Task Allocation on Networks with Execution Uncertainty

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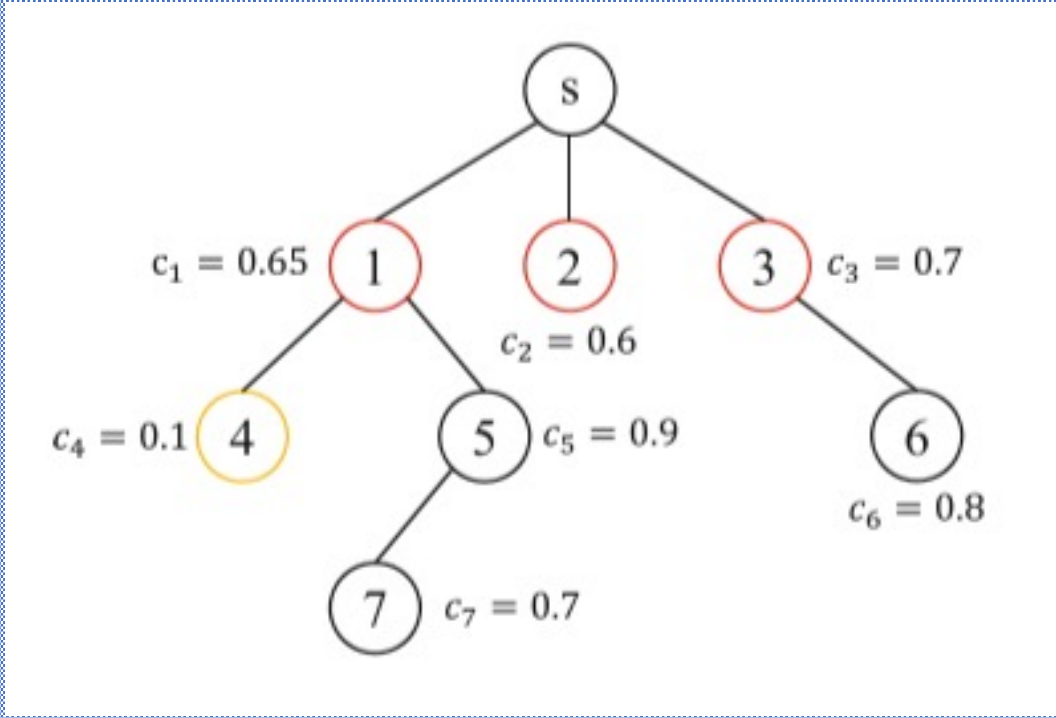
Bidding Tasks on Networks

- If utilizing the social connections among agents, we can recruit more candidates and may find more efficient workers.

