General Game Playing

Statistical Search

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Statistical Methods

Evaluation functions examined thus far

- Based on properties of small portions of game tree
- e.g. mobility, intermediate state values

Statistical Methods

- Based on statistical analysis
- Based on larger portions of game trees

Methods:

- Monte Carlo Search
- Monte Carlo Tree Search (in particular UCT)

Monte Carlo Search

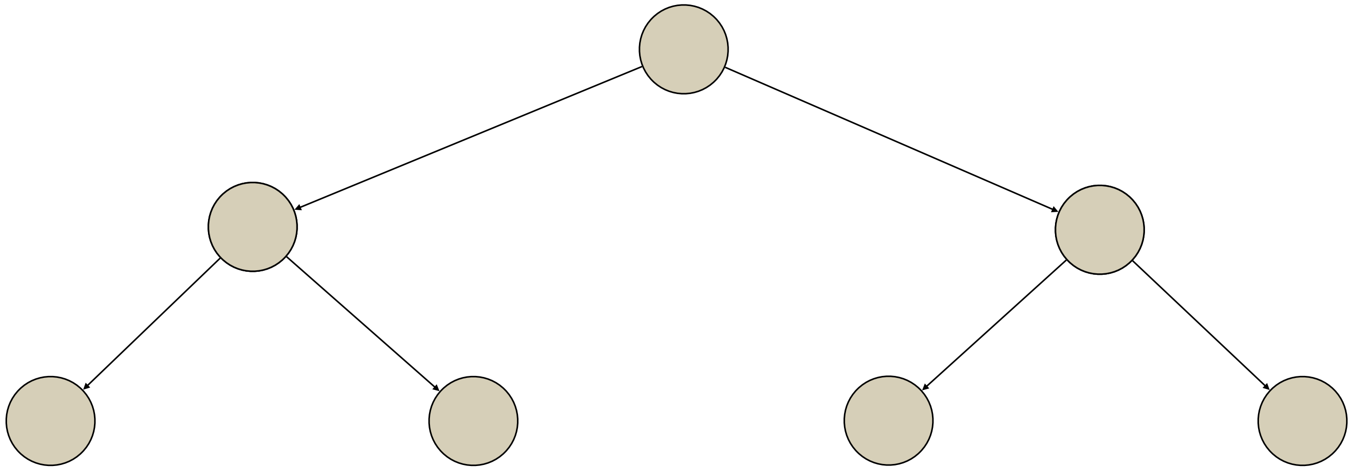
Basic Idea

(1) Optionally explore game graph to some level.

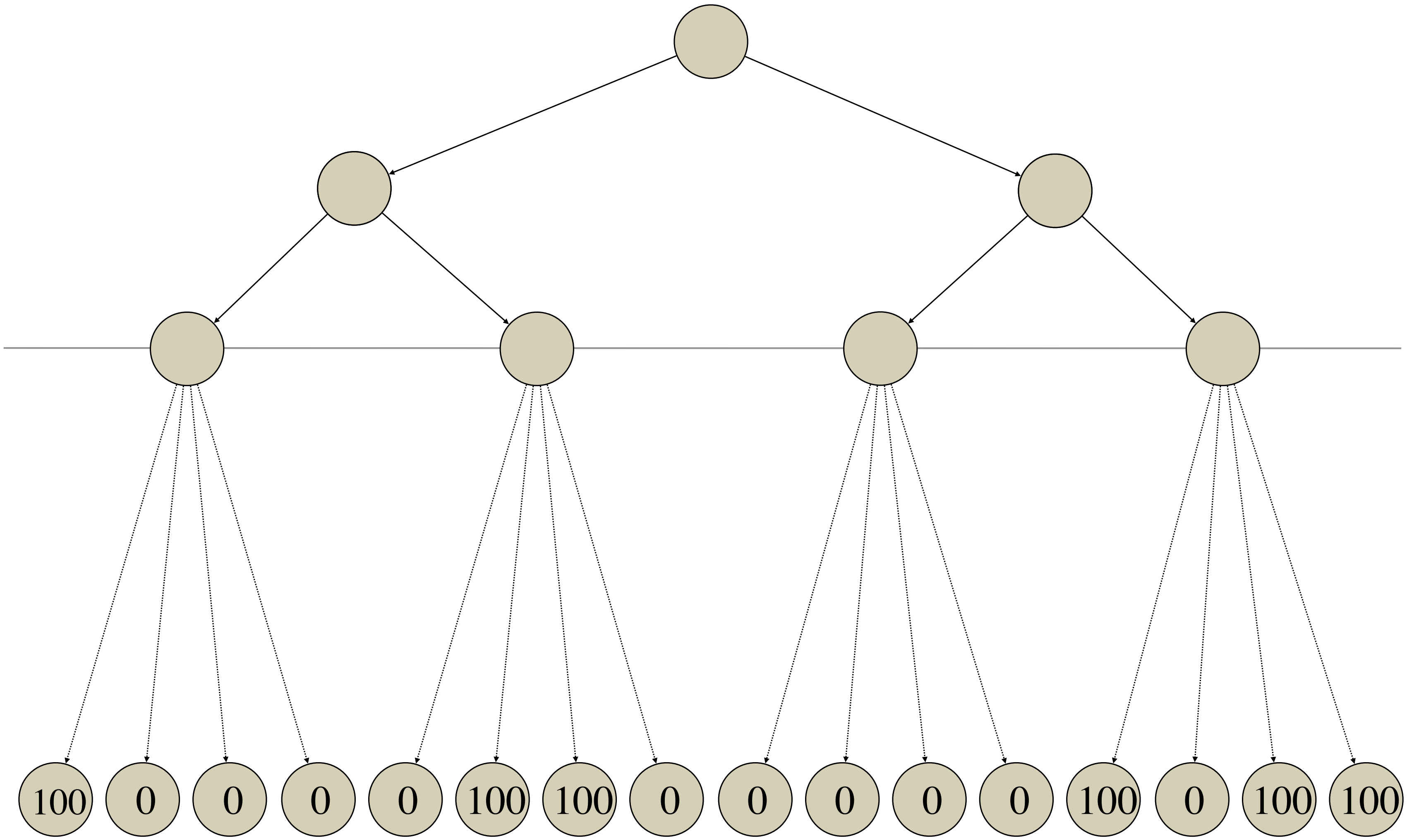
(2) Beyond this, explore to end of game from fringe nodes, making random choices for moves of all players.

(3) Assign expected utilities to fringe states by summing utilities and dividing by number of trials.

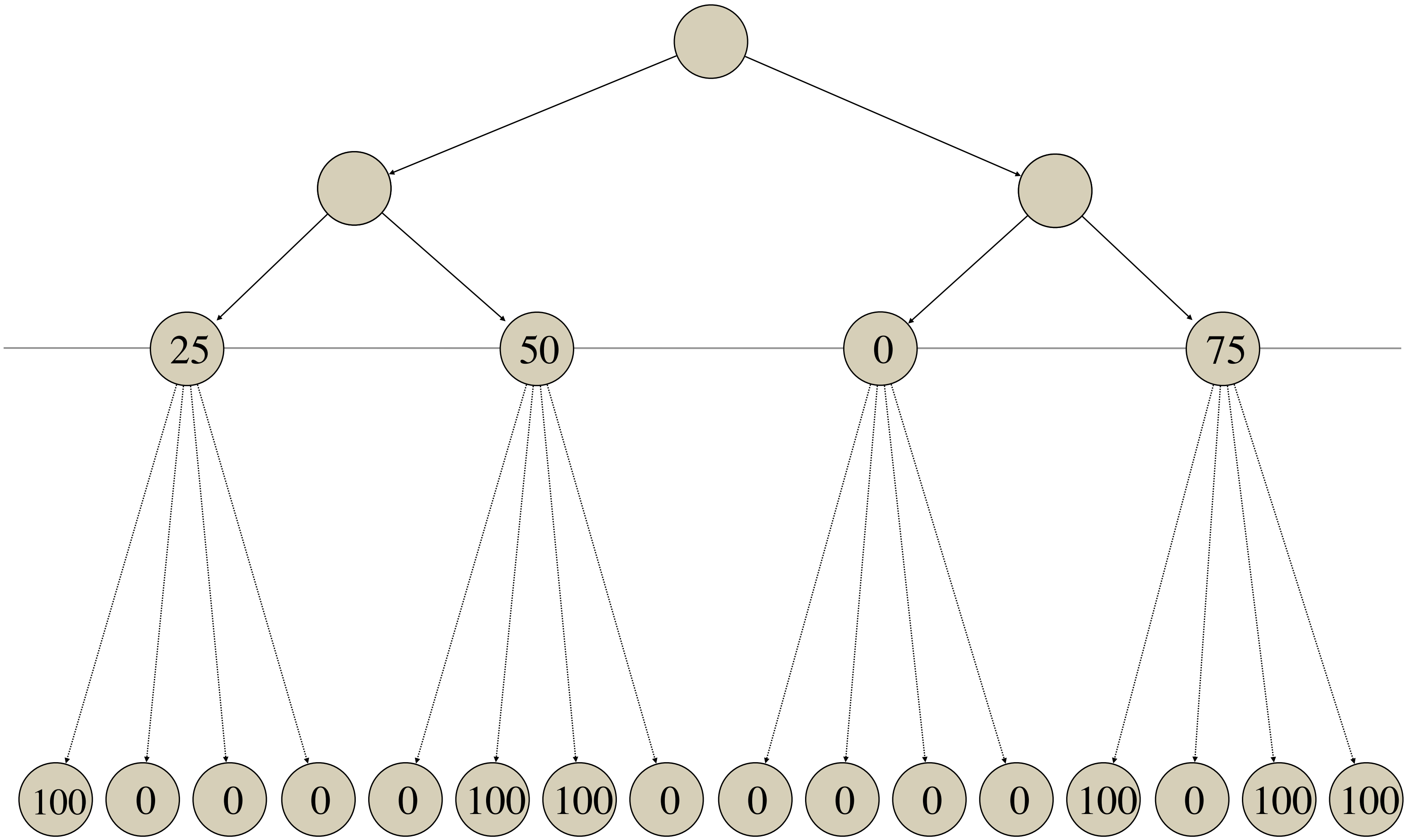
Example



Example



Example



Implementation

```
function maxscore (state,level)
 {if (findterminalp(state,ruleset))
     {return findreward(role,state,ruleset)};
  if (level>levels) {return montecarlo(state)};
  var actions = findlegals(role,state,ruleset);
  var score = 0;
  for (var i=0; i<actions.length; i++)
      {var result = minscore(actions[i],state,level);
       if (result==100) {return 100};
       if (result>score) {score = result}};
  return score}
```

Implementation

```
function montecarlo (state)
 {var total = 0;
  for (var i=0; i<count; i++)
      {total = total + depthcharge(state)};
  return total/count}

function depthcharge (state)
 {if (findterminalp(state,ruleset))
     {return findreward(role,state,ruleset)};
  var move = seq();
  for (var i=0; i<roles.length; i++)
      {var options = findlegals(roles[i],state,library);
       var best = randomindex(options.length);
       move[i] = options[best]};
  var newstate = findnexts(move,state,library);
  return depthcharge(newstate)}
```

Problems and Features

Problems

- Optimistic - opponent might not respect probabilities

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Benefits

- Fast because no branching
- Small space because nothing stored in probes
- Provides guidance when other heuristics fail

Monte Carlo Tree Search

Basic Idea

Monte Carlo Tree Search (MCTS) is a search method that relies on random probes to estimate state values. Blend of Greedy and MCS.

