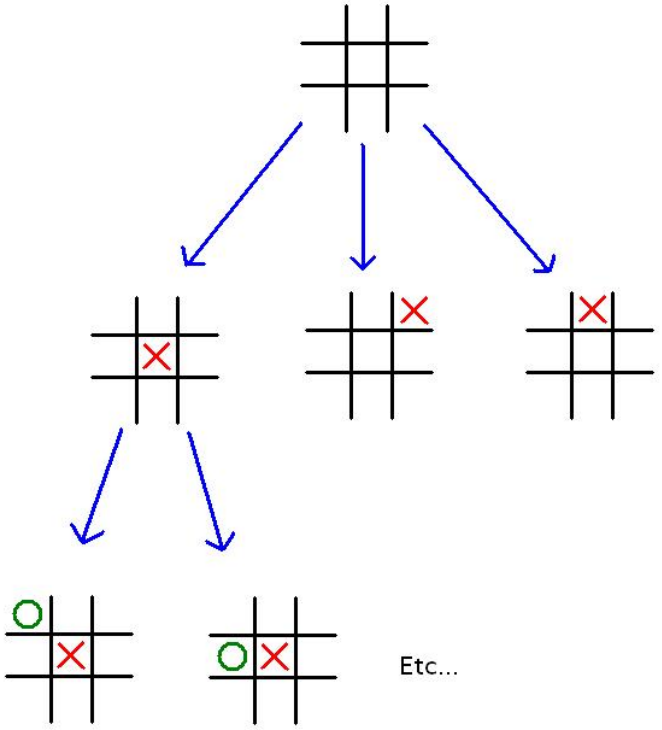
Game Tree Search



Slides By: Evan Ye

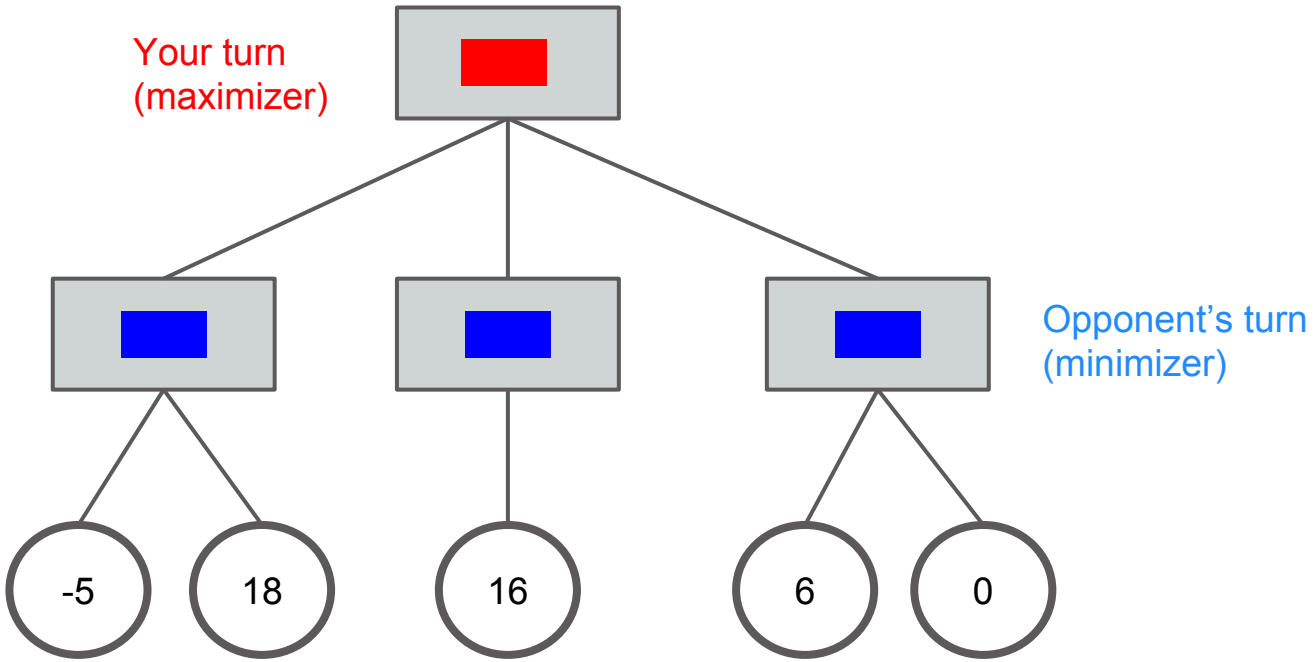
Game Tree Search

- Every position has a score
- The higher the score, the better for you, the worse for your opponent.
