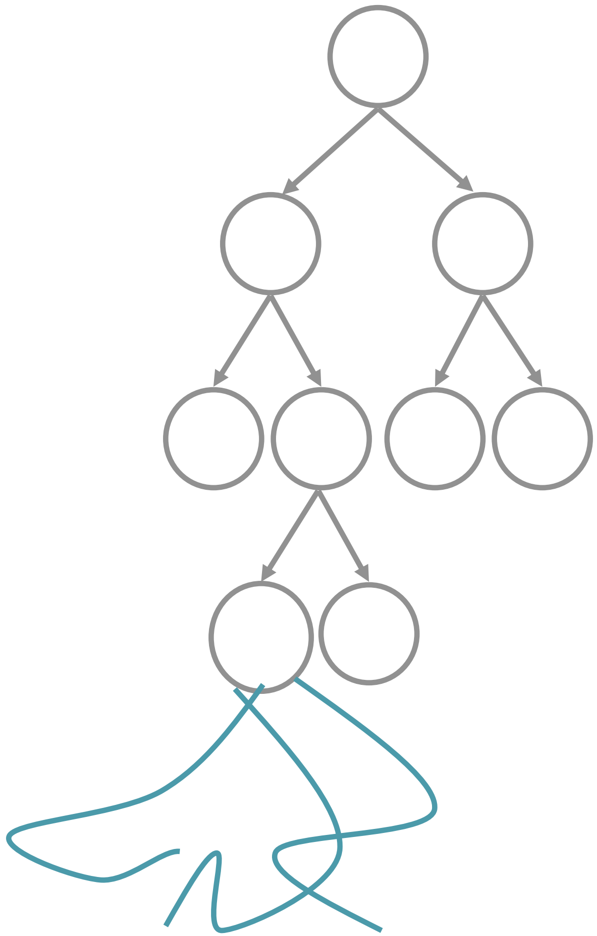

MONTE CARLO TREE SEARCH

ECS170 Spring 2018

Josh McCoy, @deftjams

Too Many Paths

α-β minimax time complexity:

$O\left(moves^{depth/2}\right)$ or $O\left(b^{m/2}\right)$

Monte Carlo Tree Search

- Alpha-Beta Minimax is good for modest branching factor with good heuristic.
- MCTS: no evaluation function/heuristic!
  - Do this many times:
    - Simulate with random moves
    - Score game outcome and keep stats
    - Play move with best stats.

The Tree Part

Statistics tree construction.

Used as a guide to focus on the most promising parts of the search tree.

Simulations determine utility/value.

MCTS Hight Level Process

1. Selection
2. Expansion
3. Play-out
4. Backpropagation

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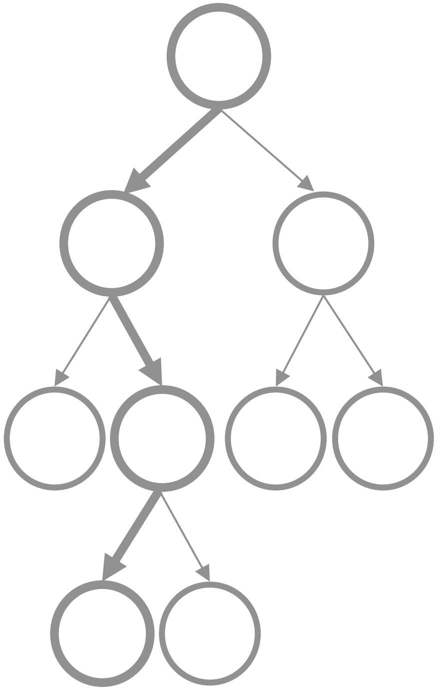

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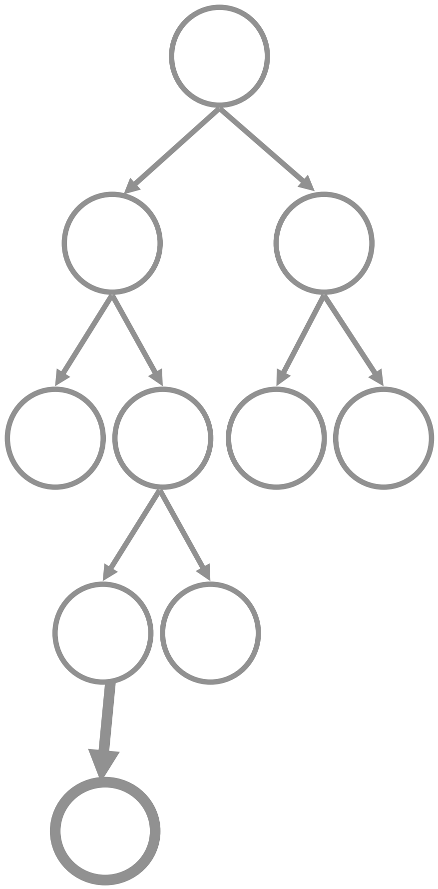