Like MCS:

Builds up game tree incrementally

Random probes to end of game to estimate state values

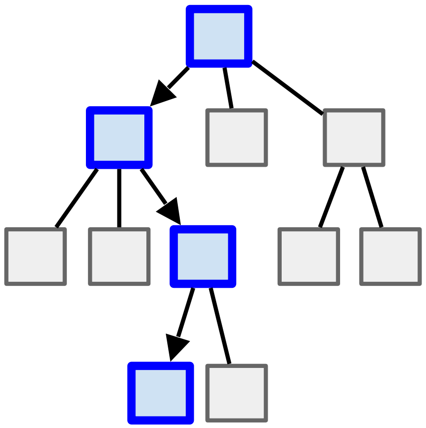
Like Greedy:

MCS expands tree uniformly

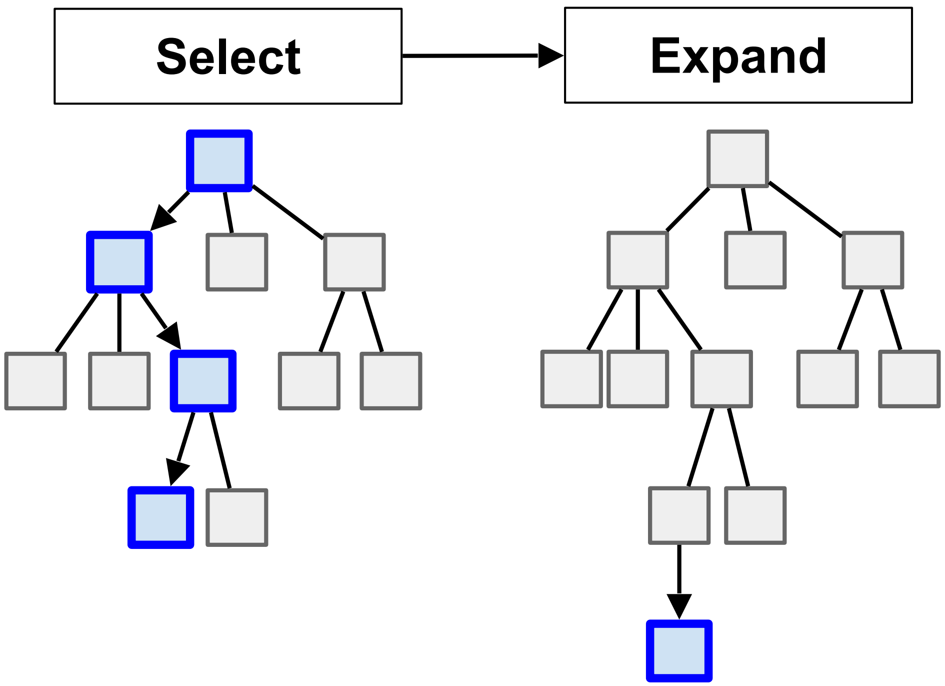
MCTS expands nonuniformly like Greedy

Overview

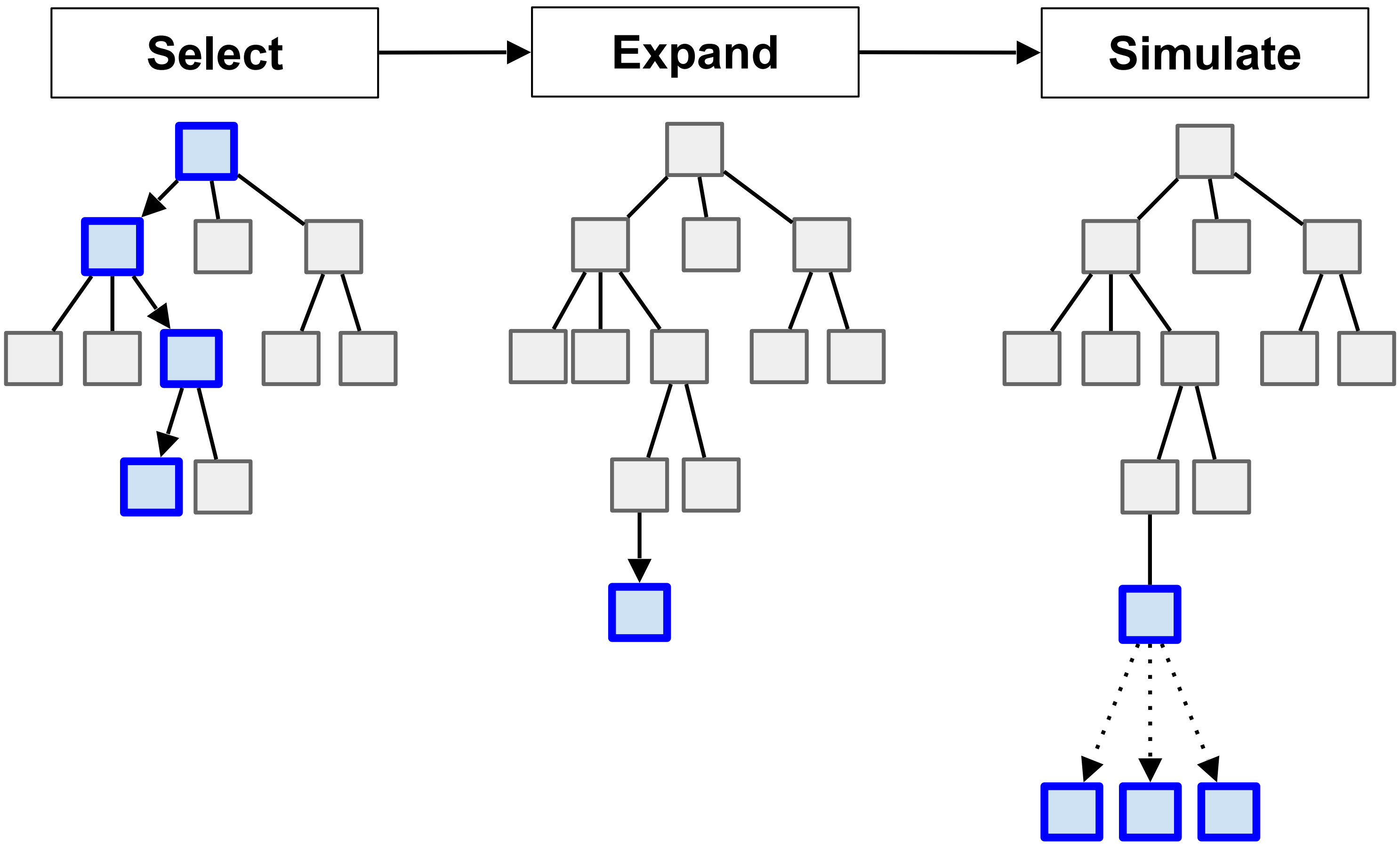
Select



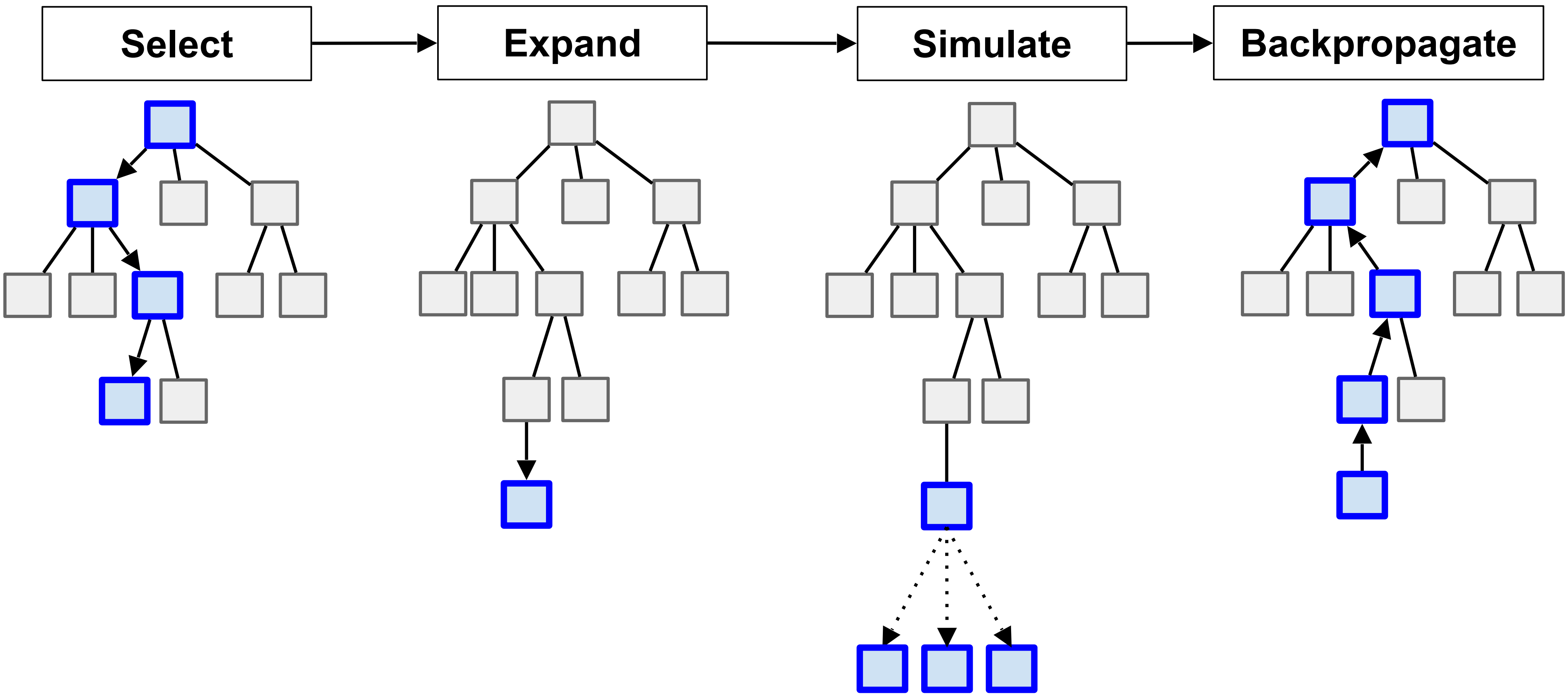
Overview



Overview



Overview



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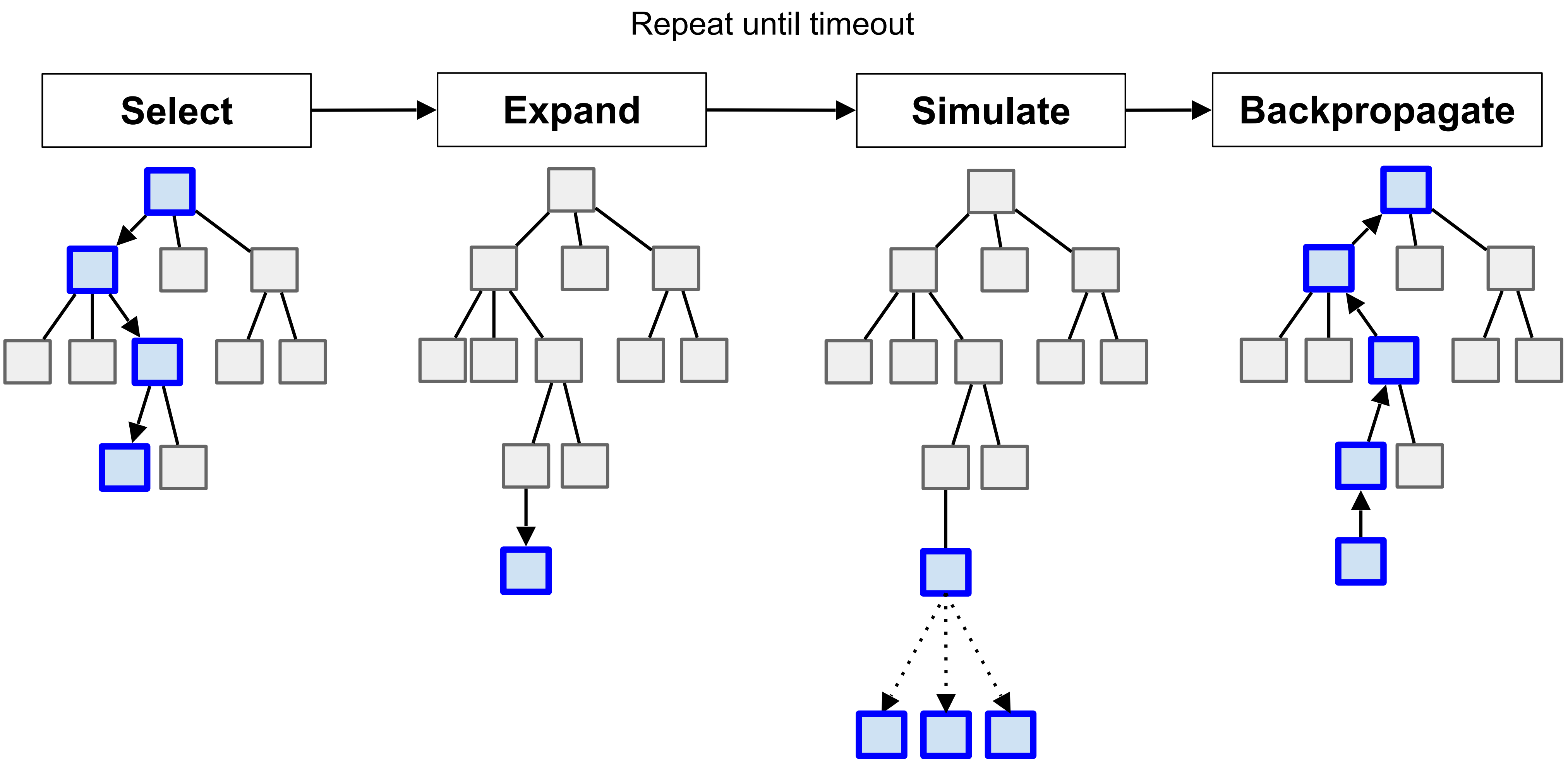
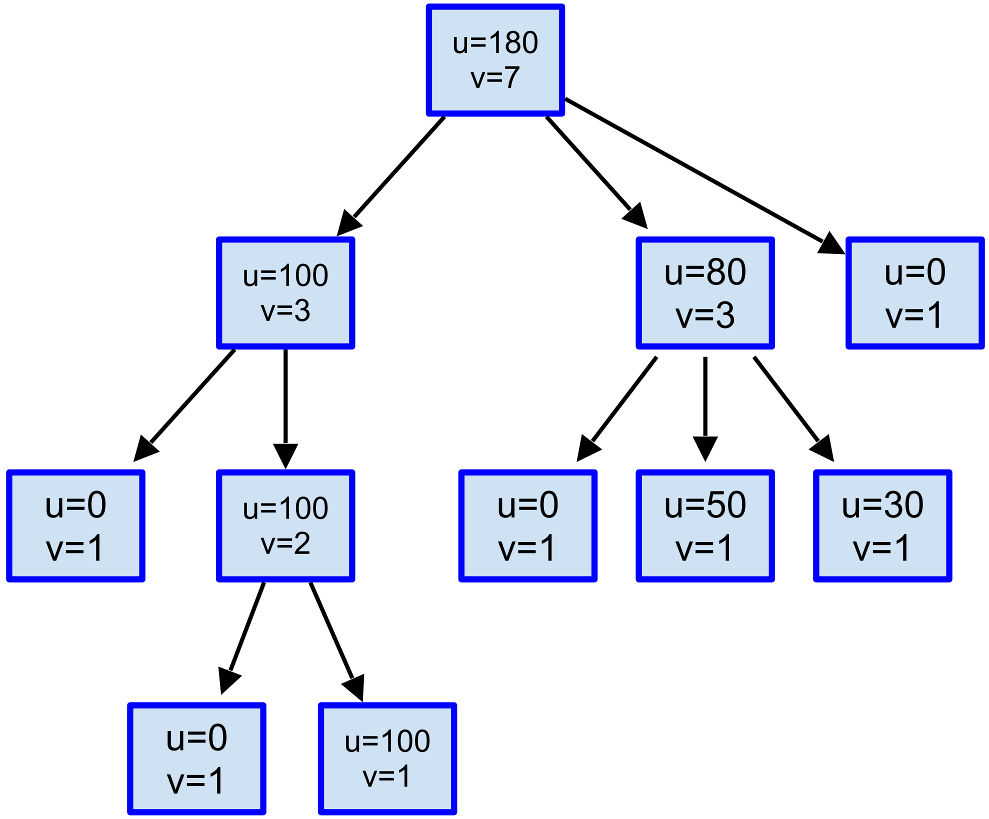
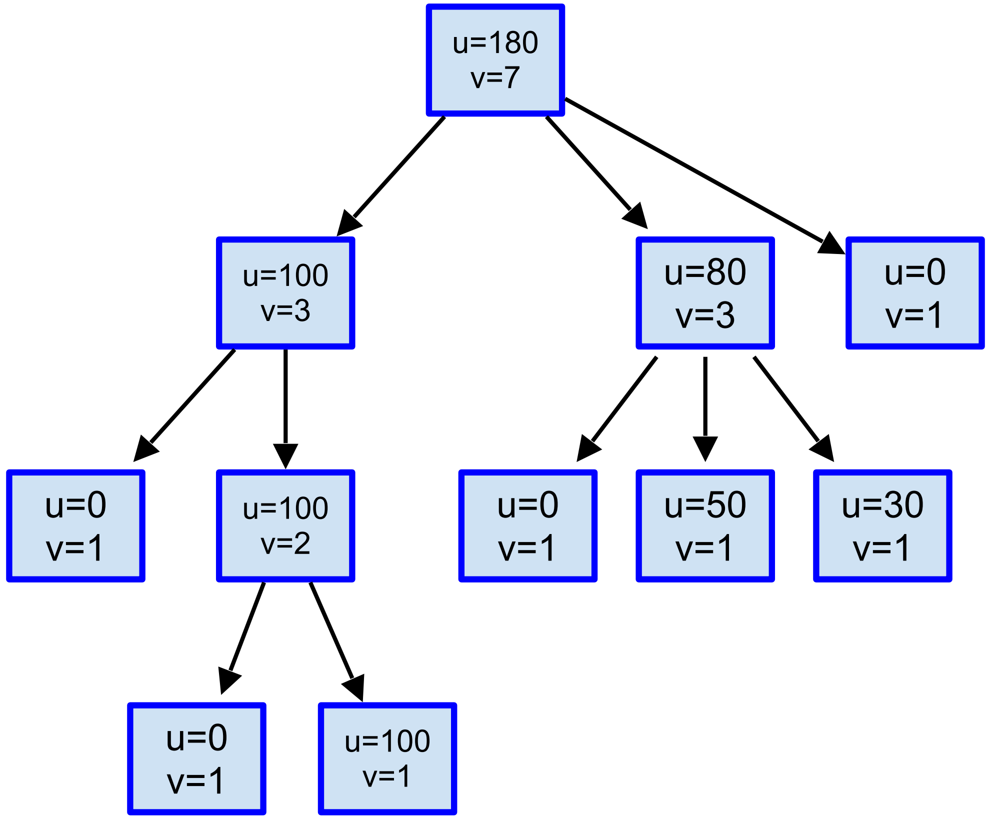

Repeat until timeout
Select
Expand
Simulate
Backpropagate

Single Player



Select