- The lower the score, the worse for you, the better for your opponent.

- Game tree search is the process of checking every possible move (tree recursion).

Minimax

Complete minimax on the tree below:



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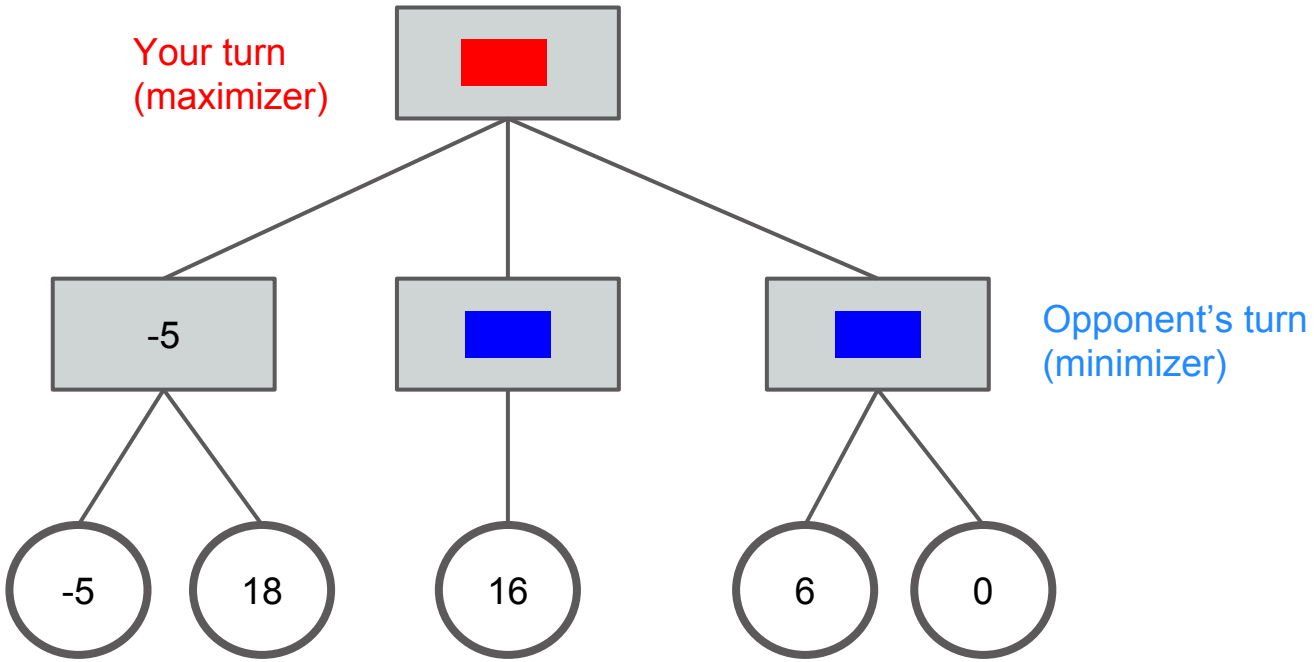