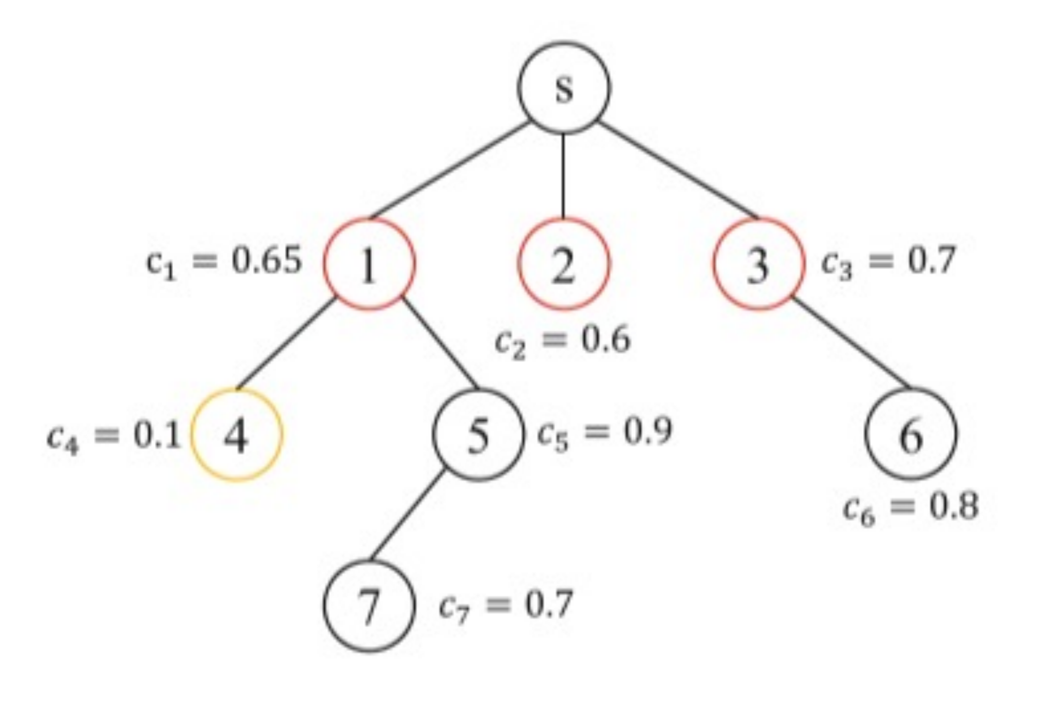
- The key is to design the diffusion incentives for agents.



Information Diffusion Mechanism [Li et al. 2017]

- The IDM is proposed to incentivize agents to diffuse the information for an auction on networks.

- The key idea of the IDM is to resale along the critical agents. We can apply the same idea in our setting (if all agents can perform the same quality, then it is equivalent to a reverse auction).



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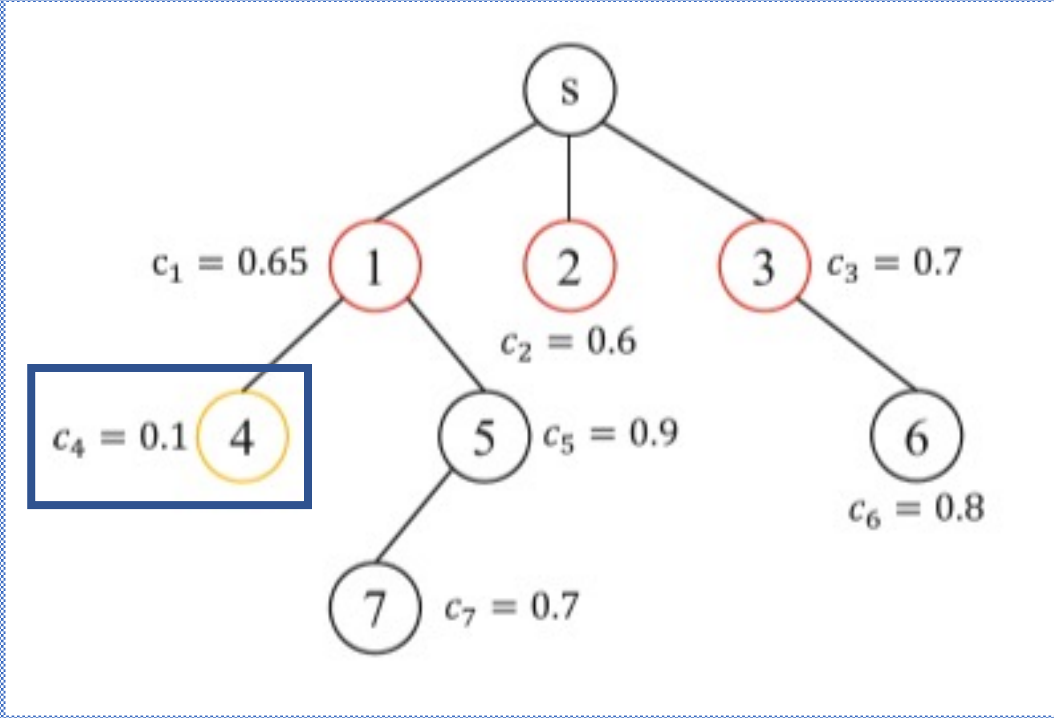