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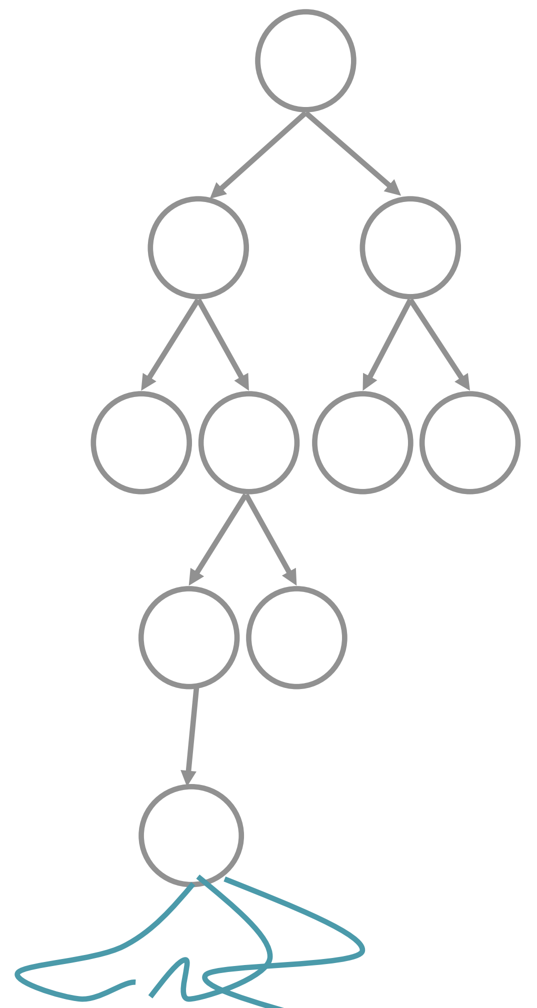

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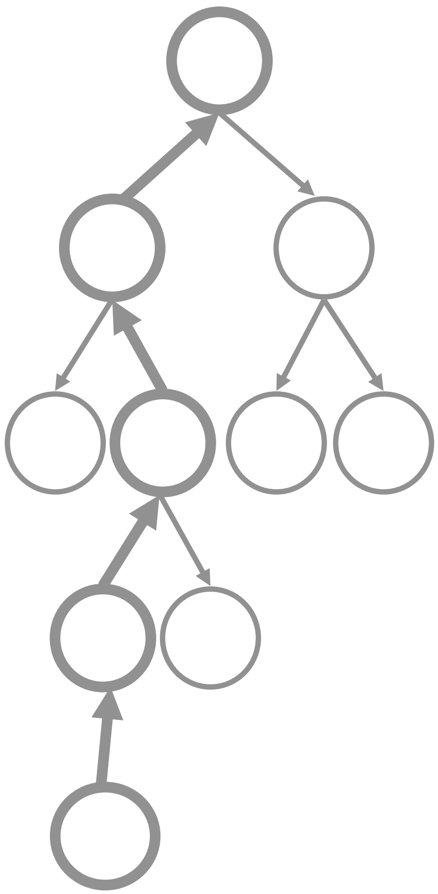


Upperbound Confidence

Multi-armed Bandit

P(A wins) = 0.4

P(B wins) = 0.55

P(C wins) = 0.7

P(D wins) = 0.3

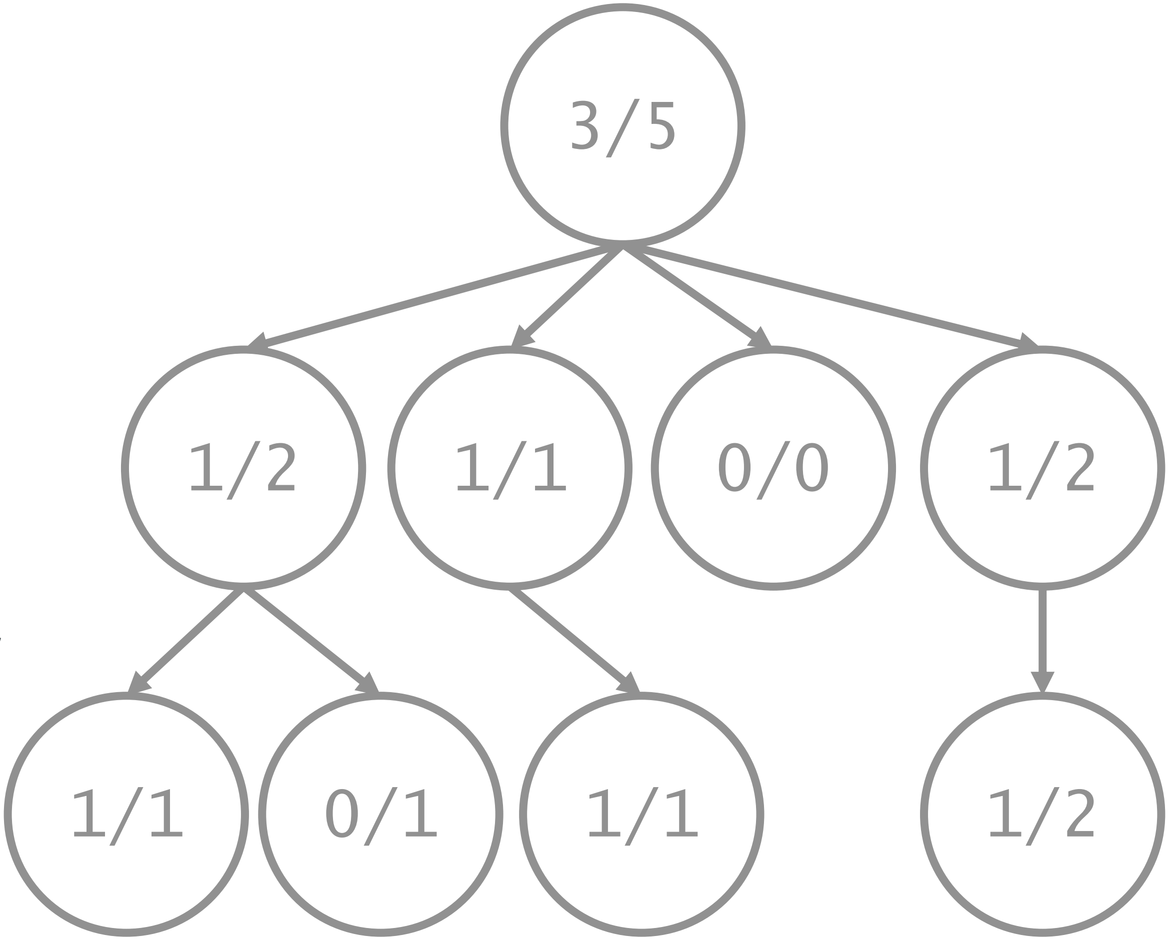
Each play has win/lose binary result.