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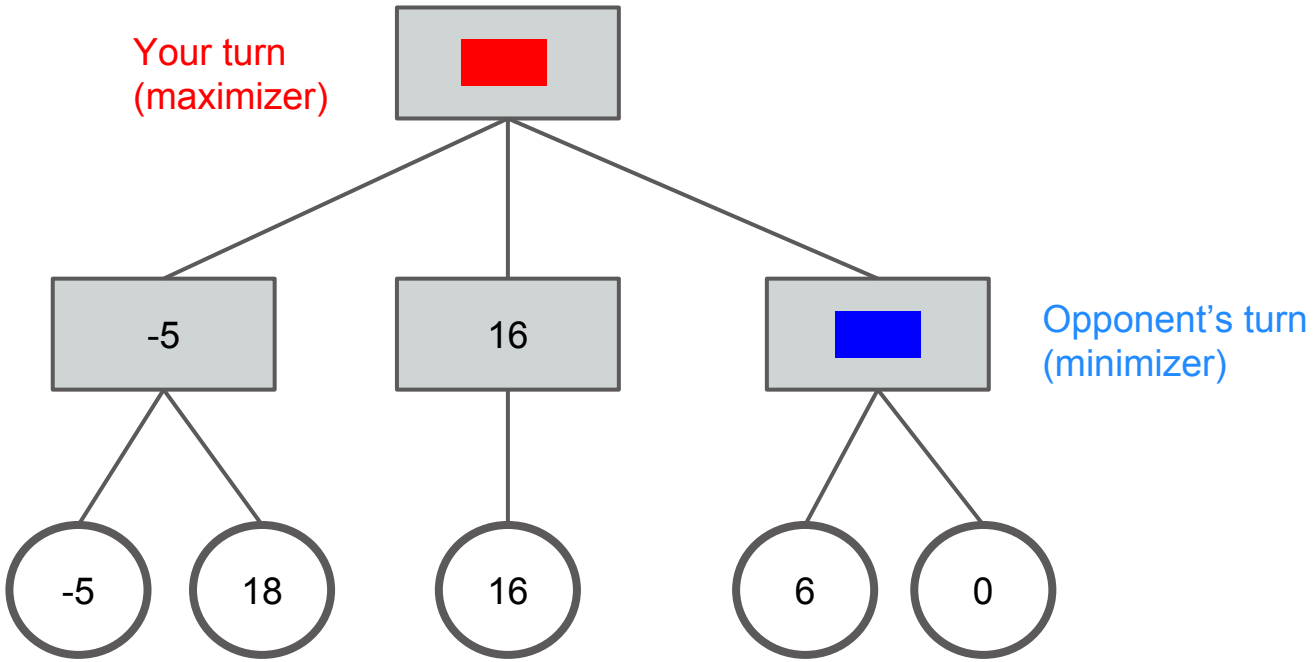

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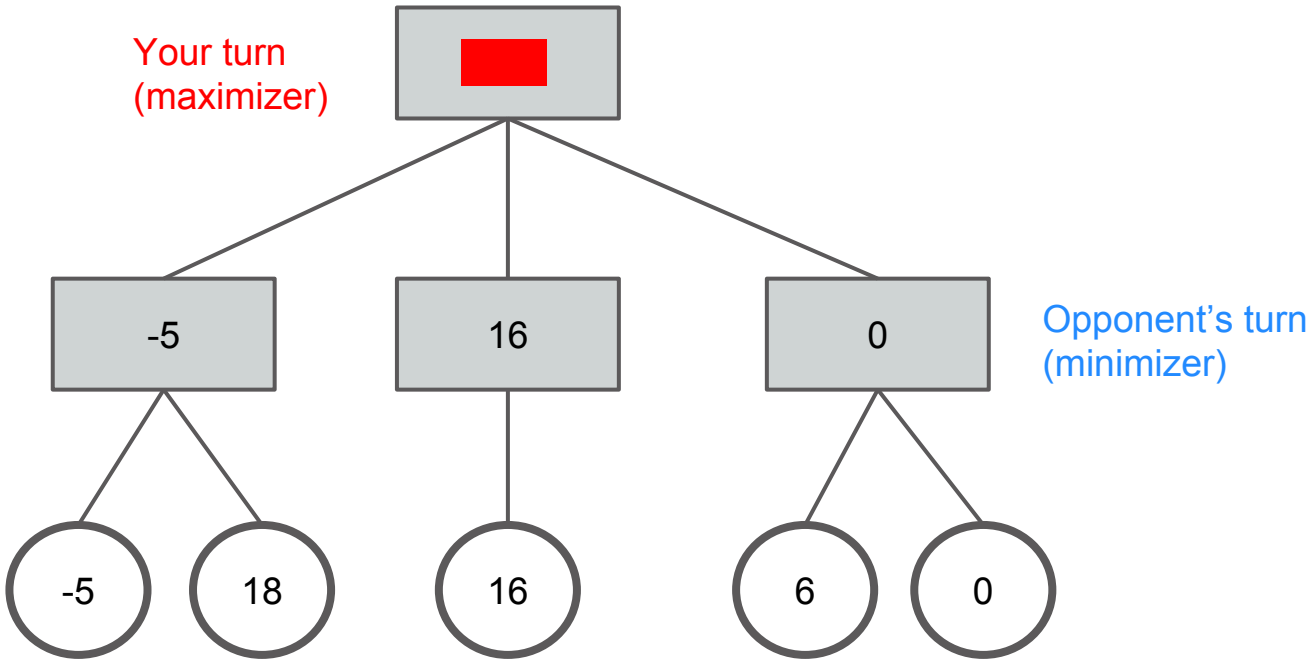