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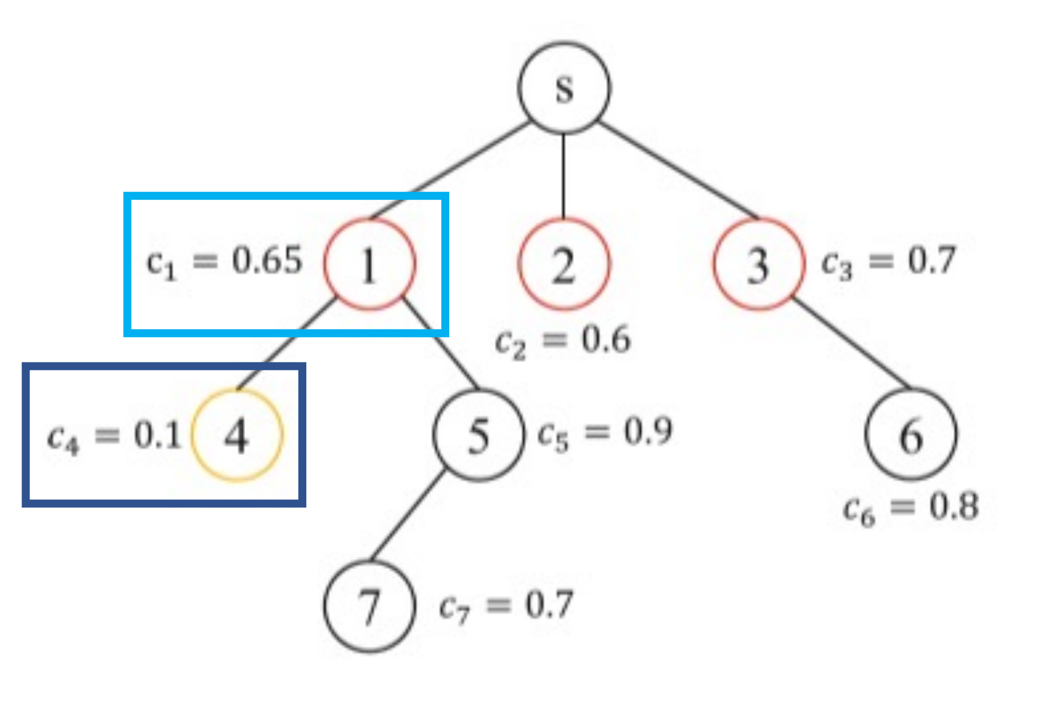