Selection

We need:

- Tree of win statistics
- Selection policy

(still alternating player and opponent at each depth)



Upper Bound Confidence

$$\underbrace{v_i}_{\text{value/ utility}} = \underbrace{x_i}_{\text{mean reward}} + \sqrt{\frac{\ln(\overbrace{N}^{\text{total trials}})}{\underbrace{n_i}_{\text{trials for subtree}}}}$$

- Higher value estimate is better
- Gives an estimate of true value.
- More trials makes better estimate

```
v_i = x_i + math.sqrt(math.log(N)/n_i)
```

AAAI-14 Games Tutorial, by Martin Muller:

Upper Bound Confidence

$$v_i = x_i + \sqrt{\frac{\ln(N)}{n_i}}$$

total trials

trials for subtree

value/ utility

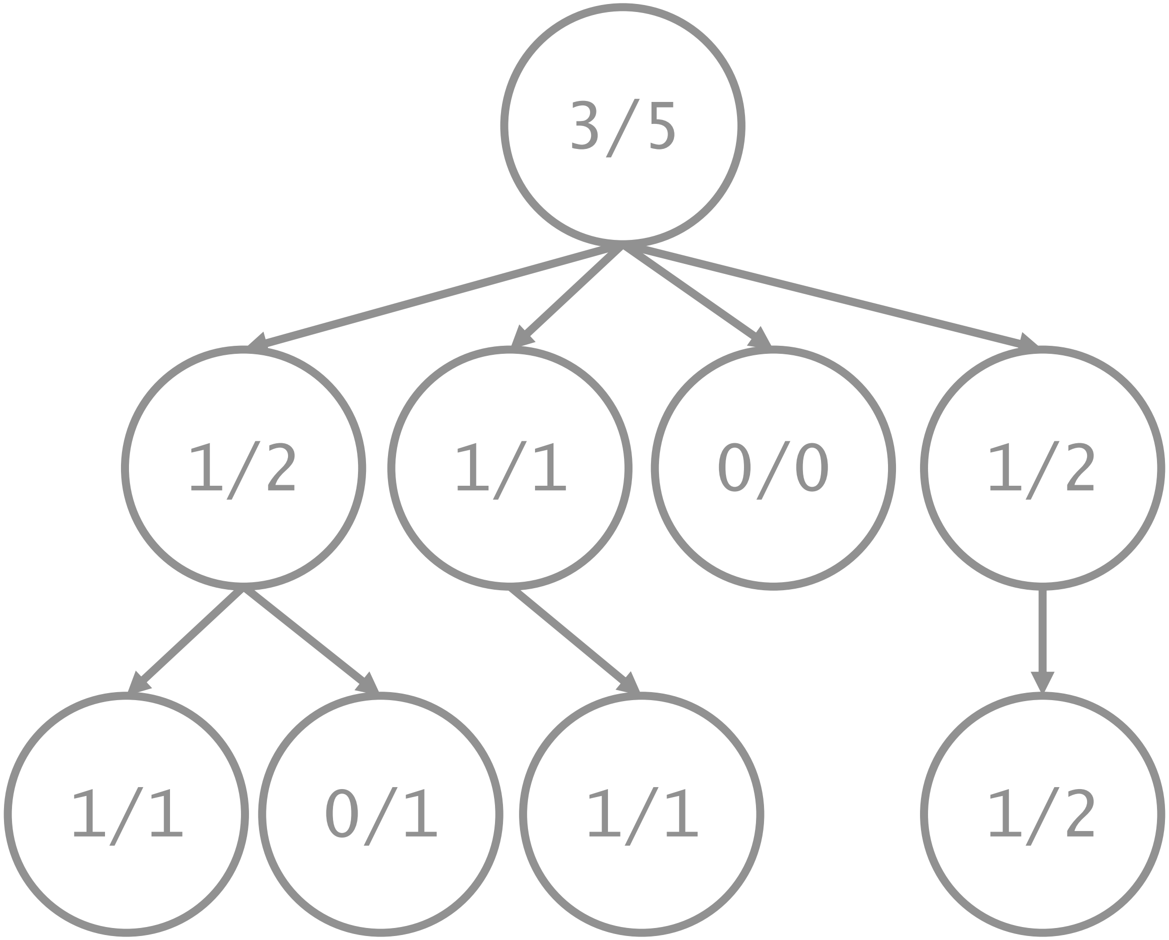
mean reward

- Confidence interval is large when n_i is small, shrinks in proportion to $\sqrt{n_i}$
  - High uncertainty about move, larger **exploration** term
- Explore: if trials is less than total trials.
- Tolerant to adversarial situations.

AAAI-14 Games Tutorial, by Martin Muller:

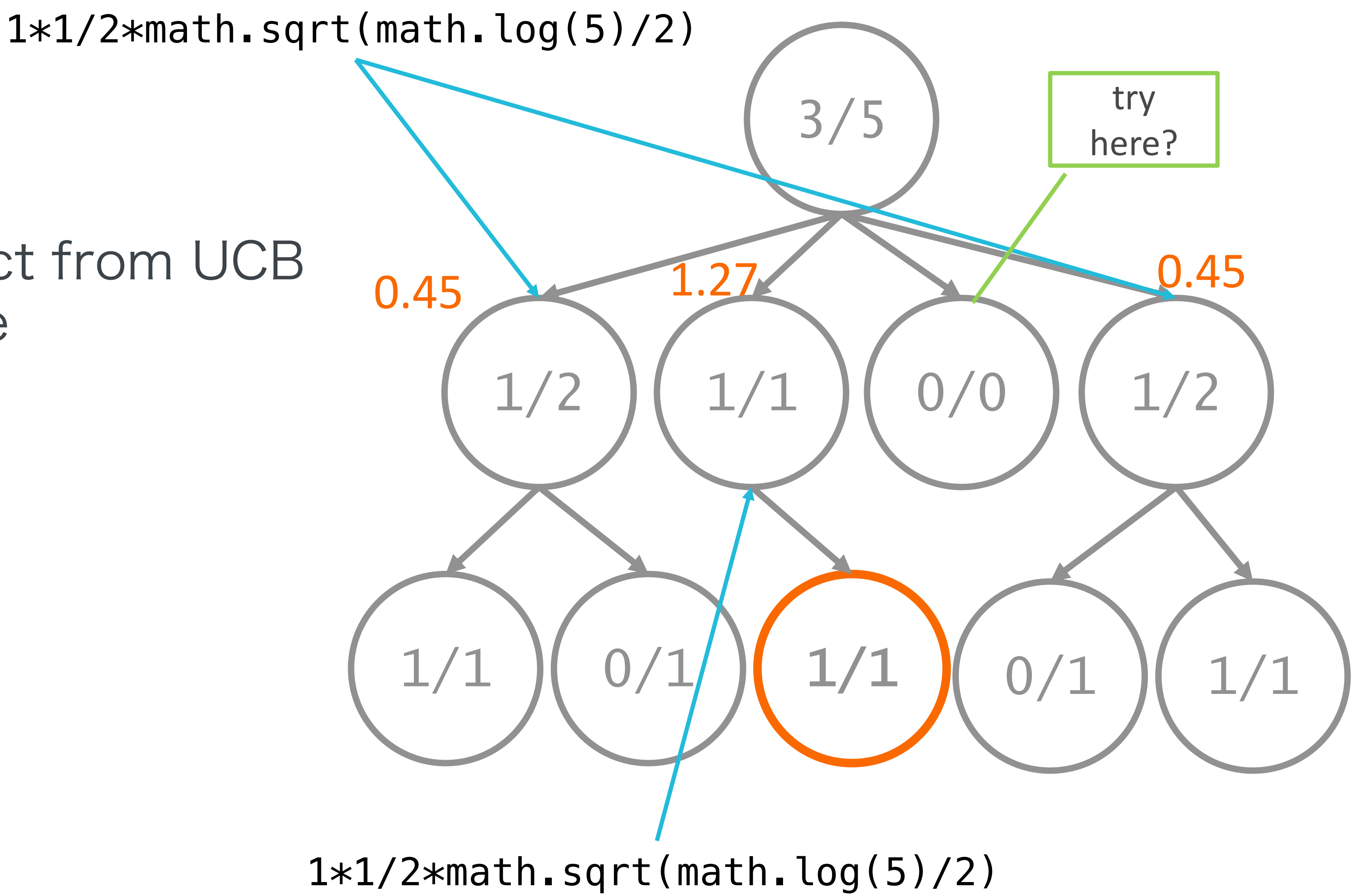
Selection

Select from UCB value



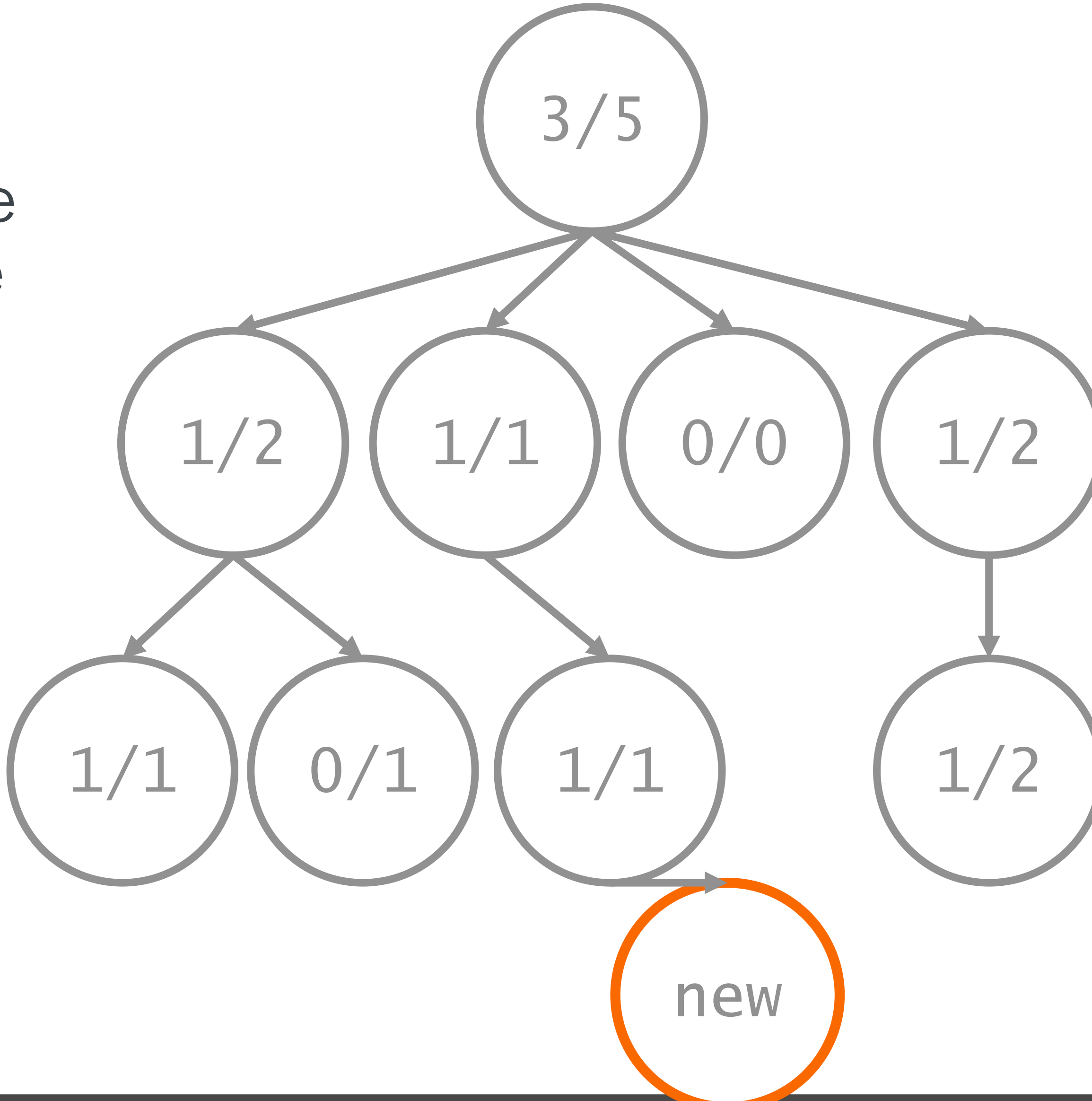
Selection