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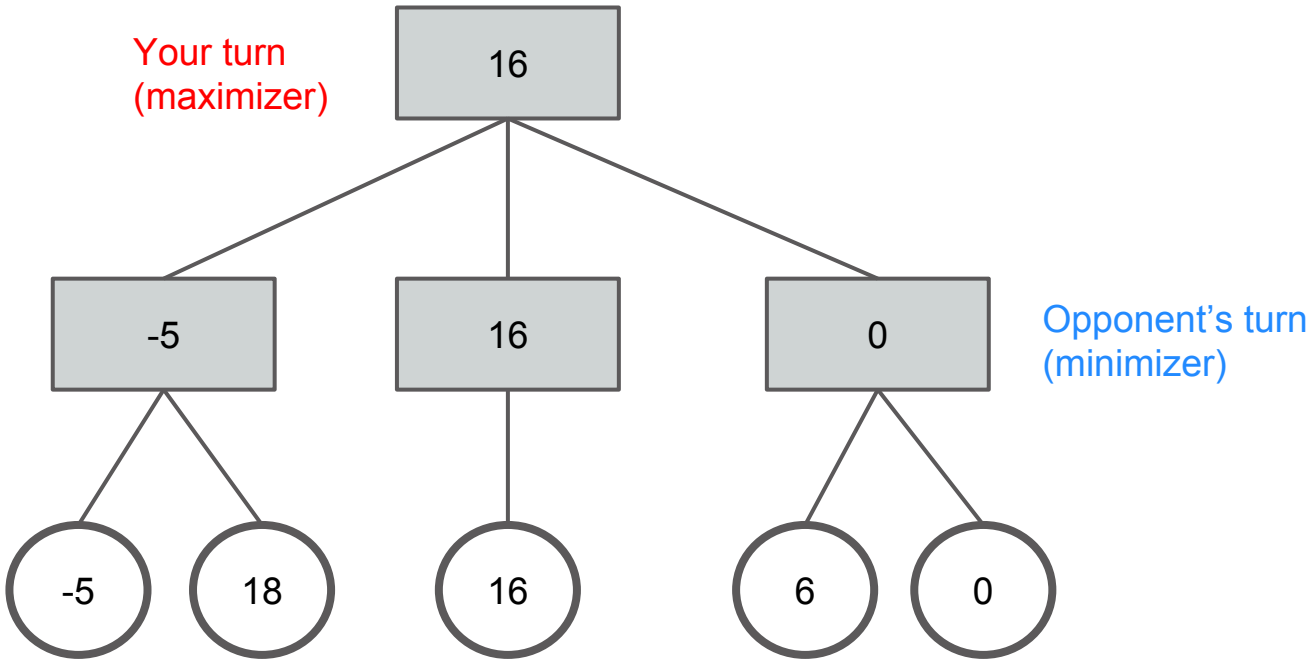

Alpha Beta Pruning

Idea: make minimax faster!