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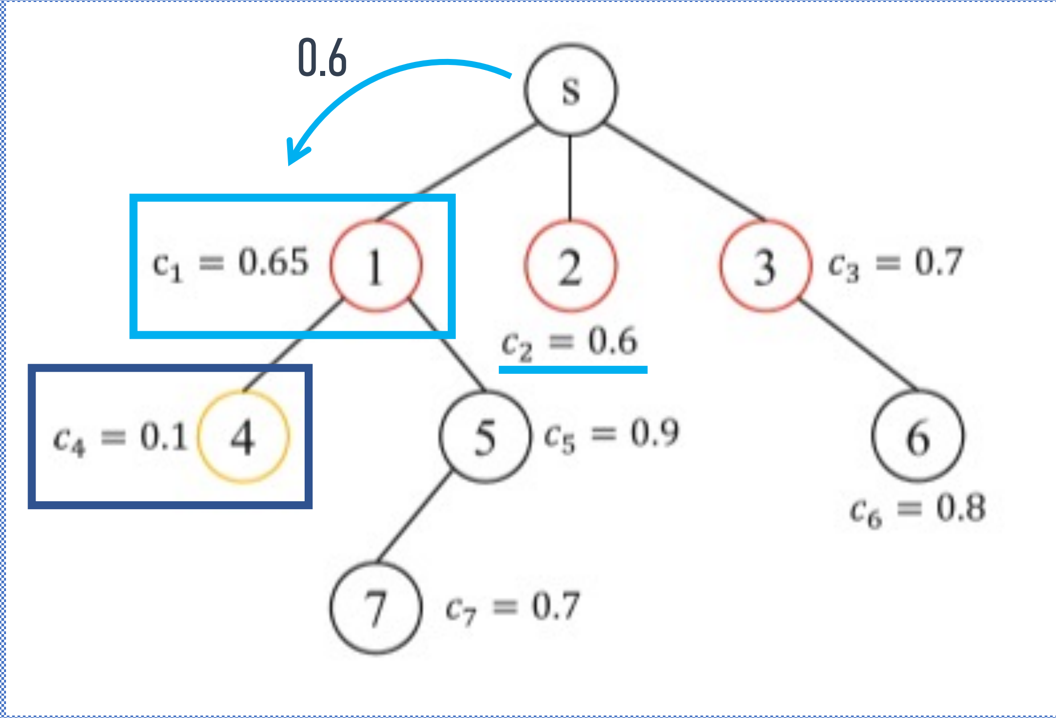

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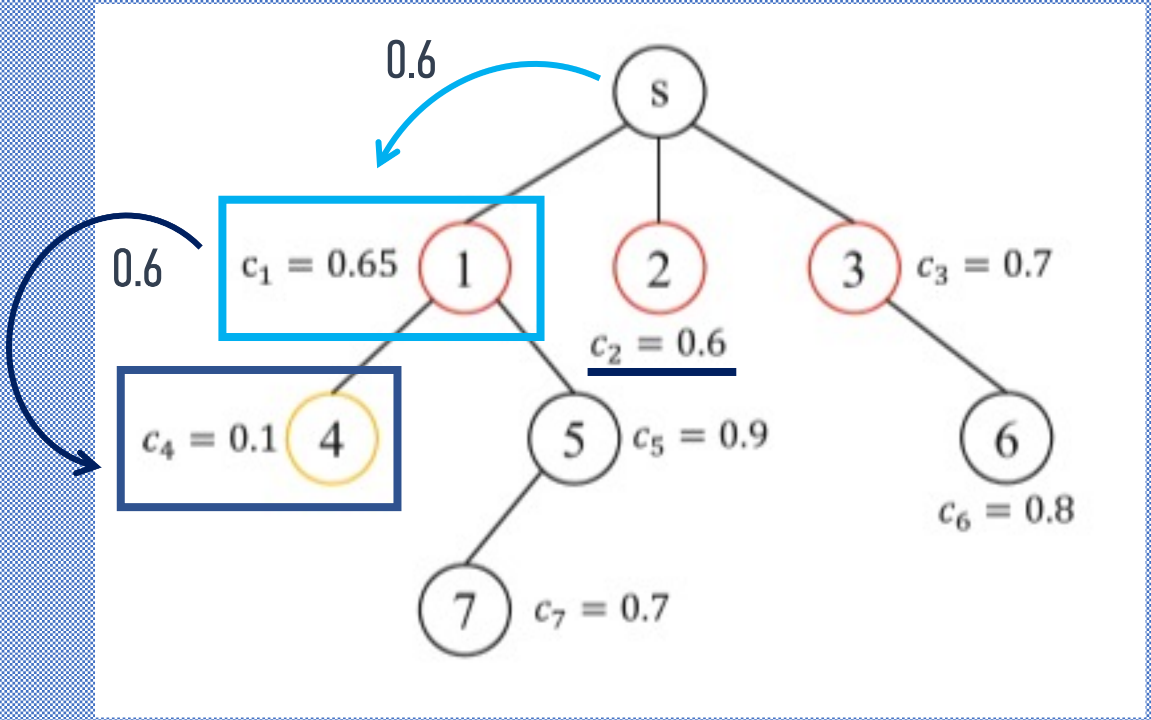


Failure in the Quality-Aware Setting

- In the quality-aware setting, the agents may perform the task with different qualities and they are required to report their probability distributions of qualities (PoQ).