Select from UCB value



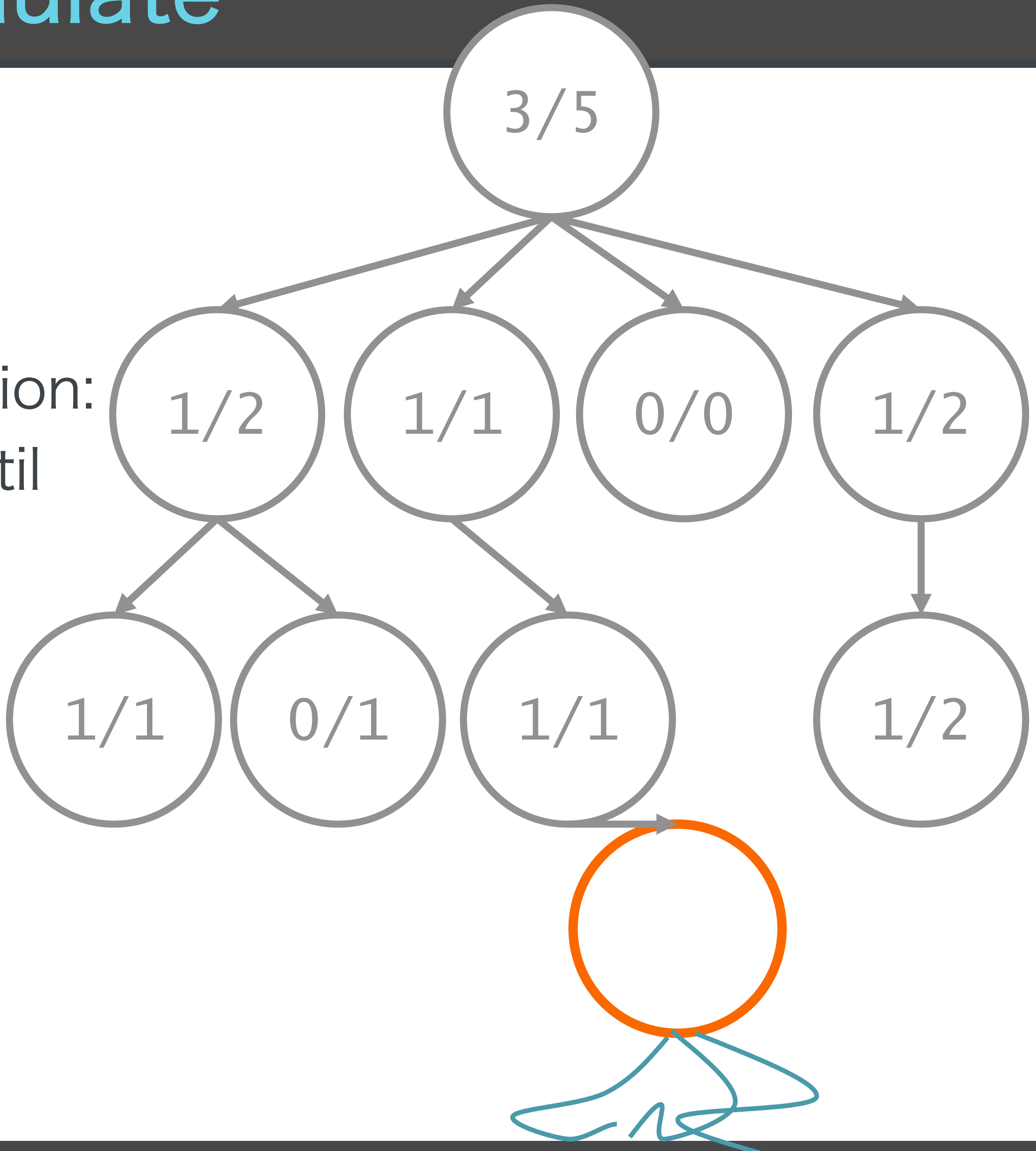
Expansion

Create a new node on the search tree based off UCB1.