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v=7
u=100
v=3
u=80
v=3
u=0
v=1
u=0
v=1
u=100
v=2
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v=1
u=50
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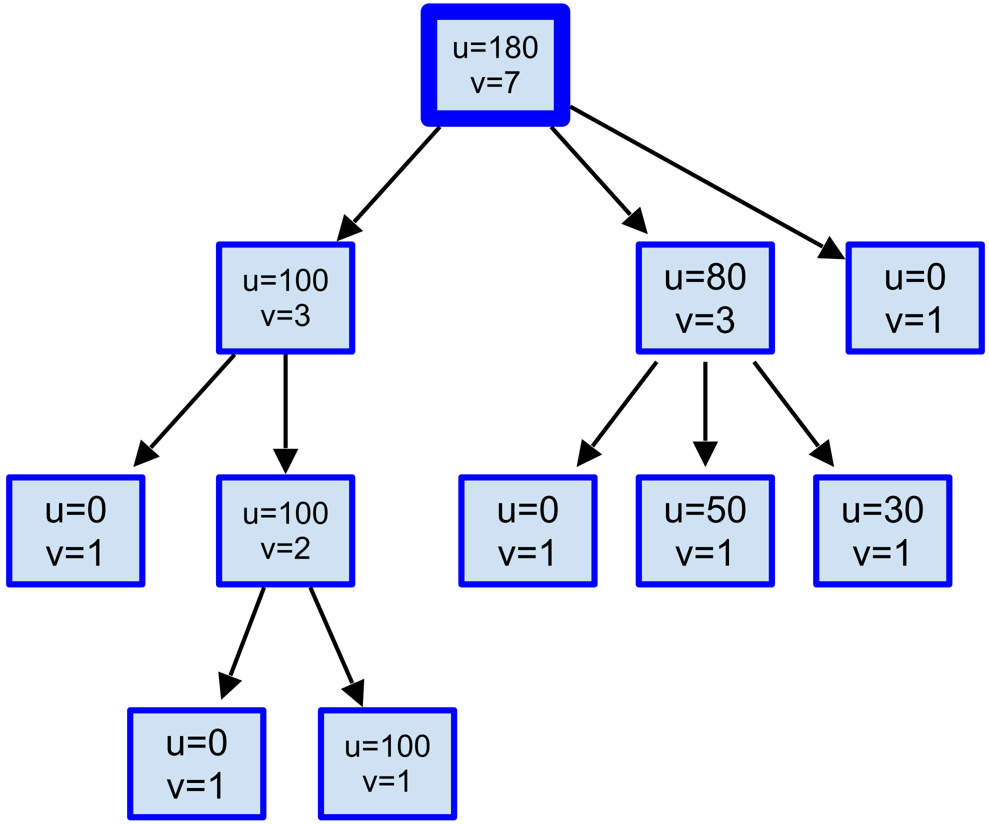
u=0
v=1
u=100
v=1

Select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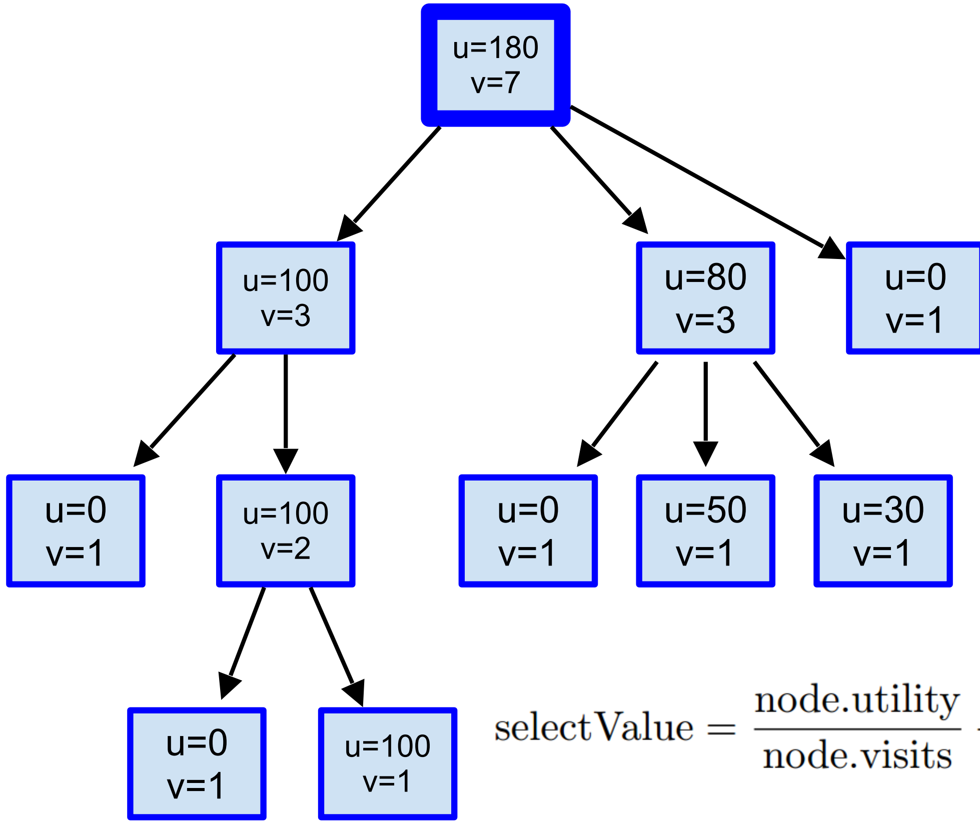
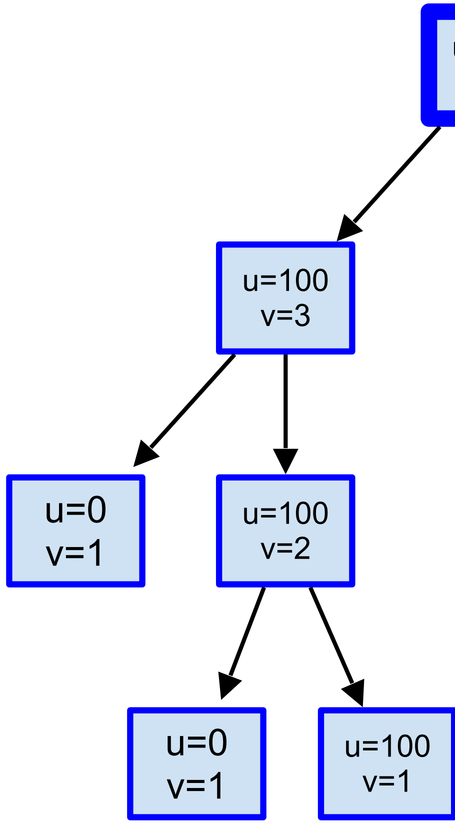


$$\text{selectValue} = \frac{\text{node.utility}}{\text{node.visits}} + C \times \sqrt{\frac{\ln(\text{node.parent.visits})}{\text{node.visits}}}$$

Select



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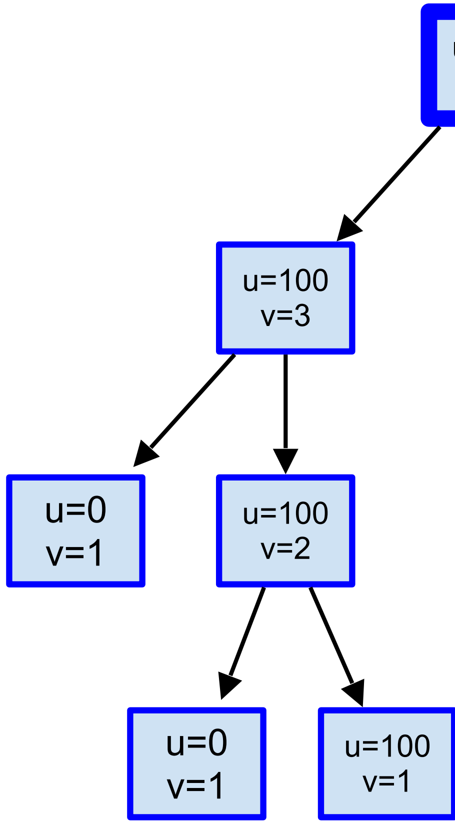
Exploitation