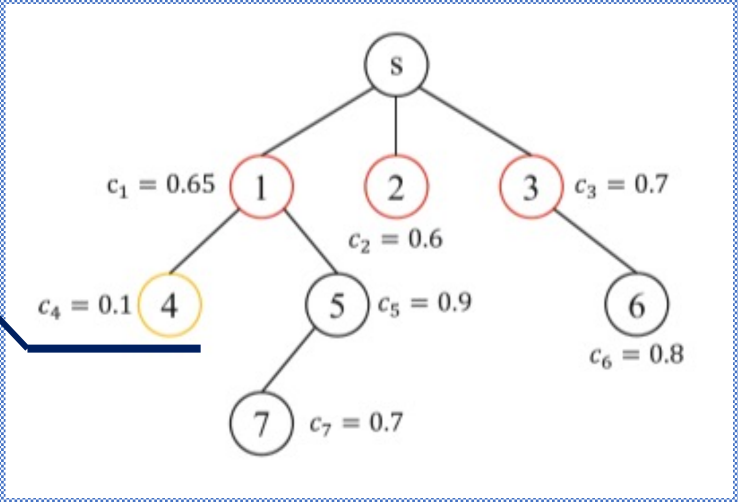
- The IDM cannot guarantee for incentive compatibility since the payoff to the selected agent is always related to her reported ability.

50% to have quality 1, 50% to have quality 0: payoff=0.5-(0.9-0.6)=0.2

↓

80% to have quality 1, 20% to have quality 0: payoff=0.8-(0.9-0.6)=0.5

*all others has quality 0.9 with probability 1.



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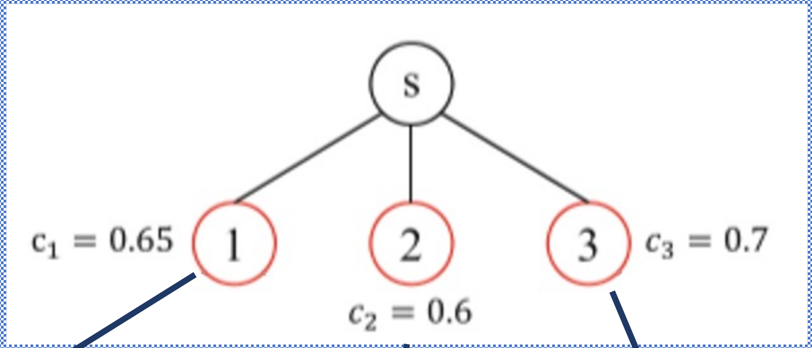
- The IDM may also cause a deficit to the task requester since she may get low-quality performance and give a high payoff.

From VCG to Post Execution Verification (PEV)

- Post verification is a common idea to conquer the execution uncertainty in traditional settings (e.g., possibilities of failure [R. Porter et al. 2008, Zhao et al. 2016], uncertain execution time [S. Stein et al. 2011, V. Conitzer et al. 2014], etc.).



Possibility of failure: 0.5

Possibility of failure: 0.1

Possibility of failure: 0.2

*all agents have quality 1 if success.

- Winner: agent 2 (with highest expected welfare 0.9-0.6 = 0.3).
- Highest expected welfare without 2 is from 3: 0.8 – 0.7 = 0.1.
- VCG payoff of agent 2: 0.9 – 0.1 = 0.8.
- Payoff with PEV:
  - = if agent 2 success: 1 – 0.1 = 0.9;
  - = if agent 2 fails: 0 – 0.1 = -0.1.