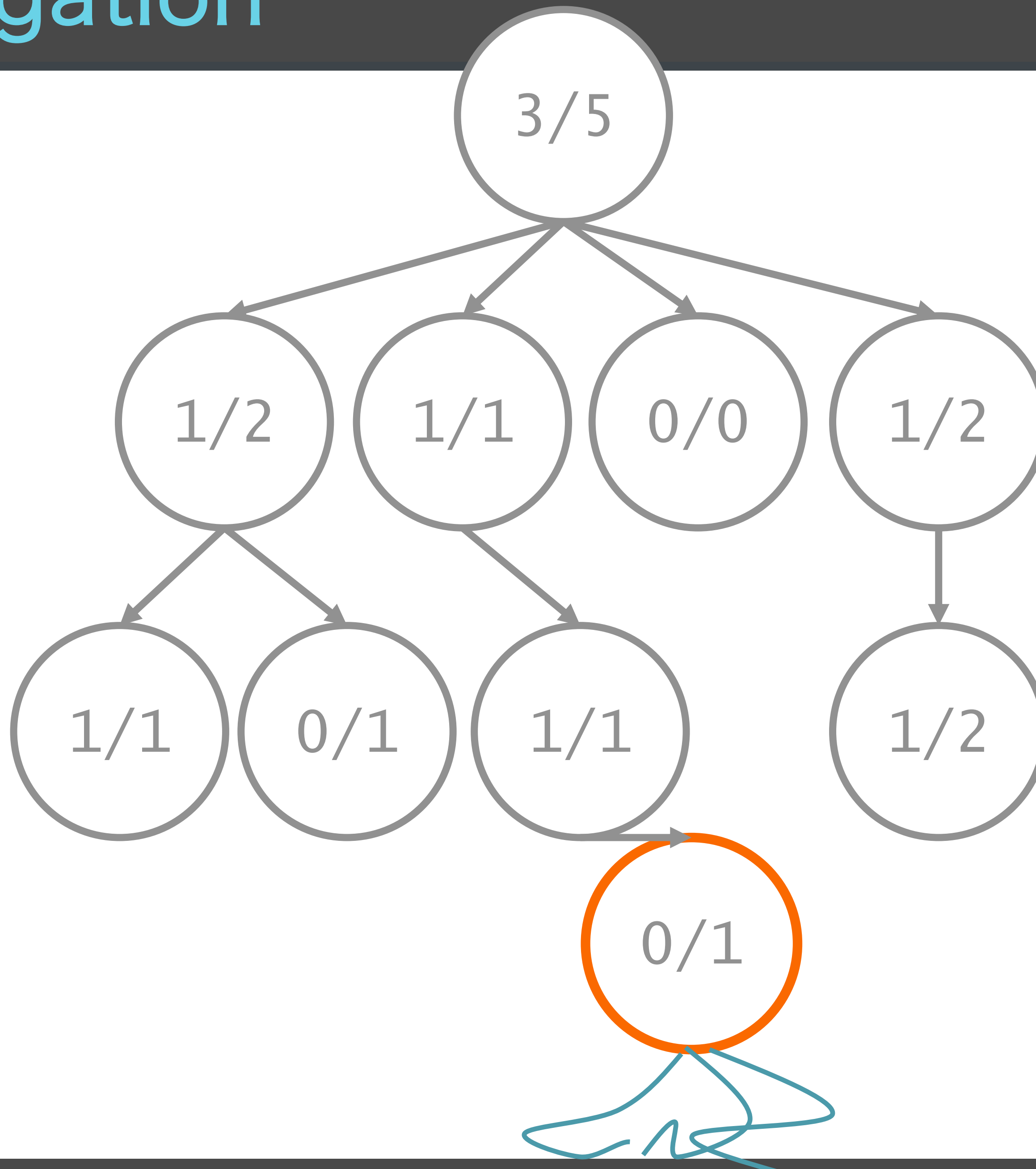
Playout/Simulate

Stochastic simulation: random moves until payout.



Back Propagation