α - best guaranteed score seen so far for YOU

- YOU = maximizer node, YOU search for HIGHER scores
- Starts at negative infinity

β - best guaranteed score seen so far for your OPPONENT

- OPPONENT = minimizer node, searches for LOWER scores
- Starts at positive infinity

Prune Cases

- prune at a minimizer node whose β value is less than or equal to the α value

- prune at a maximizer node whose α value is greater than or equal to the β value

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Prune Cases

Basically, when $\alpha \geq \beta$

Alpha Beta Pruning

How to:

1. Do the minimax search
2. Keep track of alpha, beta
   a. if you are maximizing, update alpha
   b. if you are minimizing, update beta
3. If you ever see **α** >= **β**, PRUNE

Note*: **α** and **β** are INHERITED from parent nodes.

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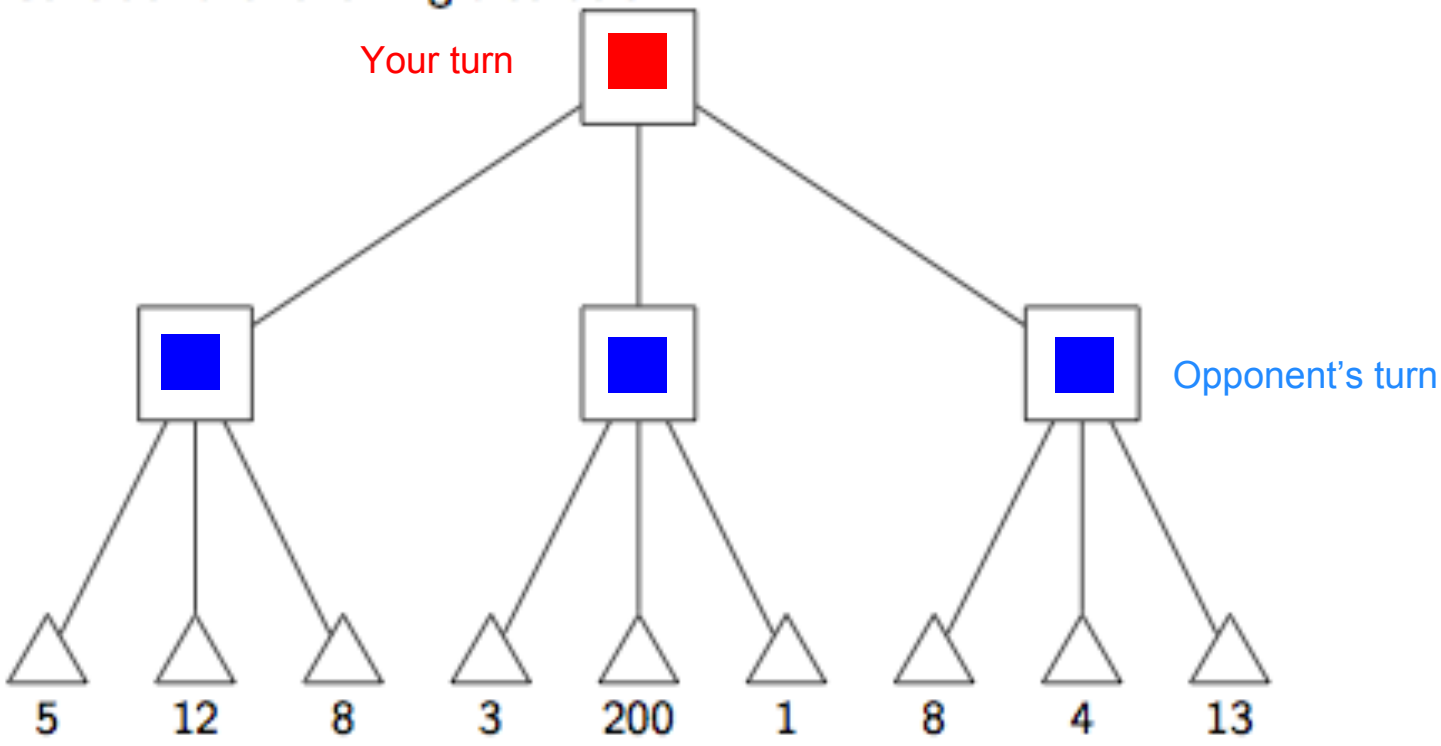

Determine which nodes will be pruned using α-β pruning and the final minimax value of the root. Assume the first player is MAX.

