CIS 521:
ARTIFICIAL INTELLIGENCE

Expectimax and Utilities

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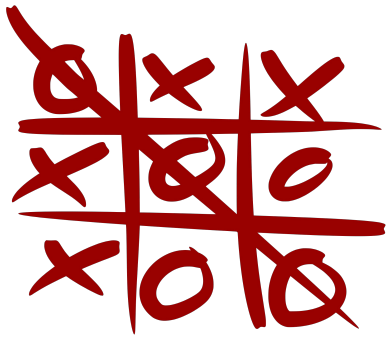
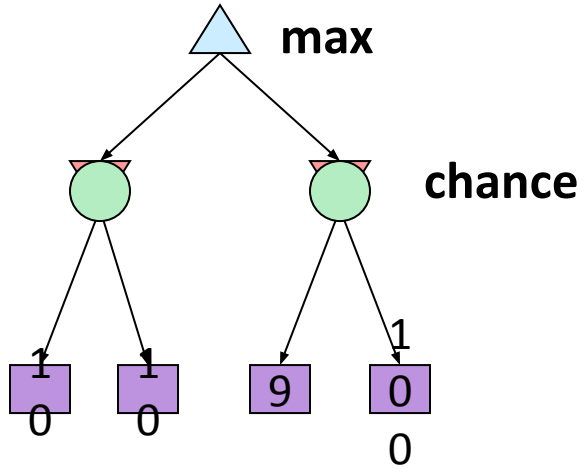
Many of today's slides are courtesy of Dan Klein and Pieter Abbeel of University of California, Berkeley

Penn Engineering
University of Pennsylvania

Uncertain Outcomes

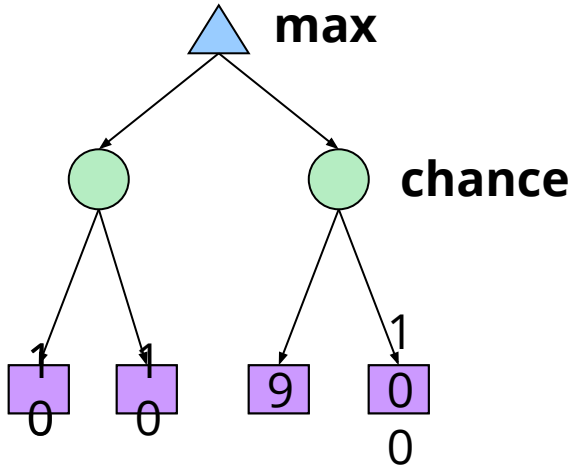




Idea: Uncertain outcomes controlled by chance, not an adversary!

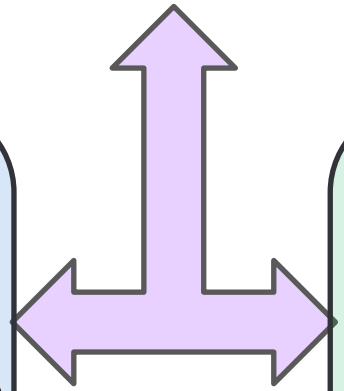
Expectimax Search

- Why wouldn't we know what the result of an action will be?
  - Explicit randomness: rolling dice
  - Unpredictable opponents: the opponent isn't optimal
  - Actions can fail: when moving a robot, wheels might slip
- Values should now reflect average-case (expectimax) outcomes, not worst-case (minimax) outcomes
- Expectimax search: compute the average score under optimal play
  - Max nodes as in minimax search
  - Chance nodes are like min nodes but the outcome is uncertain
  - Calculate their expected utilities
  - I.e. take weighted average (expectation) of children
- Later, we'll learn how to formalize the underlying uncertain-result problems as Markov Decision Processes



Expectimax Pseudocode

```
def value(state):
    if the state is a terminal state: return the state's
      utility
    if the next agent is MAX: return max-value(state)
    if the next agent is EXP: return exp-value(state)
```

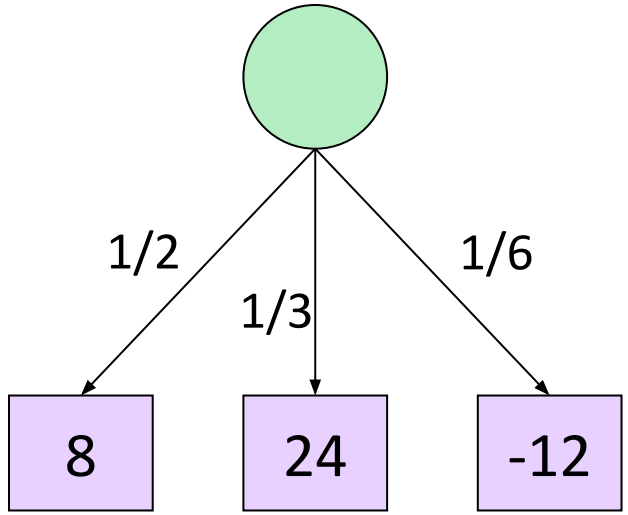


```
def max-value(state):
    initialize v = -∞
    for each successor of state:
        v = max(v, value(successor))
    return v
```