Update the tree based off simulation results.



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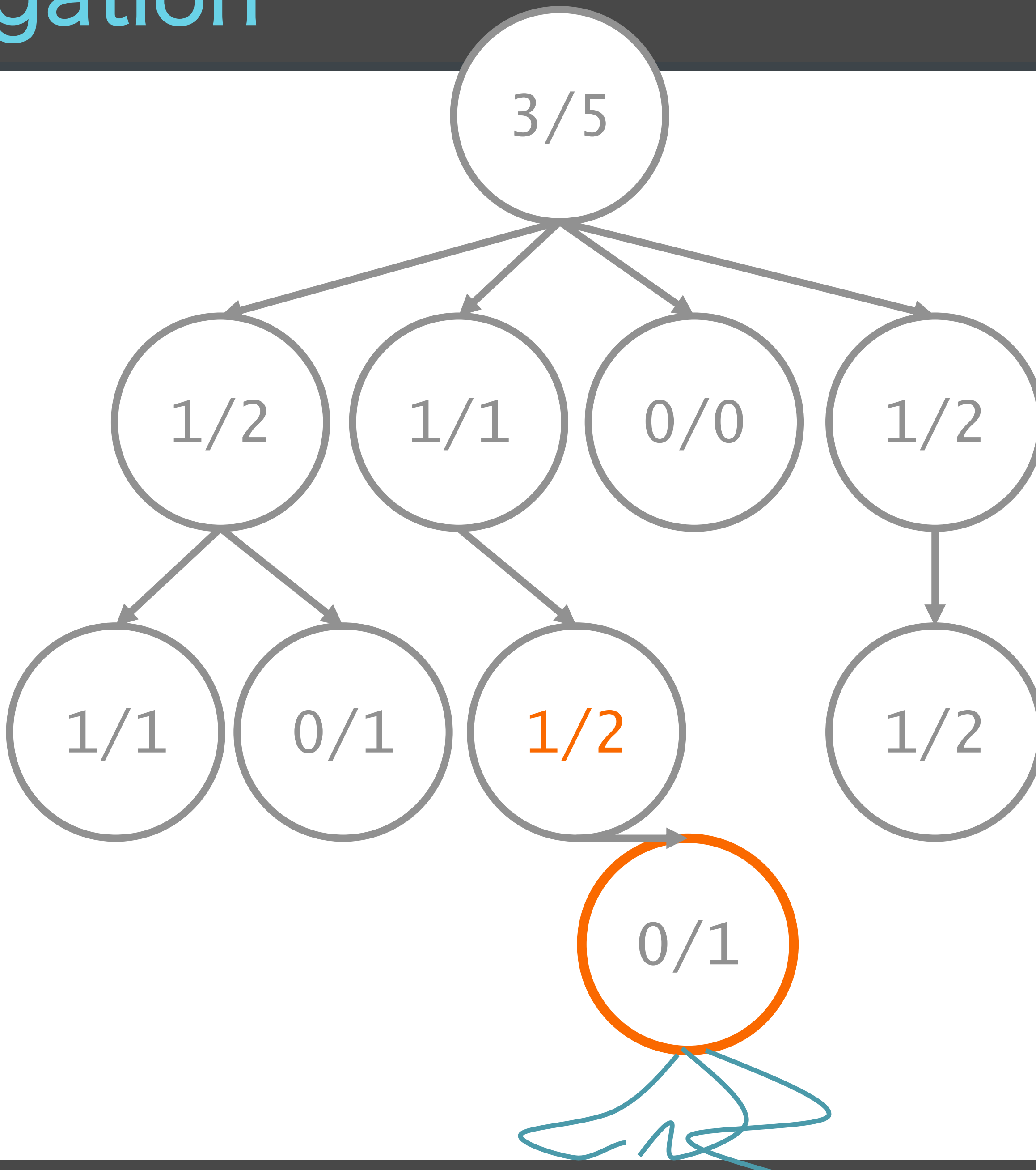

