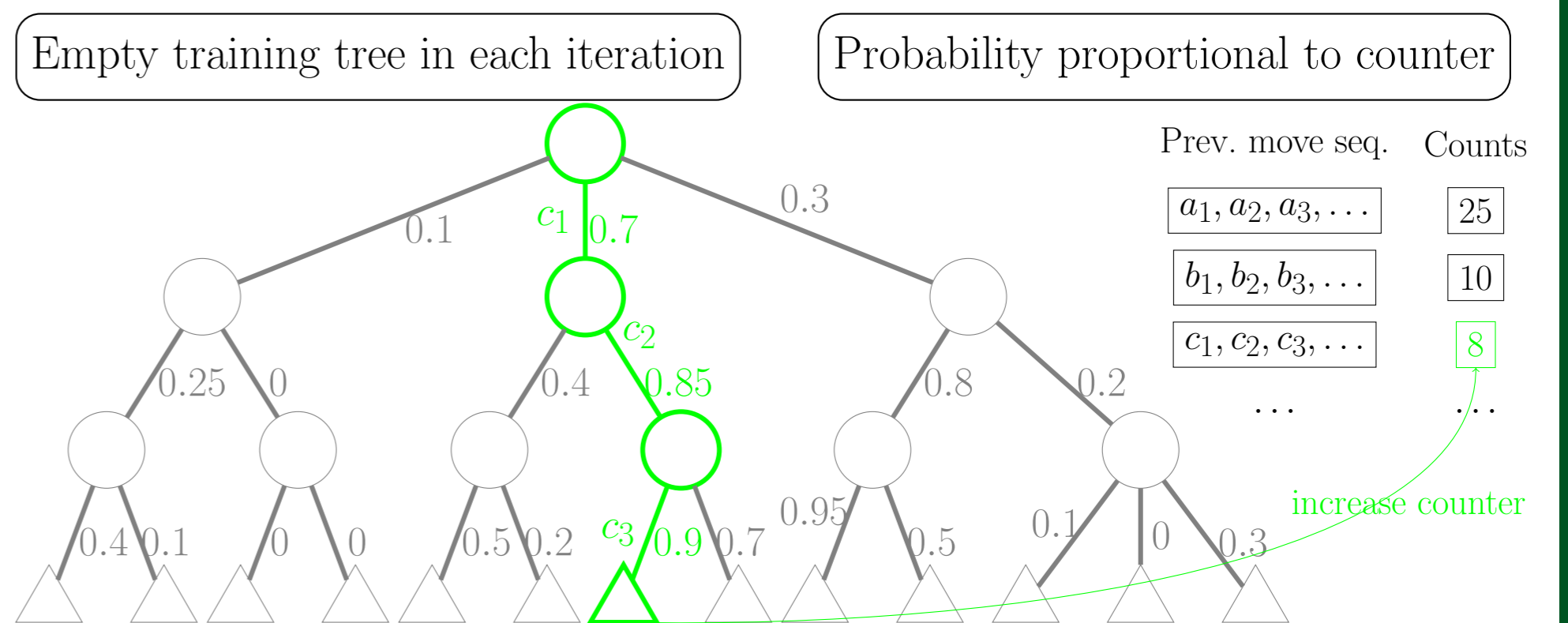
## Mixed-UCT method



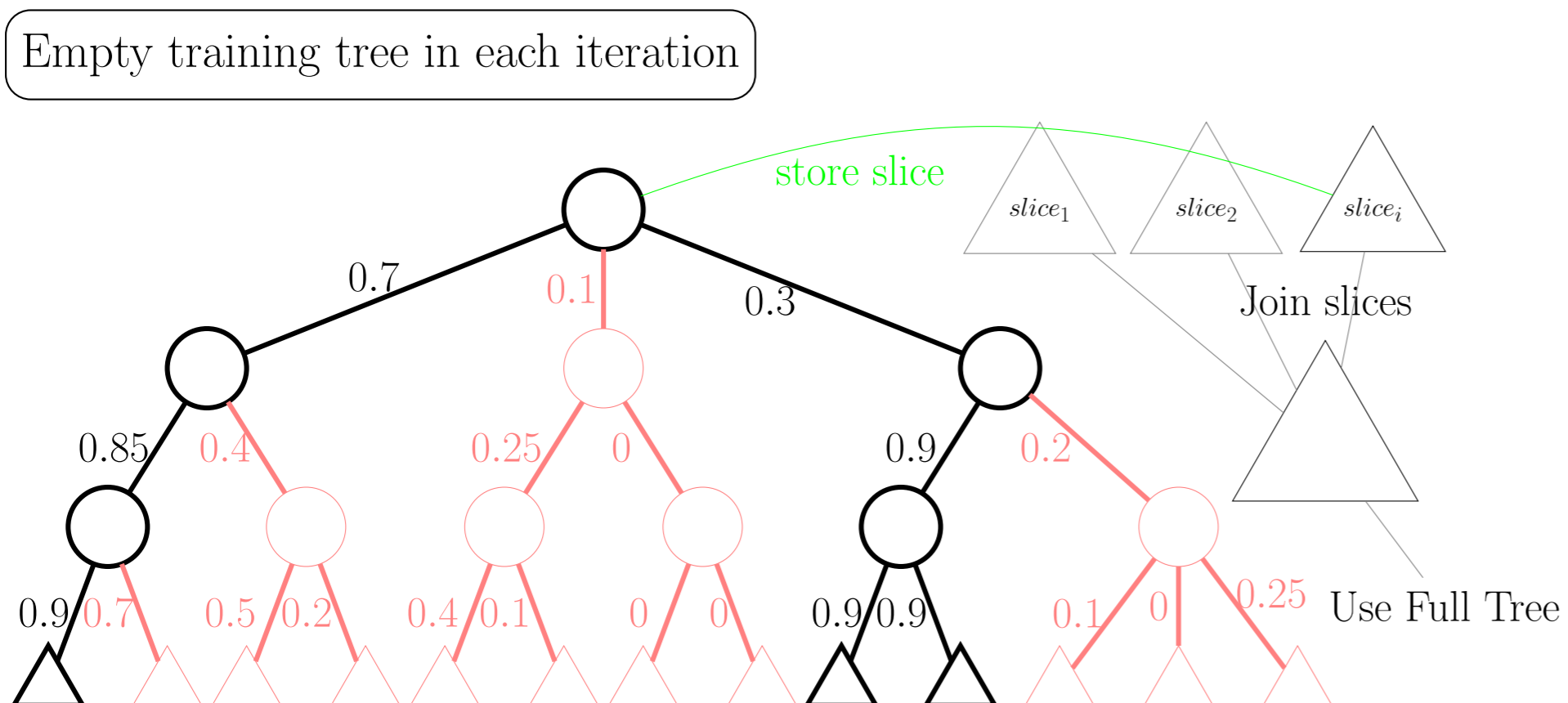
## Full tree



## Best path



## Tree slice



## Experimental results

game	Single tree			Tree slice			Best sequence			Uniform payoff	Optimal	
	payoff	time [s]	score	payoff	time [s]	score	payoff	time [s]	score		payoff	time [s]
game 1	0.49	2382.67	1	0.09	1559.9	0.96	0.44	1344.26	0.99	-10.46	0.54	28327.66
game 2	0.07	2614.28	1	0.03	2117.96	0.99	0.08	1587.29	1	-7.21	0.08	110.16
game 3	-4.27	3188.24	1	-4.39	7643.55	0.99	-4.55	2486.51	0.97	-13.97	-4.27	17394.6
game 3a	-4.5	2115.54	1	-4.5	3191.43	1	-4.5	1379.6	1	-13.97	-4.5	18734.59
game 3b	2.58	2325.9	1	2.58	3359.41	1	2.58	2484.04	1	-0.87	2.58	283.78
game 3c	-1.06	2058.87	1	-1.06	3183.31	1	-1.06	2151.49	1	-9.29	-1.06	18579.31
game 3d	0.9	2241.58	1	0.9	4062.88	1	0.9	2897.59	1	-4.61	0.9	4695.22
game 4	-4.87	1973.38	1	-4.87	2364.33	1	-4.87	1579.8	1	-13.91	-4.87	5823.96
game 4a	-6	2058.29	1	-6	2007.6	1	-6	1261.33	1	-13.84	-6	5915.89
game 4b	0.79	1393.43	1	0.78	1448.32	0.99	0.78	1585.96	0.99	-0.81	0.79	5519.87
game 4c	-2.85	2579.43	1	-2.85	2416.2	1	-2.85	2093.65	1	-9.23	-2.85	5928.66
game 4d	0.16	1713.11	1	0.17	2686.56	1	0.17	1775.95	1	-4.55	0.17	5149.78

## References

[1] Jan Karwowski and Jacek Mańdziuk. A new approach to security games. In *International Conference on Artificial Intelligence and Soft Computing*, volume 9120 of *LNAI*, pages 402–411. Springer-Verlag, 2015.

[2] Levente Kocsis and Csaba Szepesvári. Bandit based monte-carlo planning. In *Machine Learning: ECML 2006*, pages 282–293. Springer, 2006.