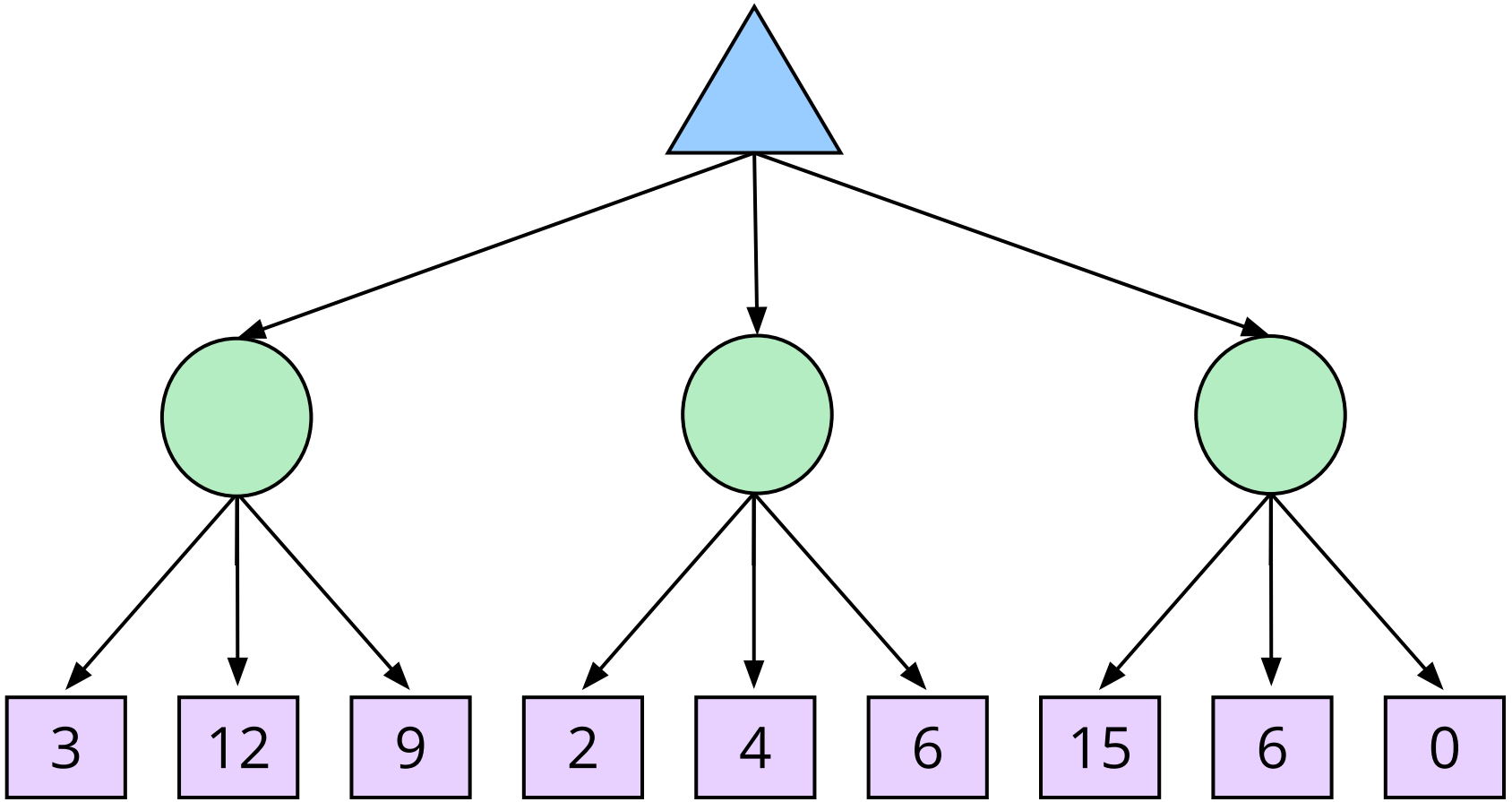
```
def exp-value(state):
    initialize v = 0
    for each successor of state:
        p = probability(successor)
        v += p *
      value(successor)
    return v
```