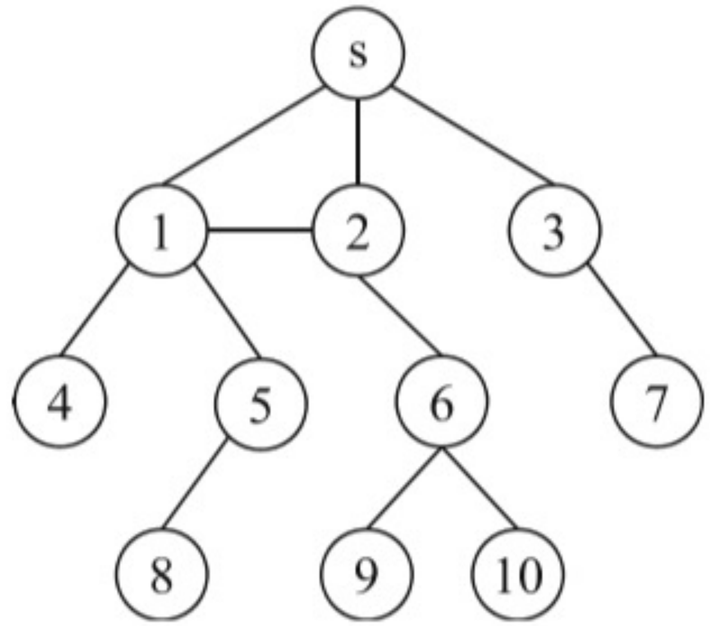
PEV-based Diffusion Mechanism

- The PEV-based diffusion mechanism follows the idea of IDM, which checks the critical agents of the one who can maximize expected social welfare.

- The final chosen agent achieves the highest expected welfare when the next agent in the critical sequence did not participate.

- The intermediate agents' contributions are measured by the increase of the expected welfare from their diffusion, while <u>the payoff to the chosen agent will be determined by her actual execution quality</u> (i.e., post execution verification).

A Running Example of the PEV-based DM



i	f_i	c_i	Expected welfare
1	$f_1(2) = .5, f_1(3) = .5$	$c_1 = 0.5$	2
2	$f_2(1) = 1$	$c_2 = 0.2$	.8
3	$f_3(5) = 1$	$c_3 = 1$	4
4	$f_4(3) = 1$	$c_4 = 1$	2
5	$f_5(4) = .4, f_5(6) = .6$	$c_5 = 1.6$	3.6
6	$f_6(3) = .3, f_6(4) = .6, f_6(7) = .1$	$c_6 = 0.9$	3.1
7	$f_7(6) = .5, f_7(8) = .5$	$c_7 = 4.2$	2.8
8	$f_8(1) = .2, f_8(3) = .8$	$c_8 = 0$	2.6
9	$f_9(8) = .8, f_9(10) = .2$	$c_9 = 1$	7.4
10	$f_{10}(4) = .5, f_{10}(5) = .3, f_{10}(6) = .2$	$c_{10} = 0.2$	4.5

- Final Winner: agent 9; Critical Sequence: (s, 2, 6, 9).
- If the actual execution quality is 8, then payoffs for (2, 6, 9) is (0, 0.5, 3.5).