Select



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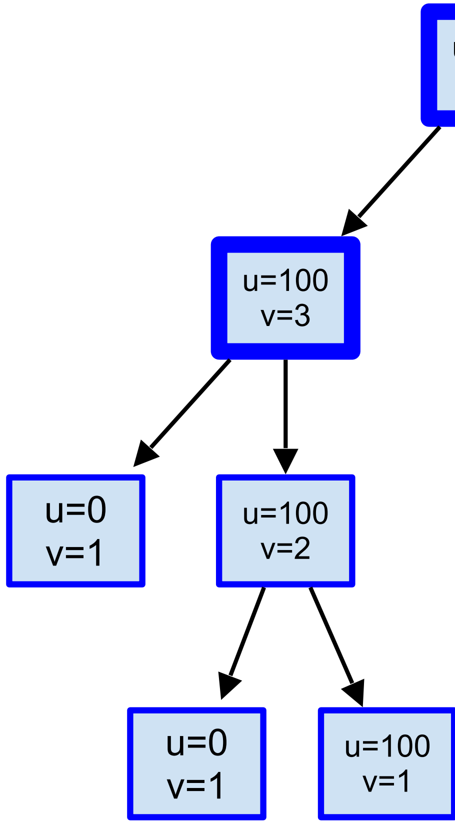
Exploitation Exploration

Select



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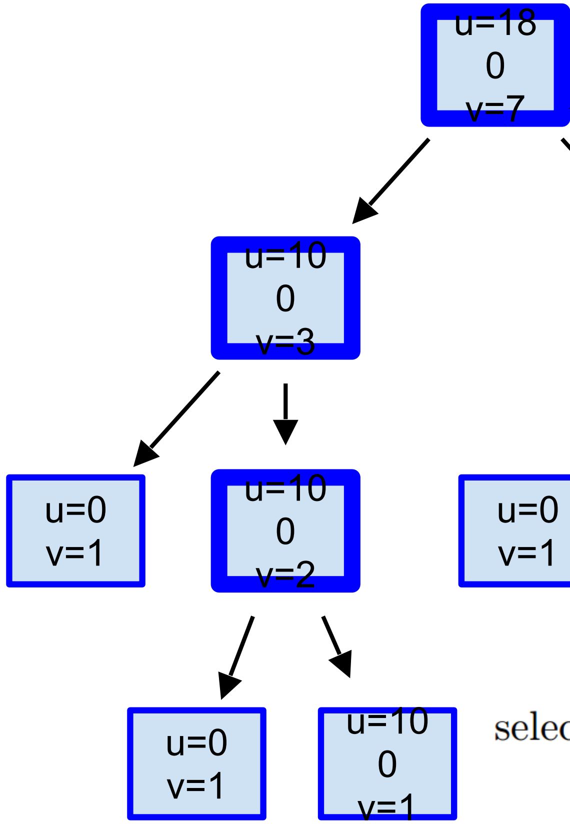

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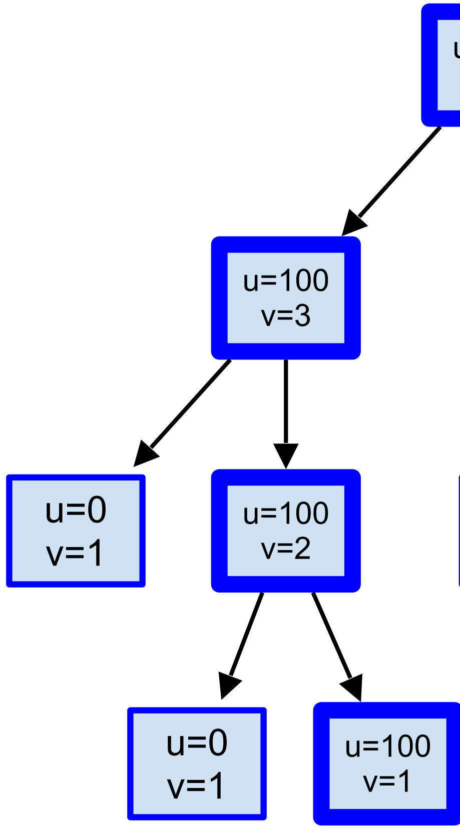

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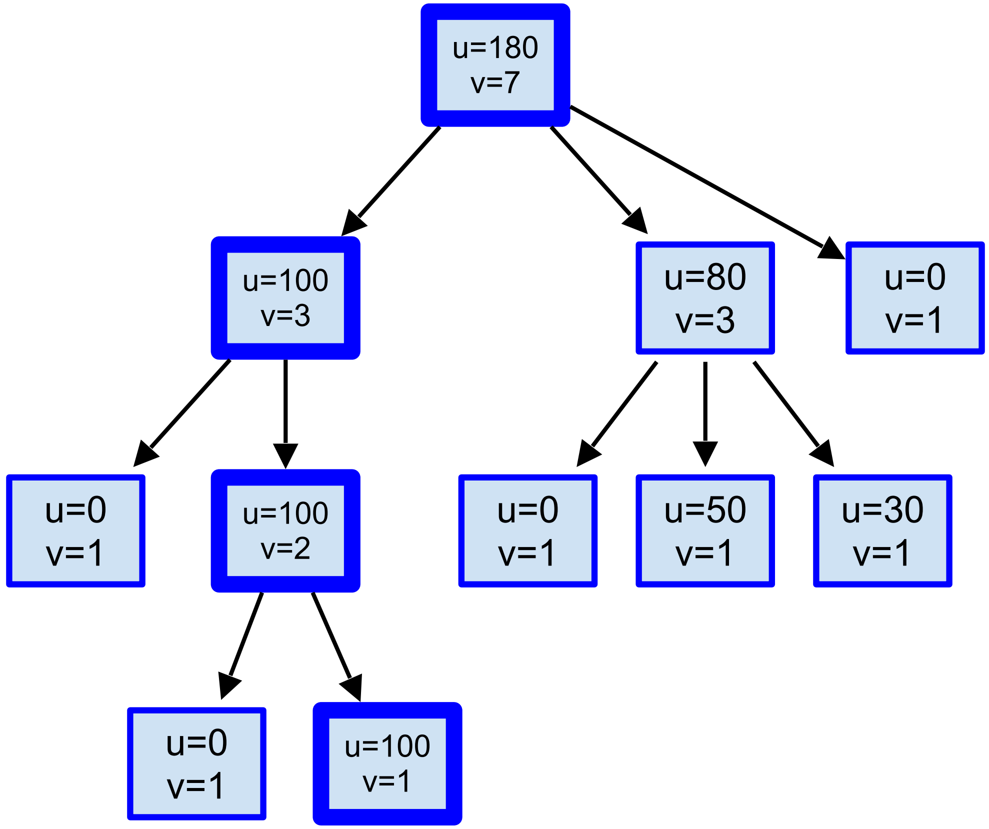
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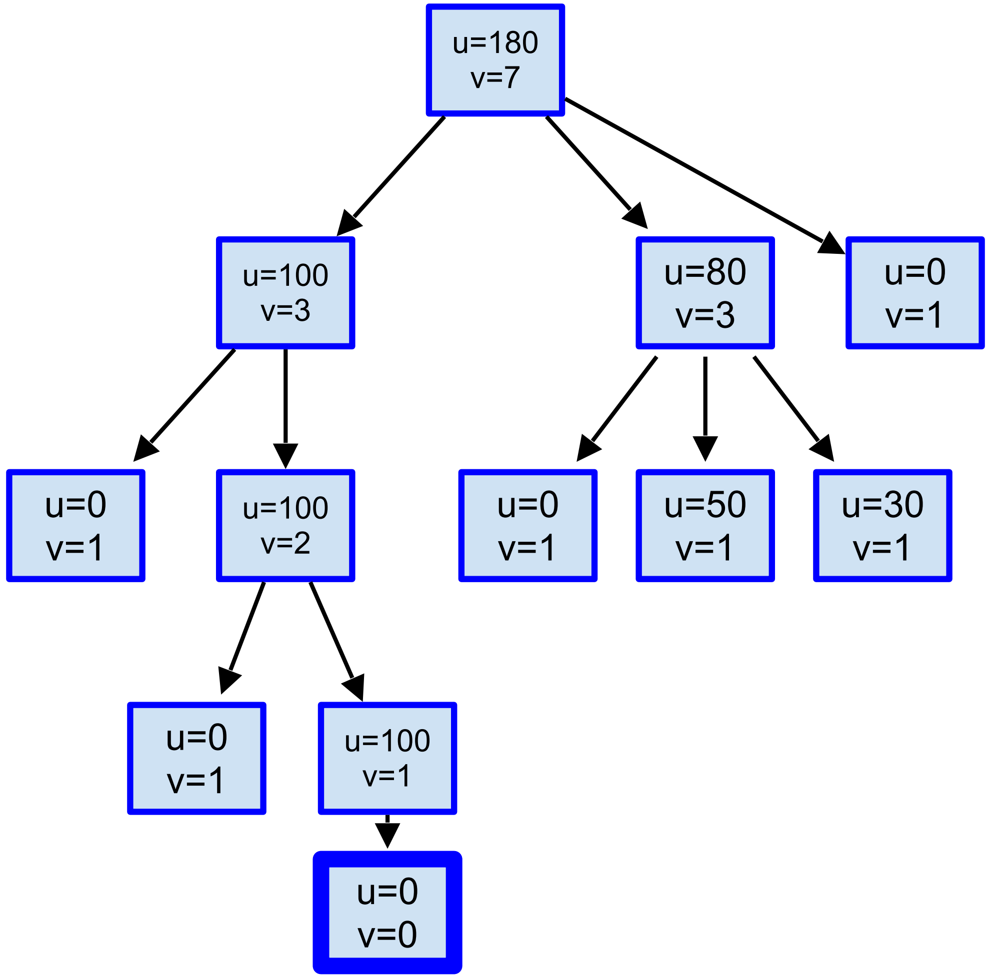
v=1
u=100
v=1

Expand



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u=0
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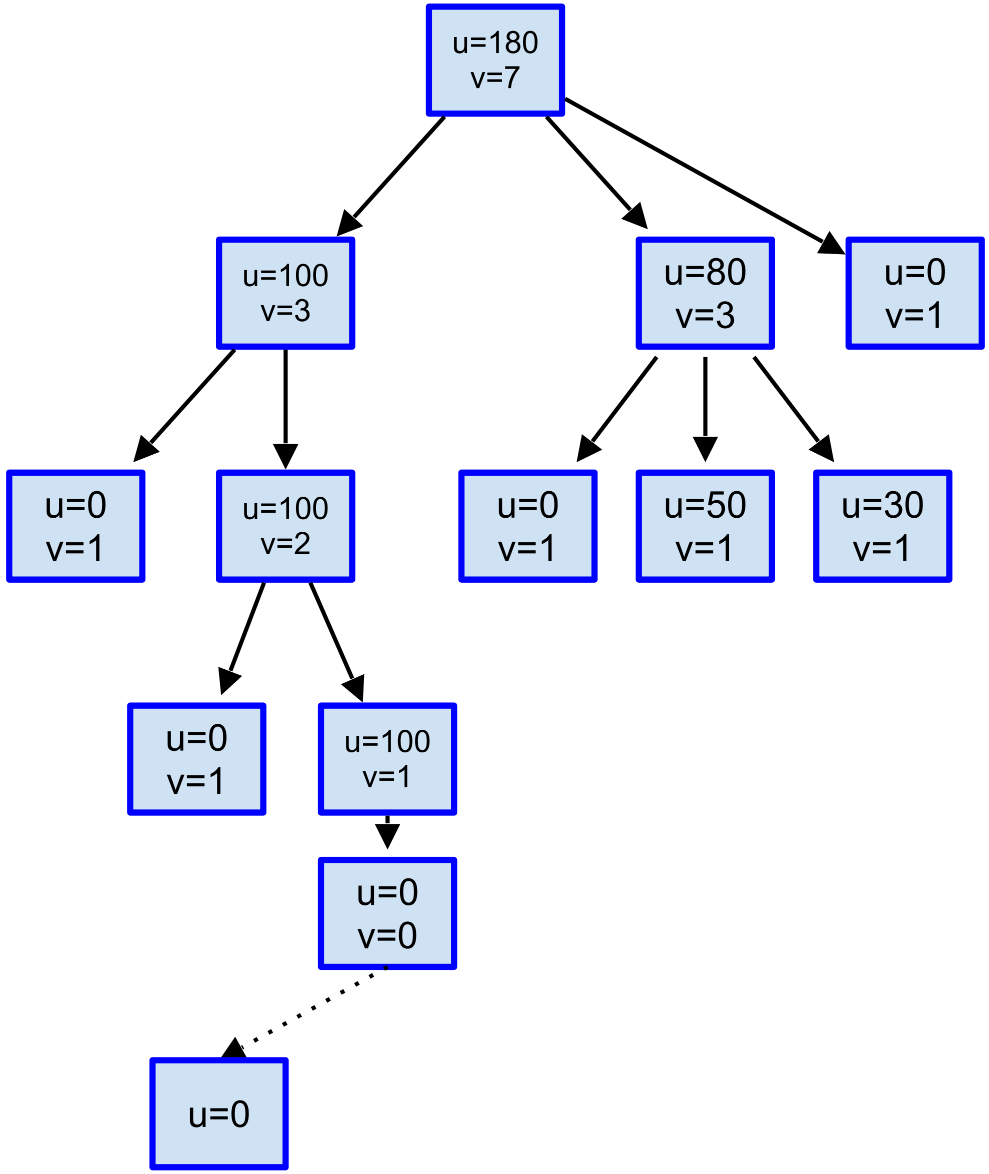
u=0
v=0