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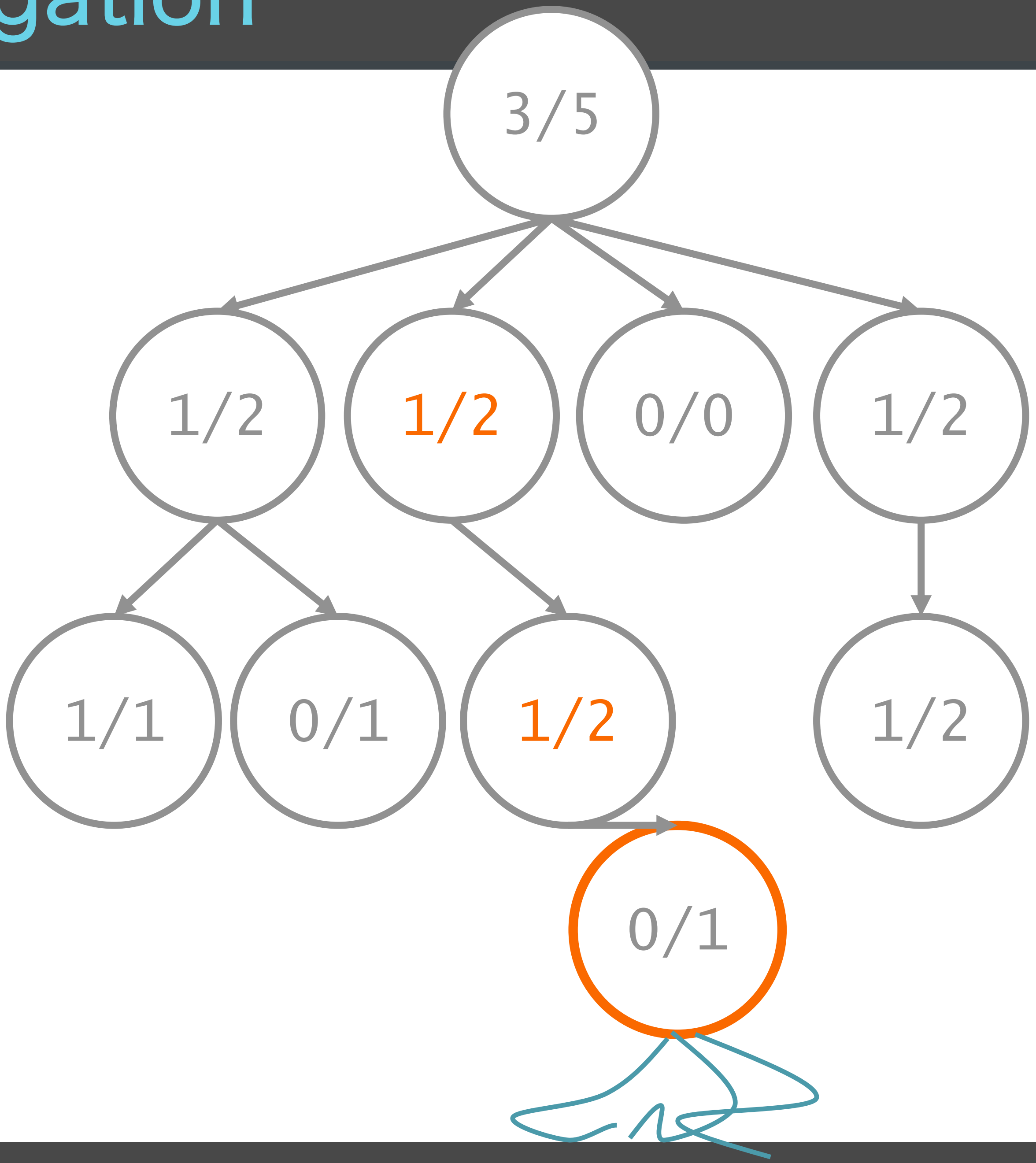

Back Propagation

Update the tree based off simulation results.