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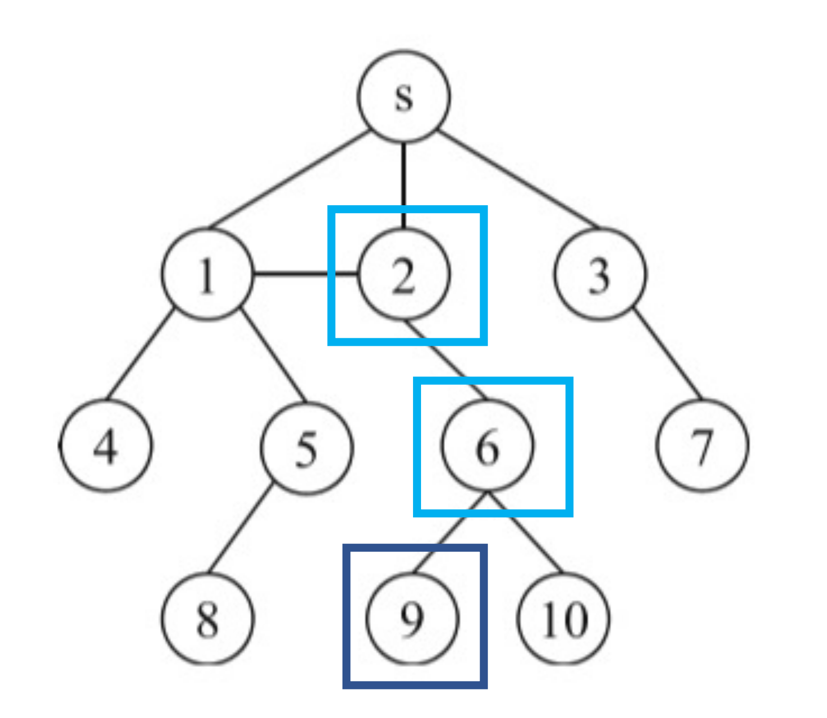

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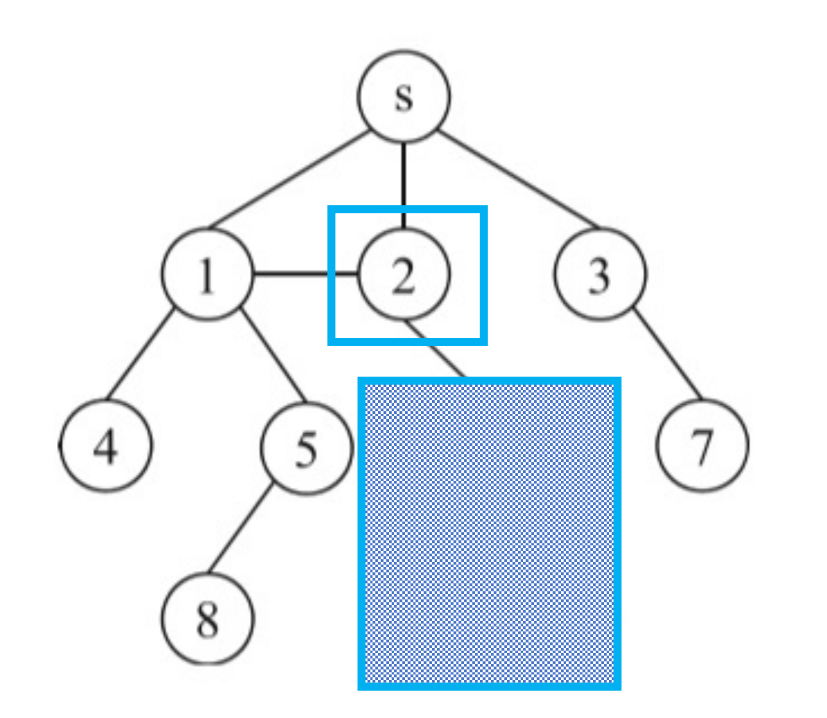