Simulate



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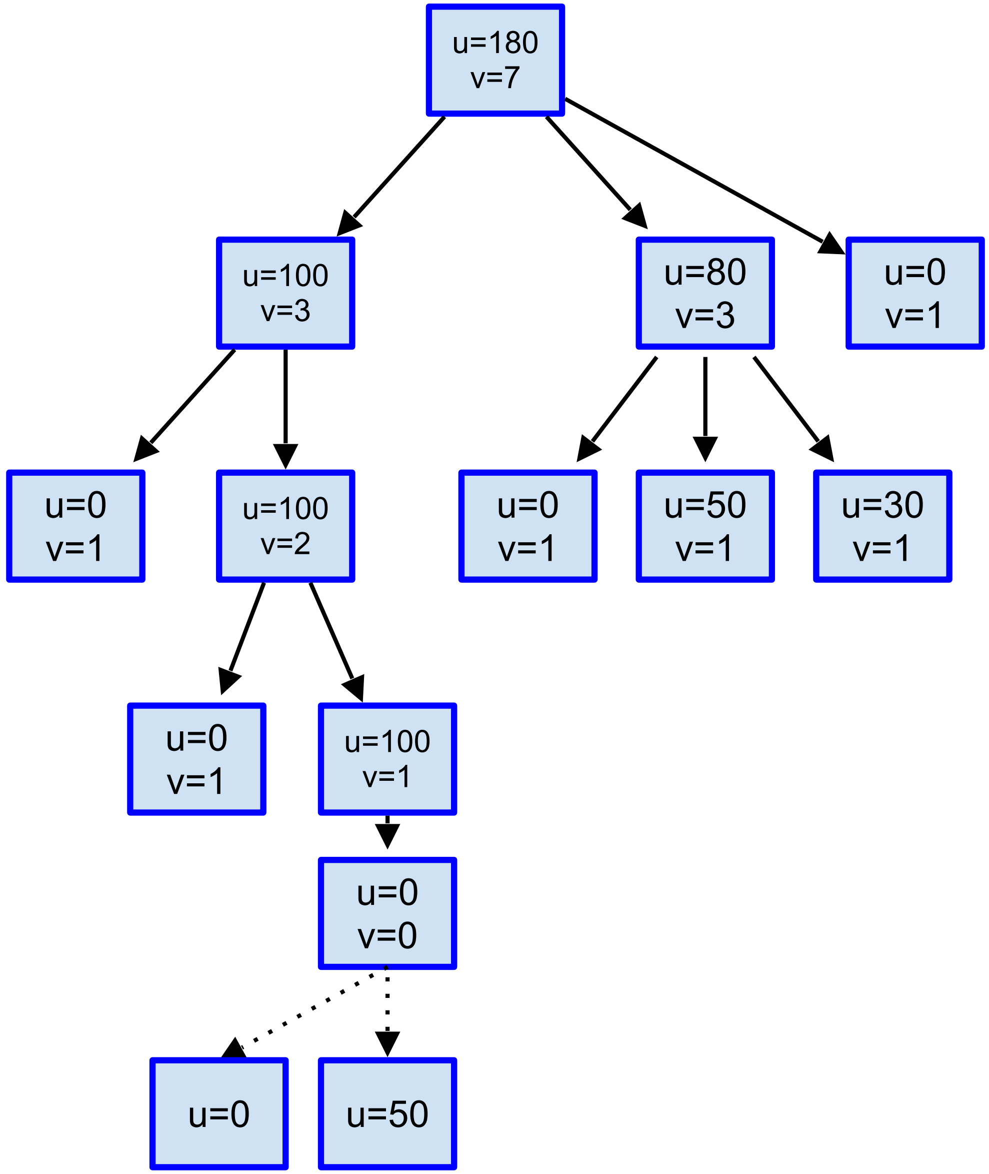

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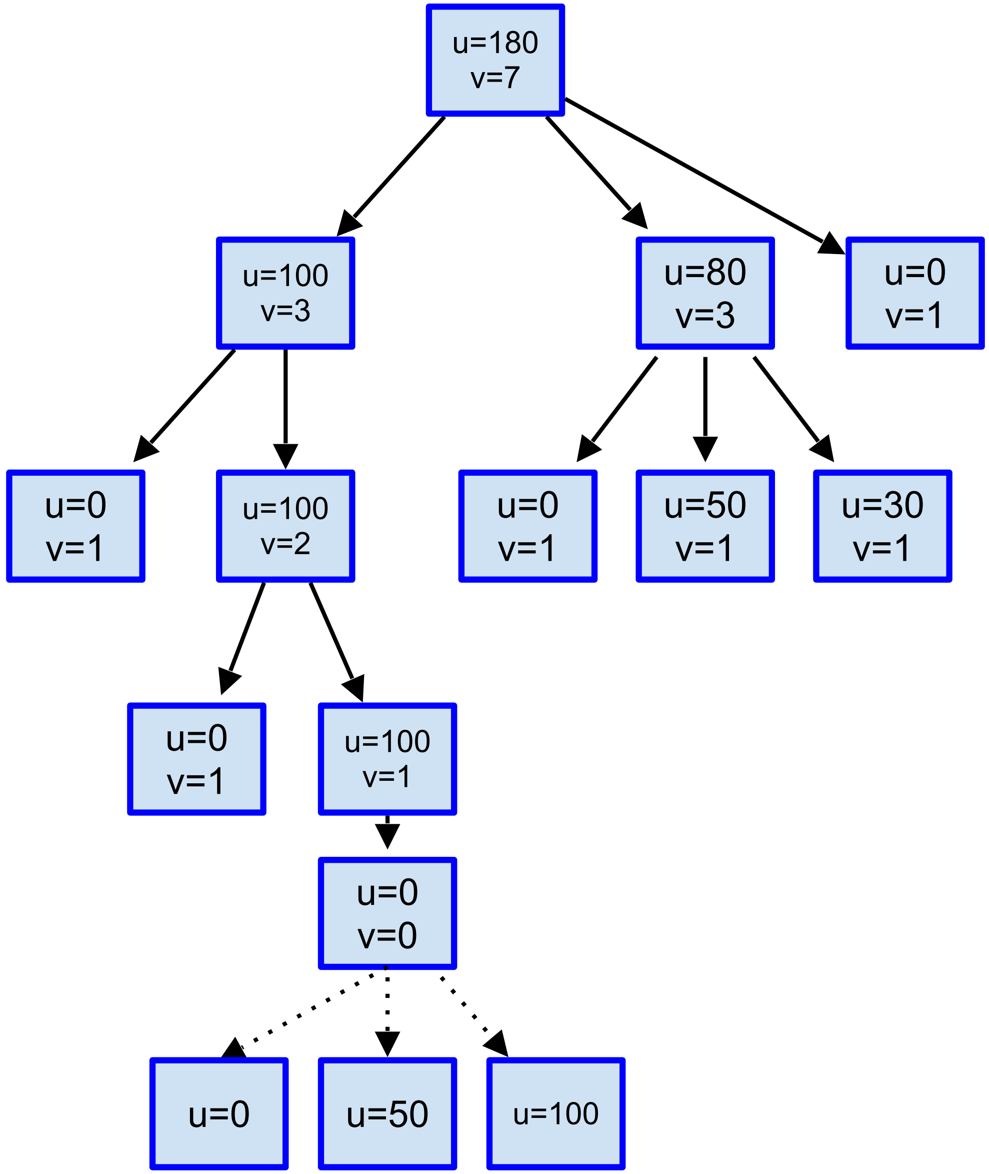
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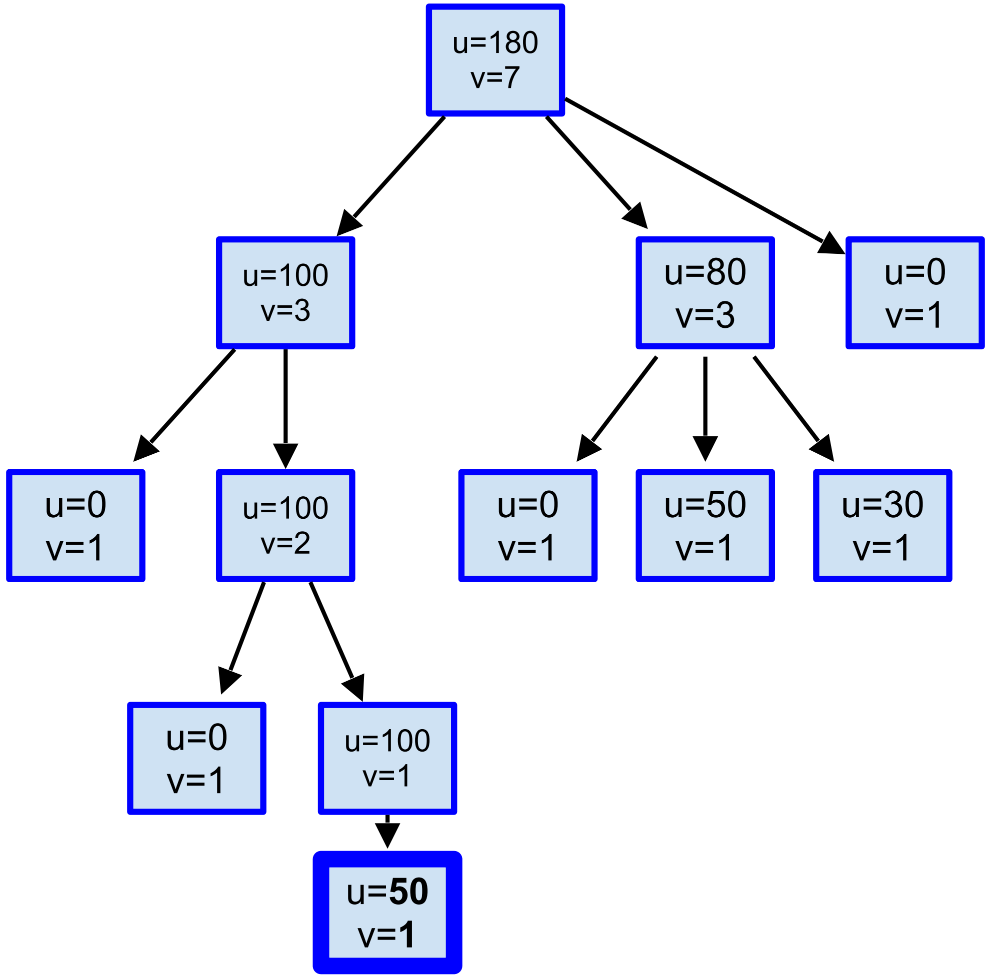
v=1
u=50
v=1
u=30
v=1
u=0
v=1
u=100
v=1
u=0
v=0
u=0
u=50
u=100