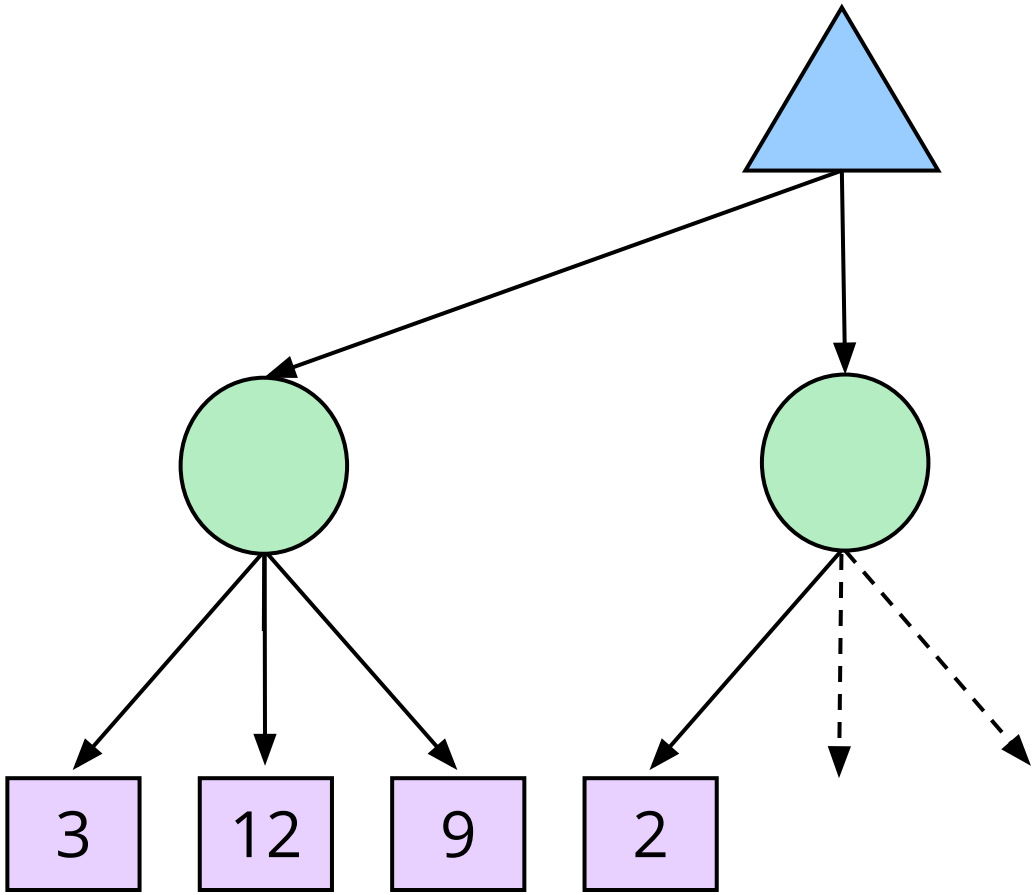
Expectimax Pseudocode

```
def exp-value(state):
  initialize v = 0
  for each successor of state:
      p =
   probability(successor)
      v += p *
   value(successor)
  return v
```



$$v = \frac{1}{2} \cdot (8) + \frac{1}{3} \cdot (24) + \frac{1}{6} \cdot (-12)$$


3
12
9
2
4
6
15
6
0


3
12
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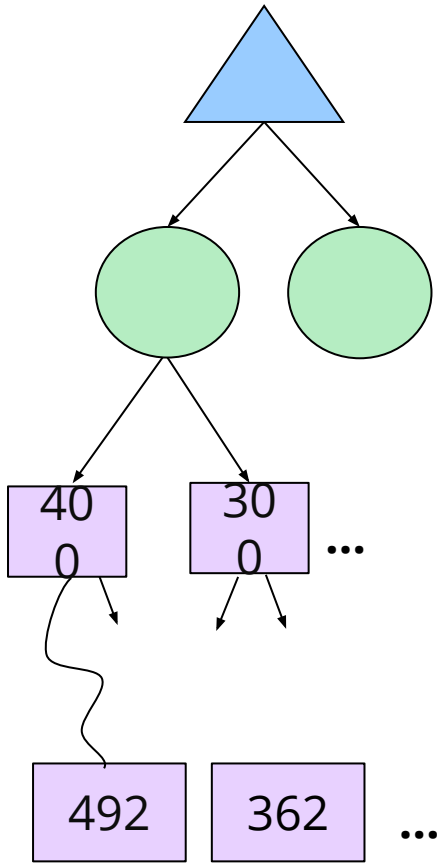

Estimate of true expectimax value (which would require a lot of work to compute)