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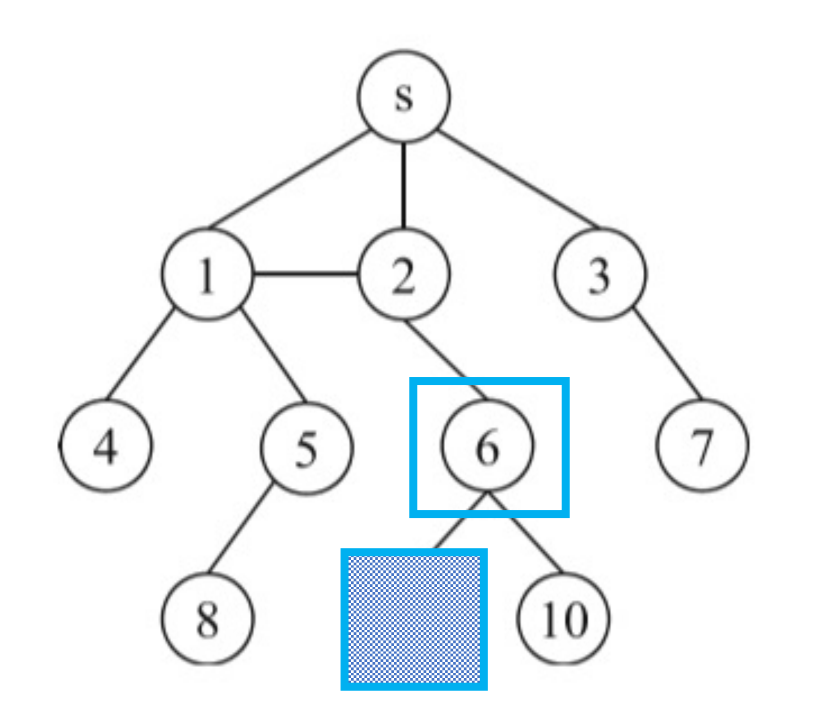

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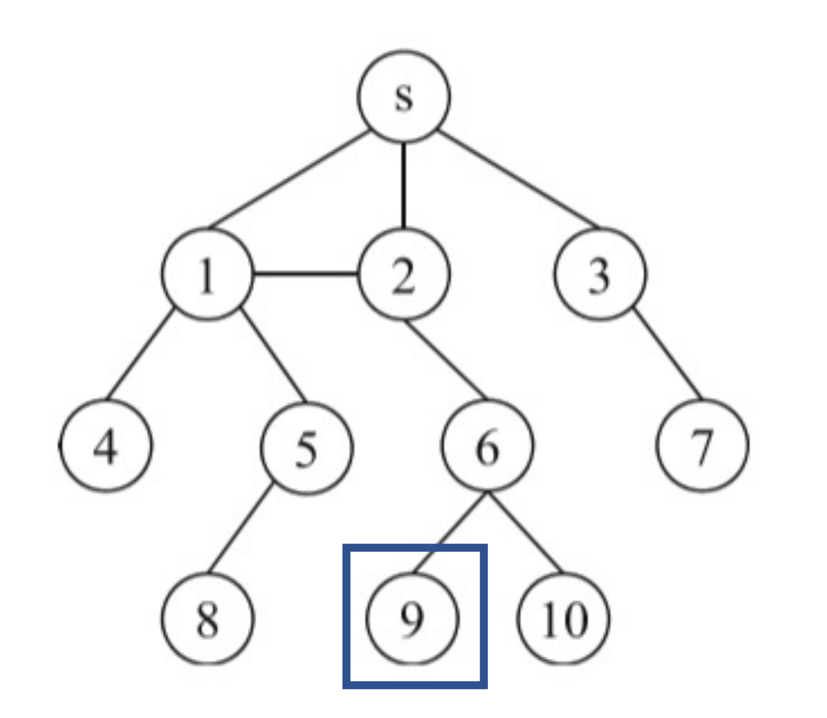

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Properties of the PEV-based DM

- The PEV-based diffusion mechanism is individually rational, incentive compatible and weakly budget balanced (all in expectation).
- The PEV-based diffusion mechanism cannot ensure efficiency (maximizing expected social welfare) in all instances.
- However, there is no mechanism can satisfy all four properties at the same time.

Summary

- We focus on the single-task allocation problem with execution uncertainty in the social network.

- We propose the PEV-based diffusion mechanism to incentivize agents to propagate the task information, thus involving more participants and finding a better worker. It finally successfully increase the expected utility of the task requester.

- Open problem: applicable mechanisms for multiple-task allocation settings where tasks have combinatorial qualities or there exist dependencies between tasks.

Thanks!

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