Backpropagate



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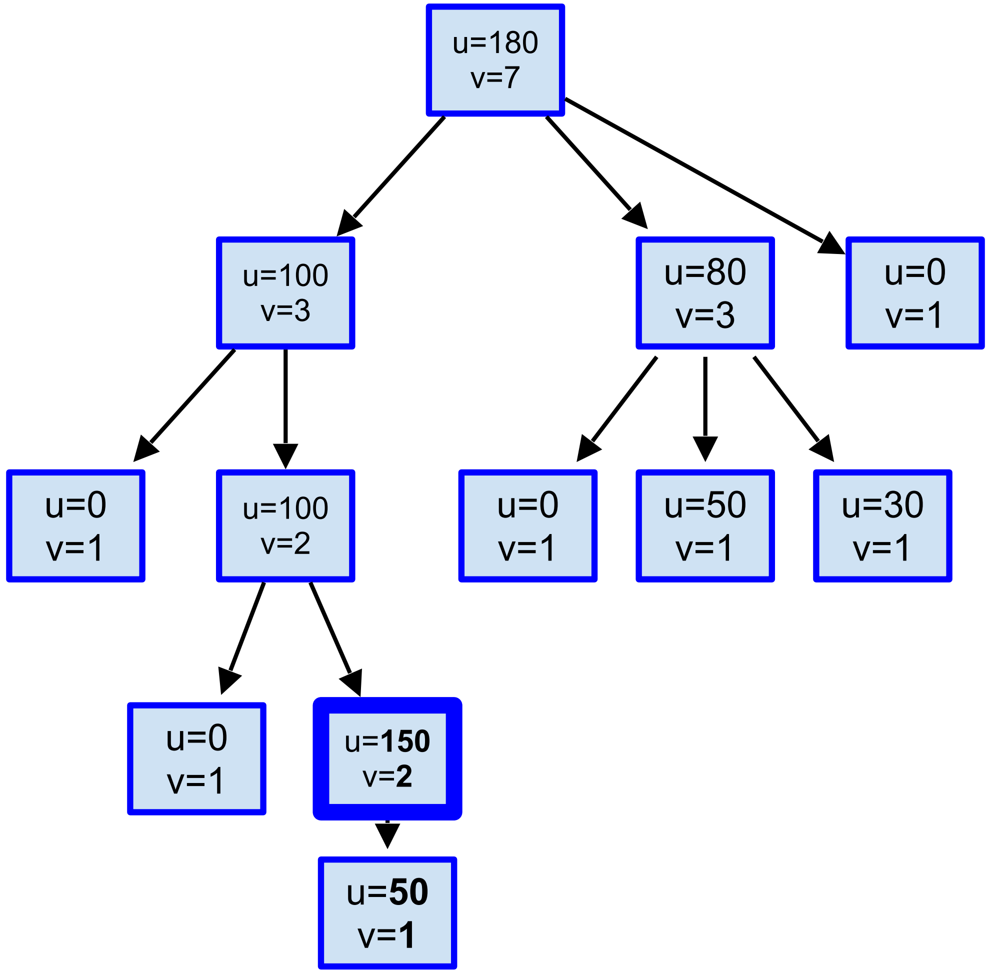

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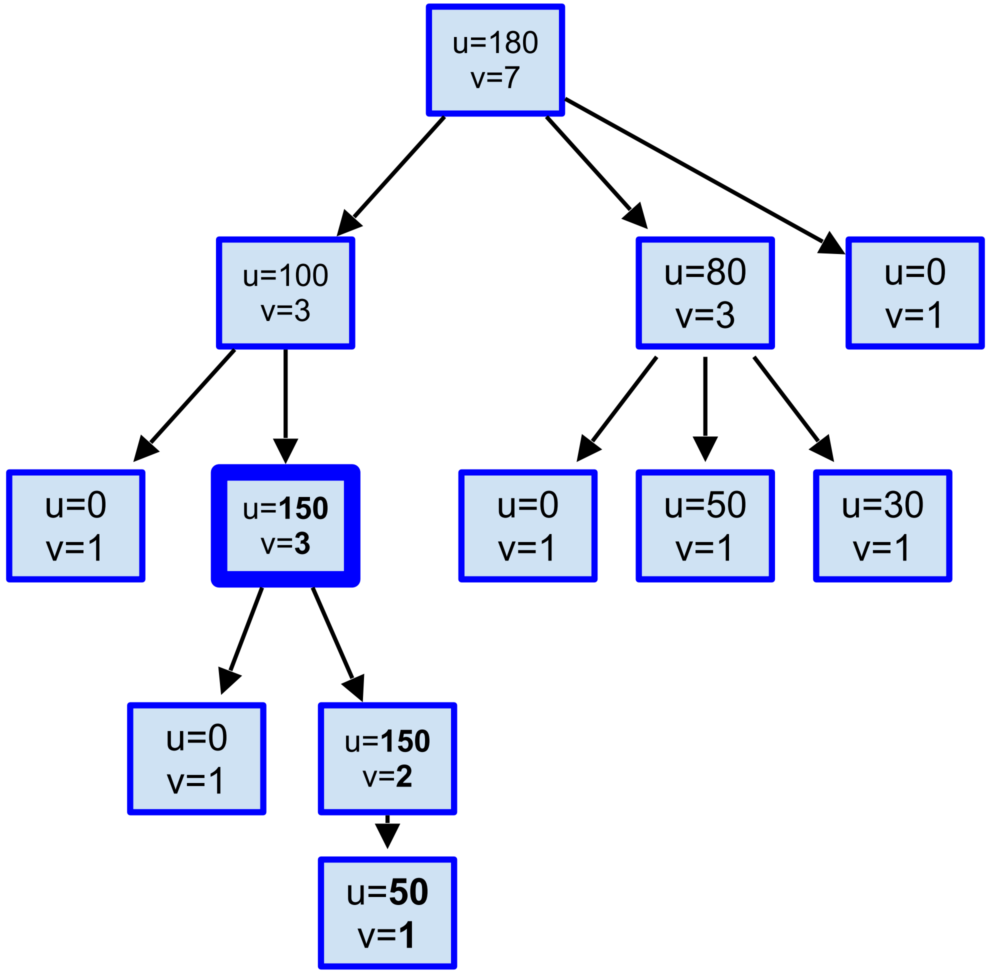

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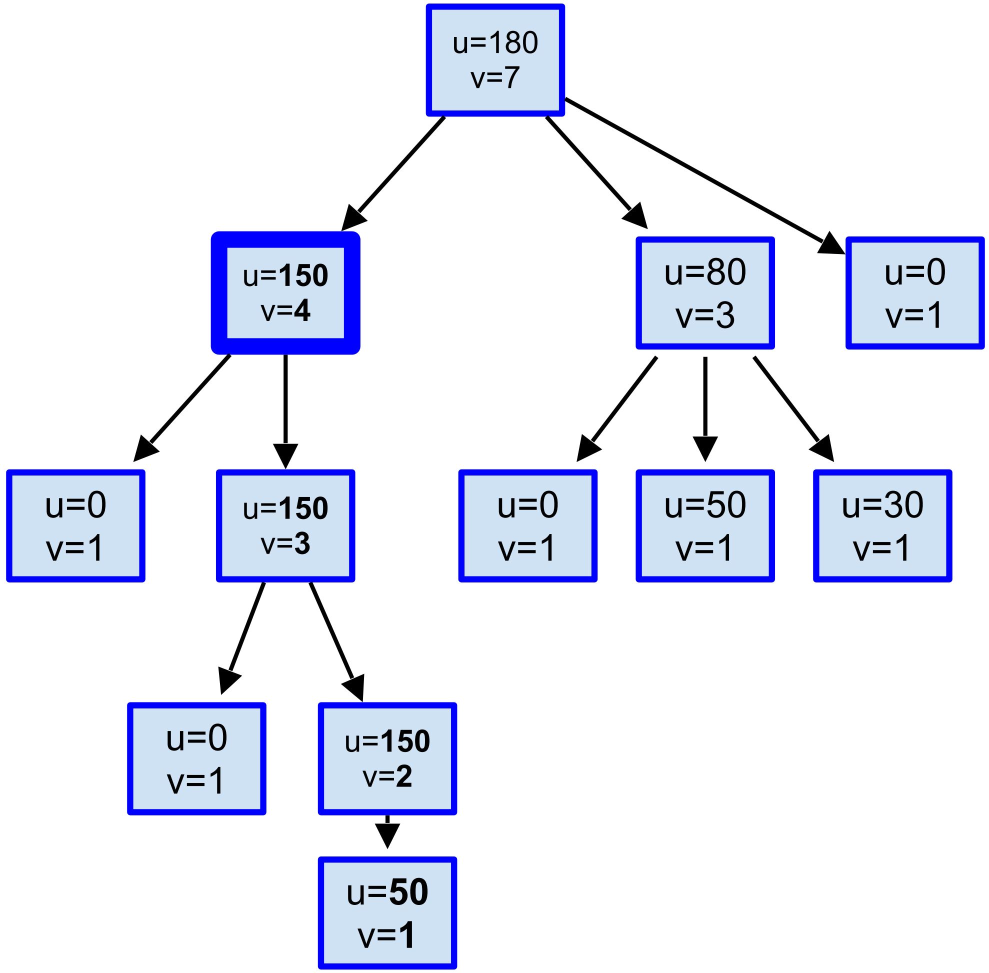

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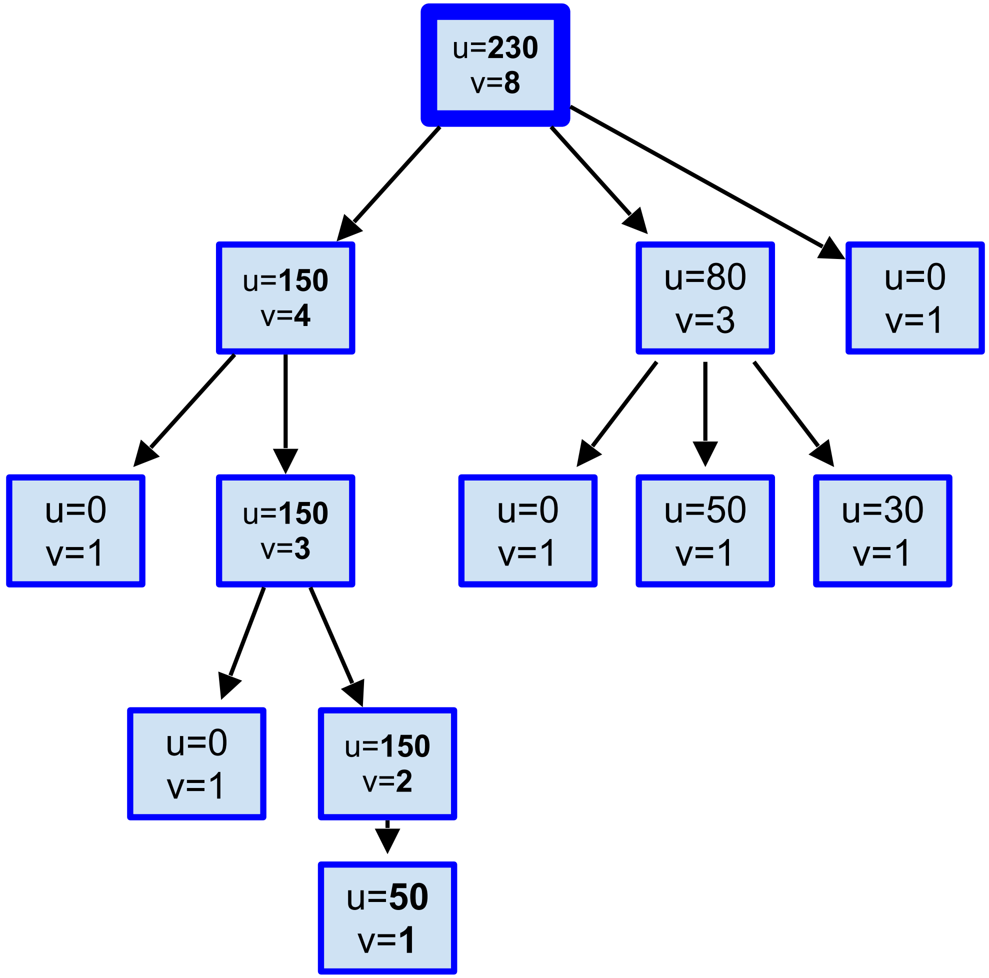

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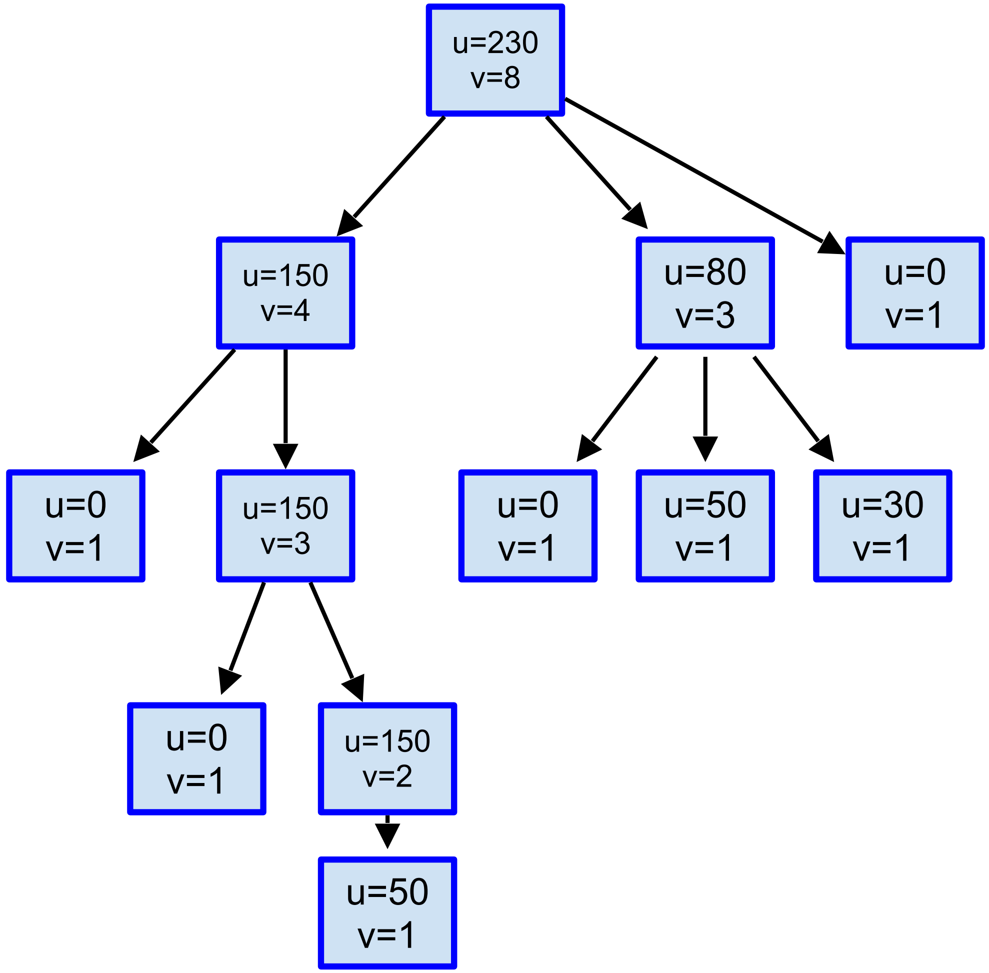
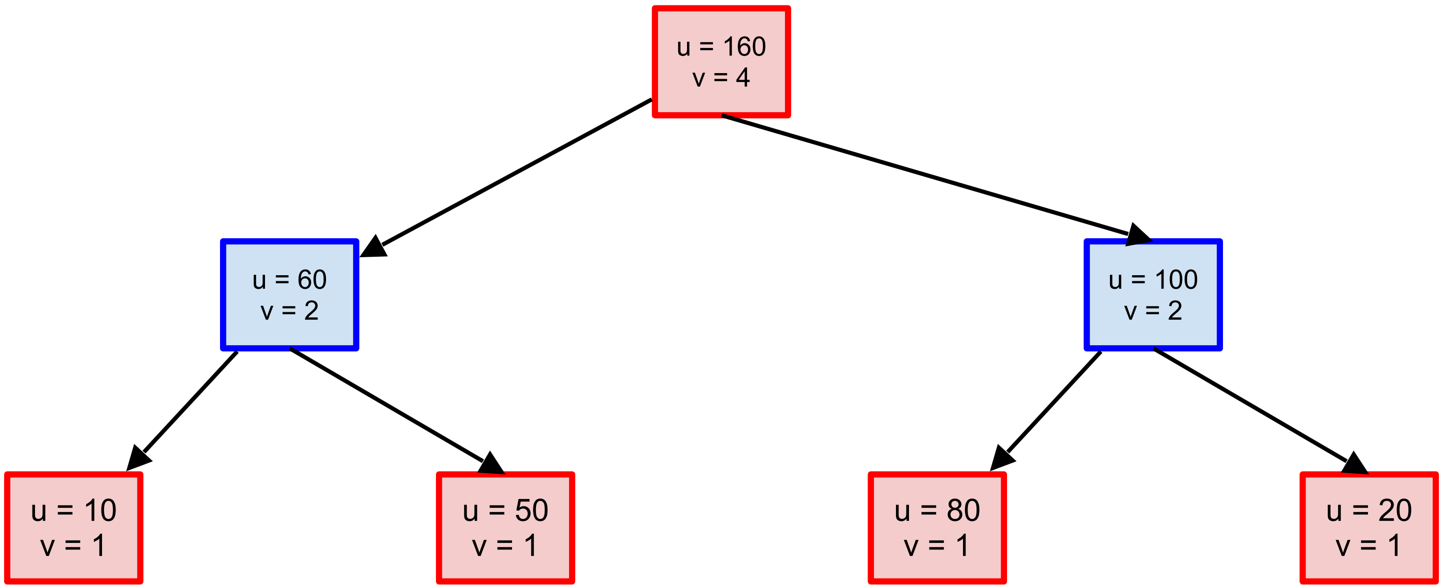


Multiple Players



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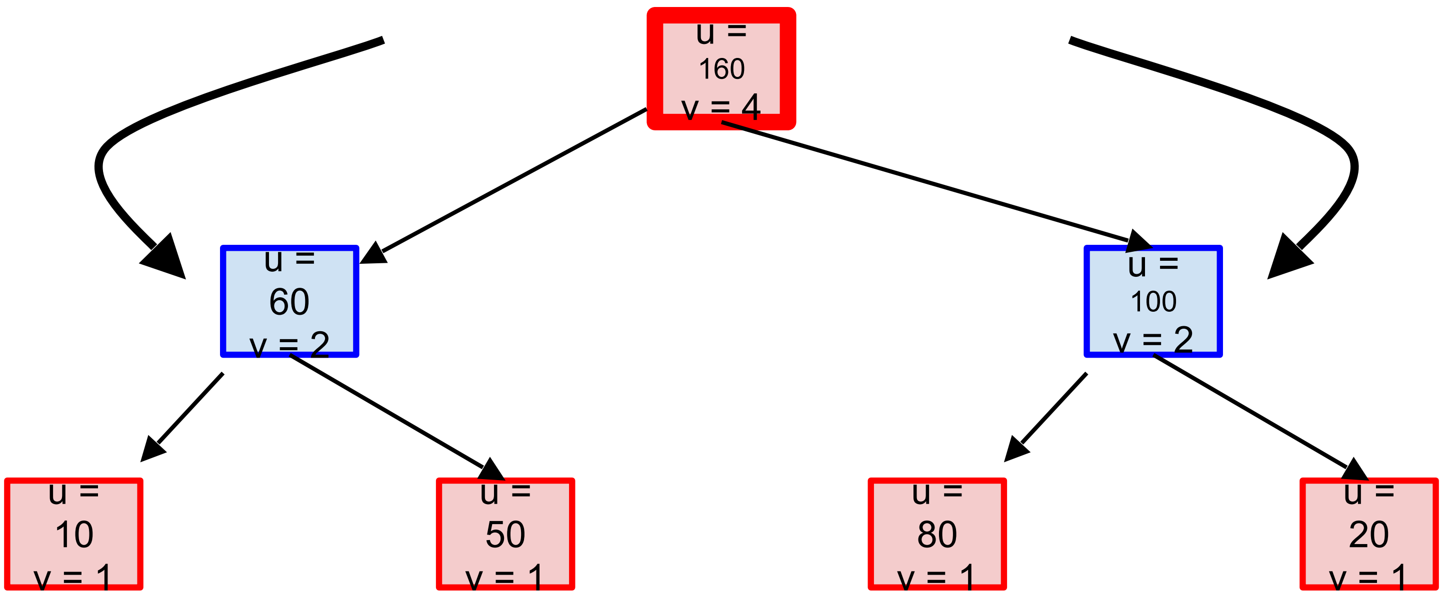

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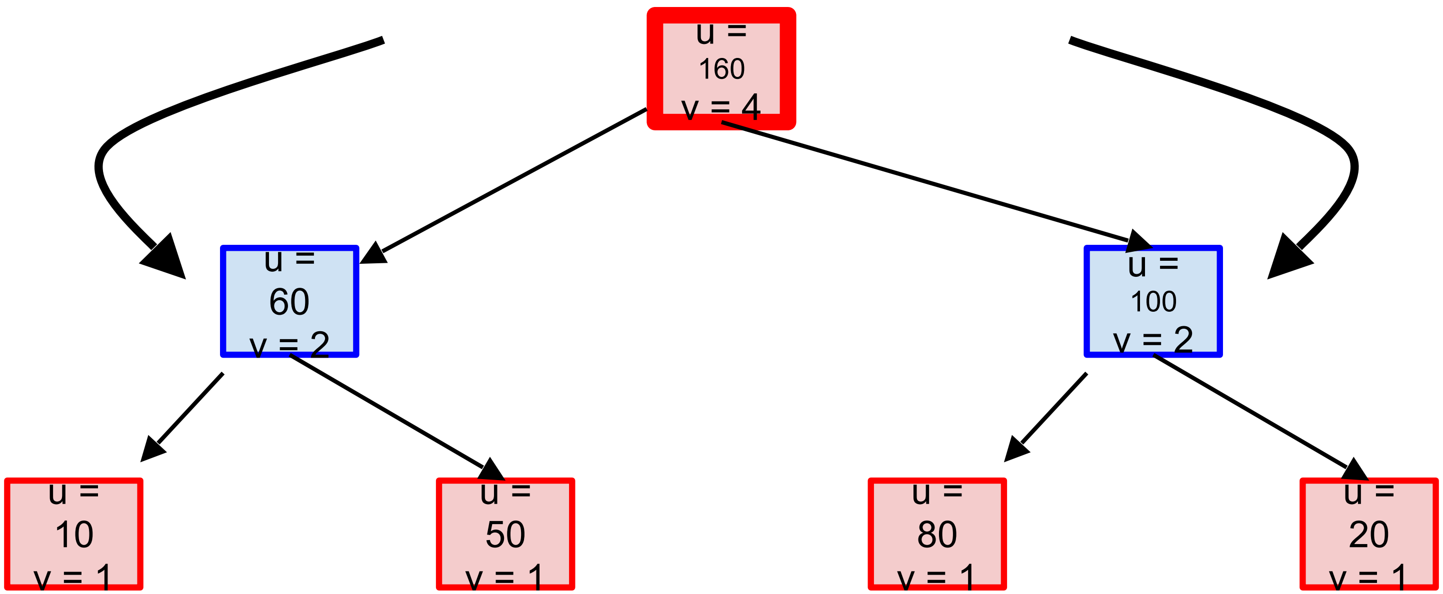

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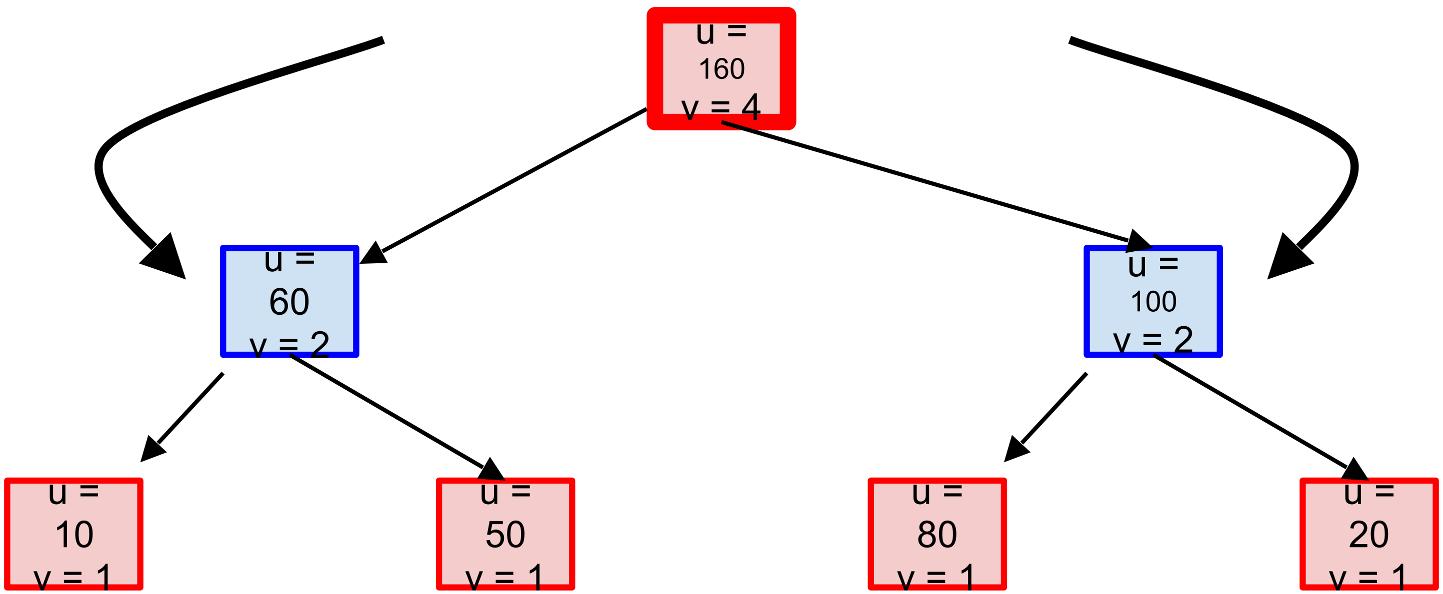
Multiple Players

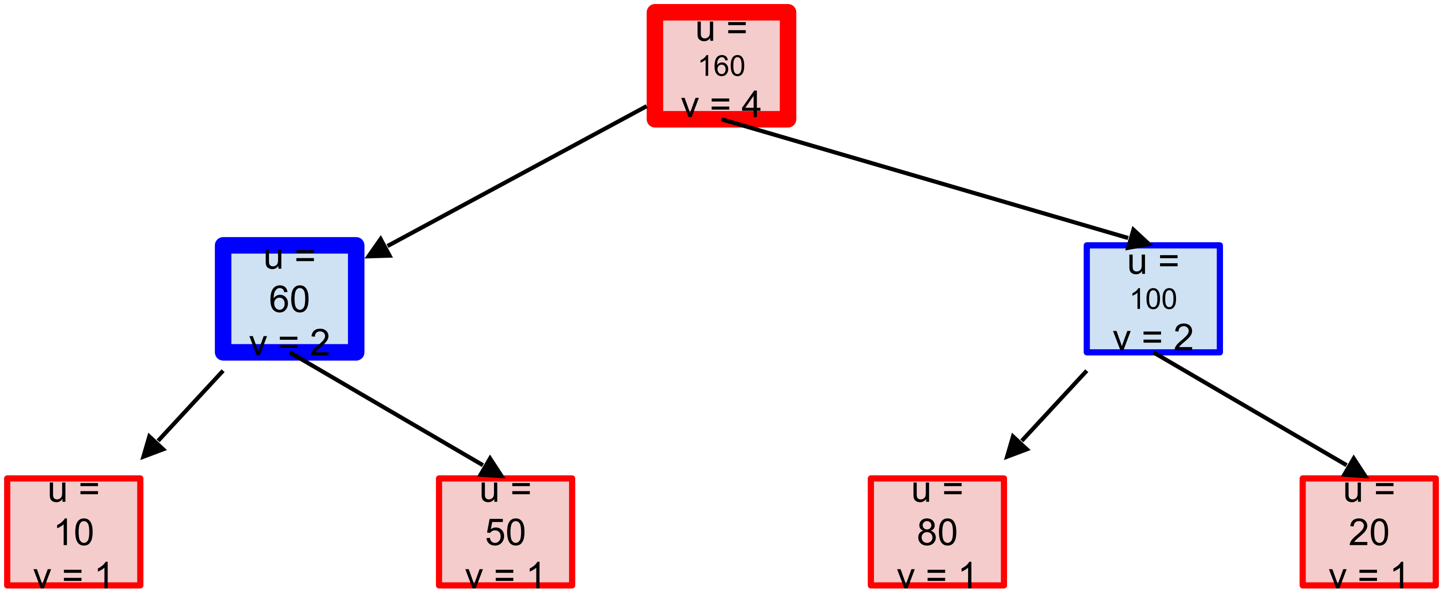


$-1\times$

V

$$\text{selectValue} = \frac{\text{node.utility}}{\text{node.visits}} + C \times \sqrt{\frac{\ln(\text{node.parent.visits})}{\text{node.visits}}}$$

Multiple Players



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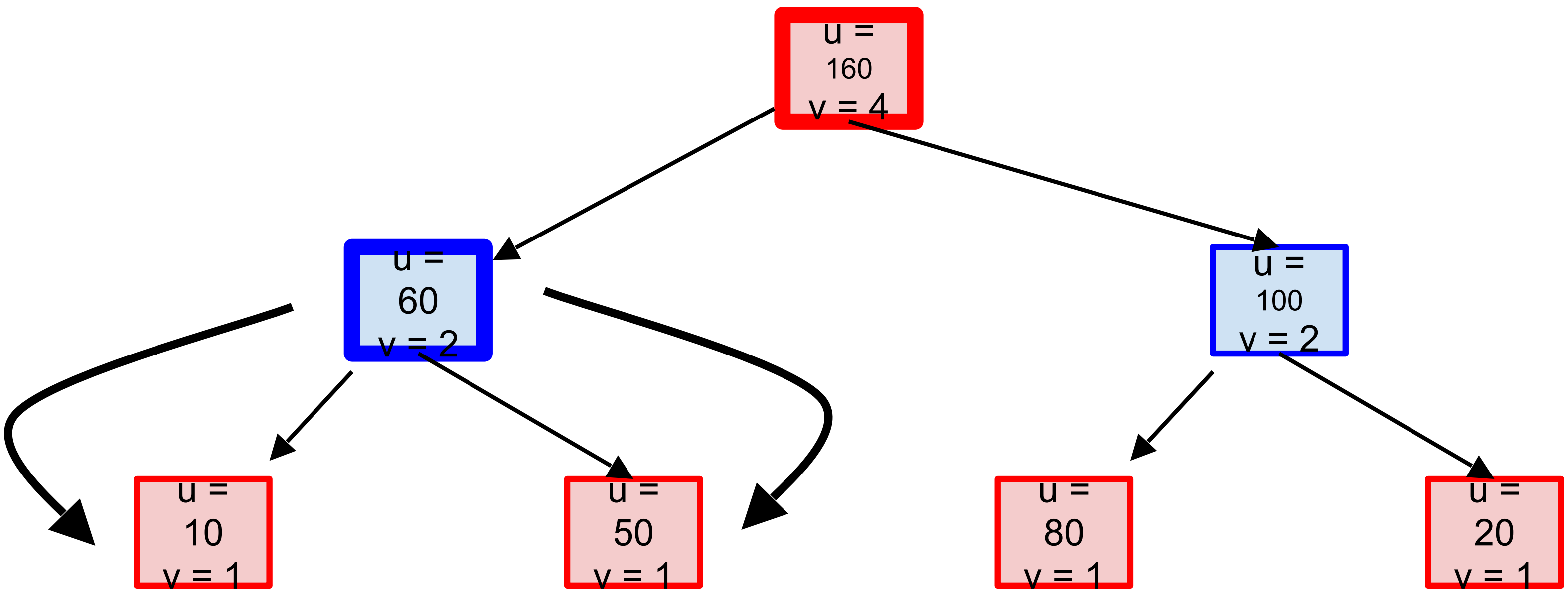

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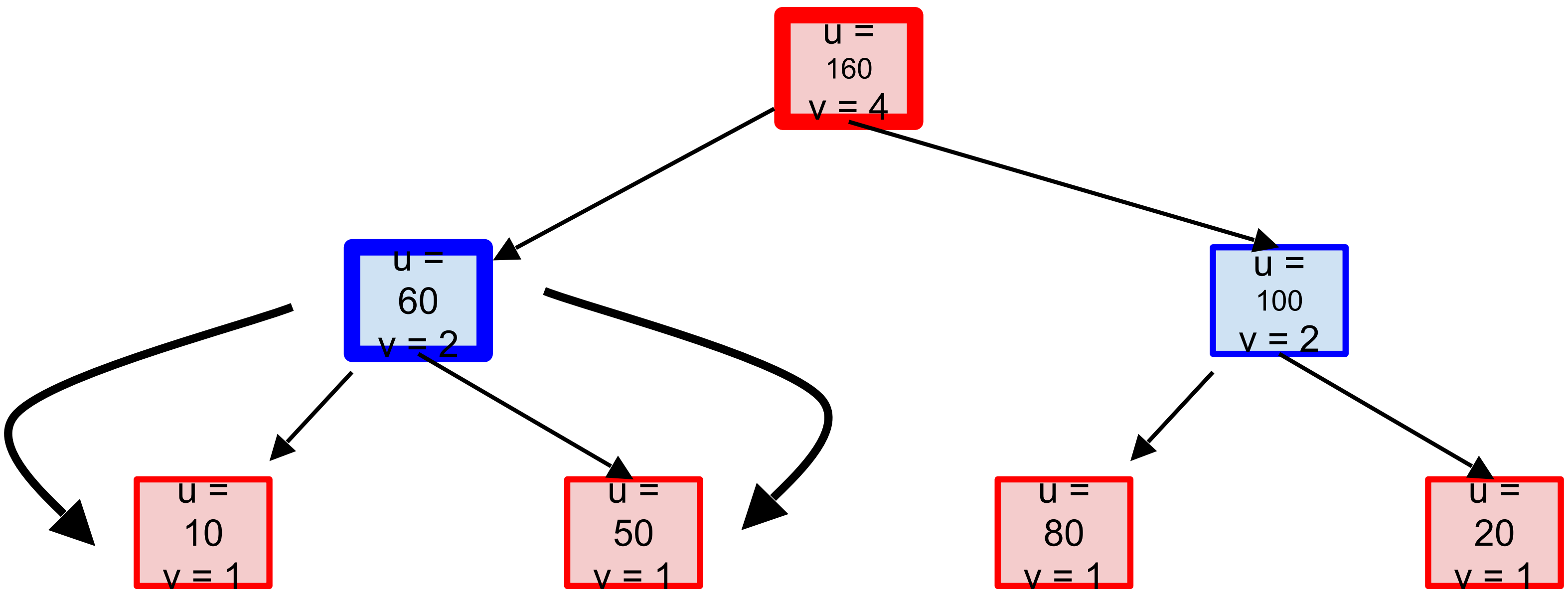

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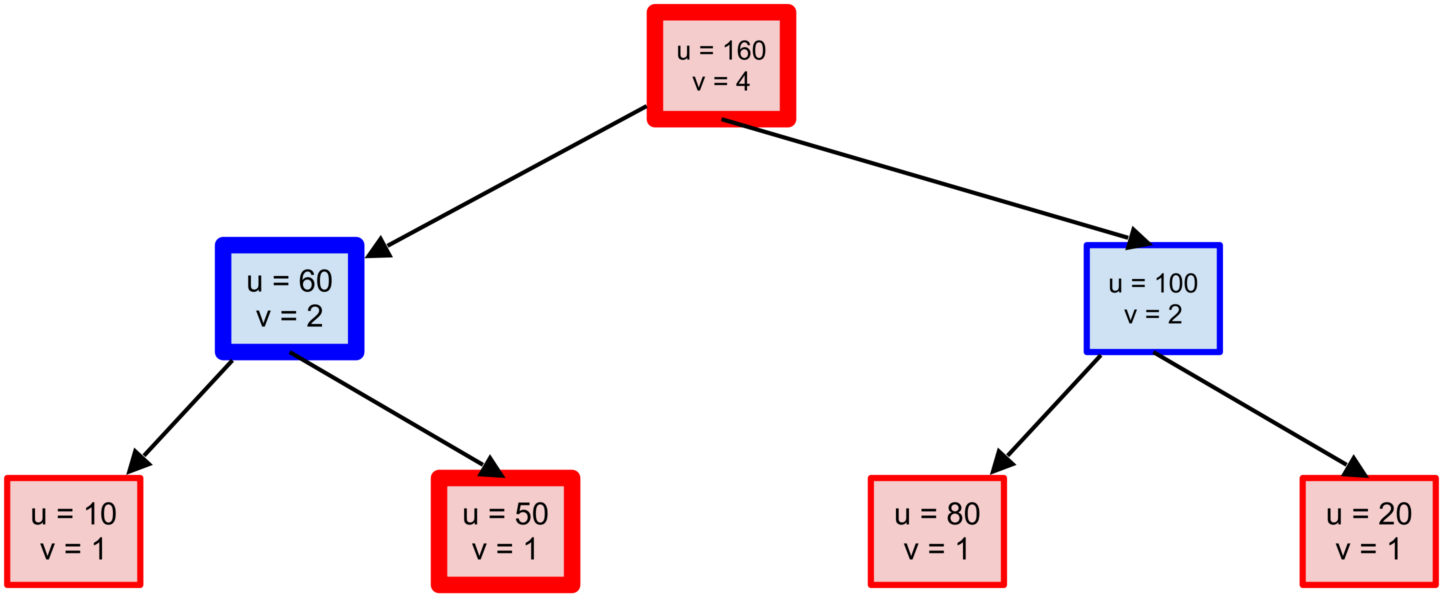

Why is MCTS better than MCS?

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Move	Depth Charges
A	0, 0, 0, 0, 0, 0
B	60, 60, 60, 60, 60, 60
C	0, 100, 0, 100, 0, 100

Why is MCTS better than MCS?

Move	Depth Charges	Mean
A	0, 0, 0, 0, 0, 0	0
B	60, 60, 60, 60, 60, 60	60
C	0, 100, 0, 100, 0, 100	50

Why is MCTS better than MCS?

Move	Depth Charges	Mean	Std dev
A	0, 0, 0, 0, 0, 0	0	0
B	60, 60, 60, 60, 60, 60	60	0
C	0, 100, 0, 100, 0, 100	50	54.8

More Information

https://en.wikipedia.org/wiki/Monte_Carlo_tree_search


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