Also assume we traverse children from left to right.

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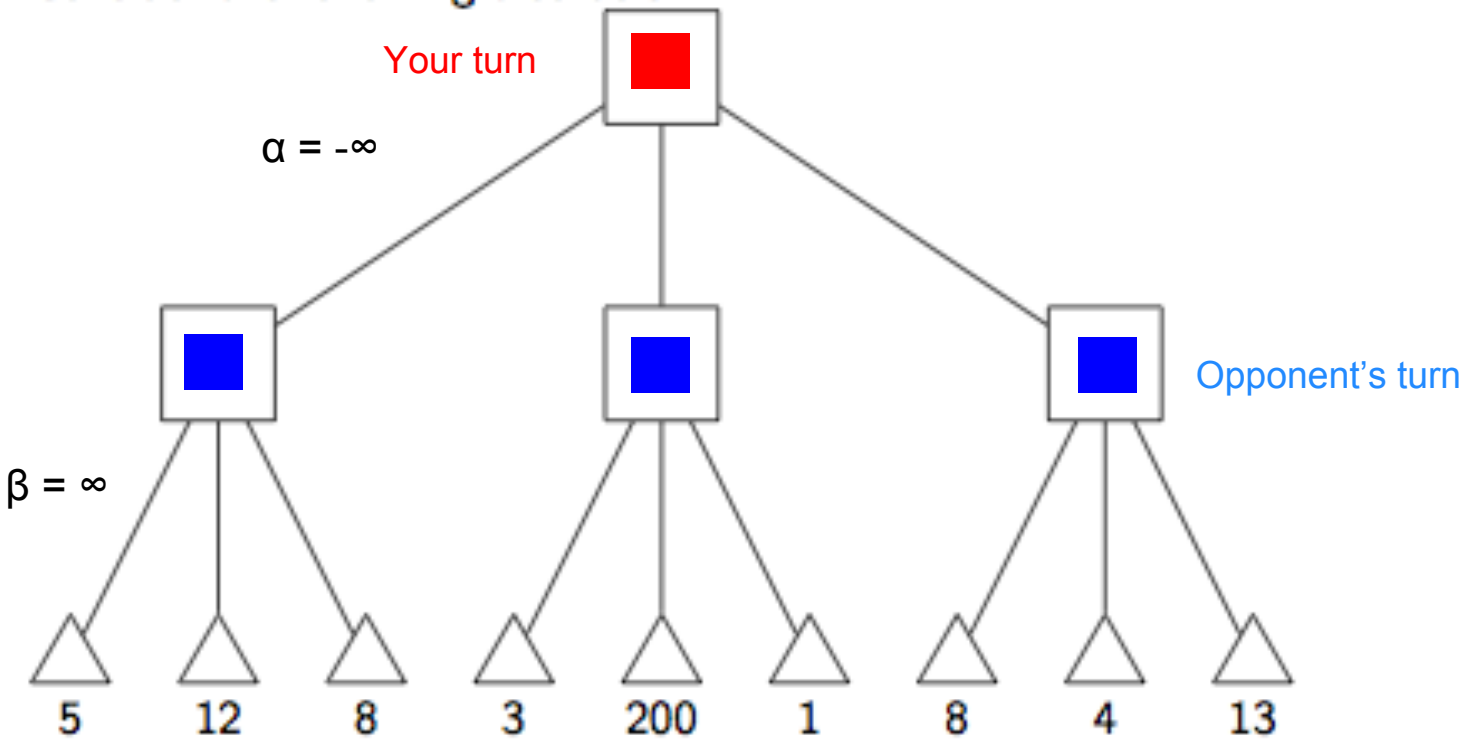

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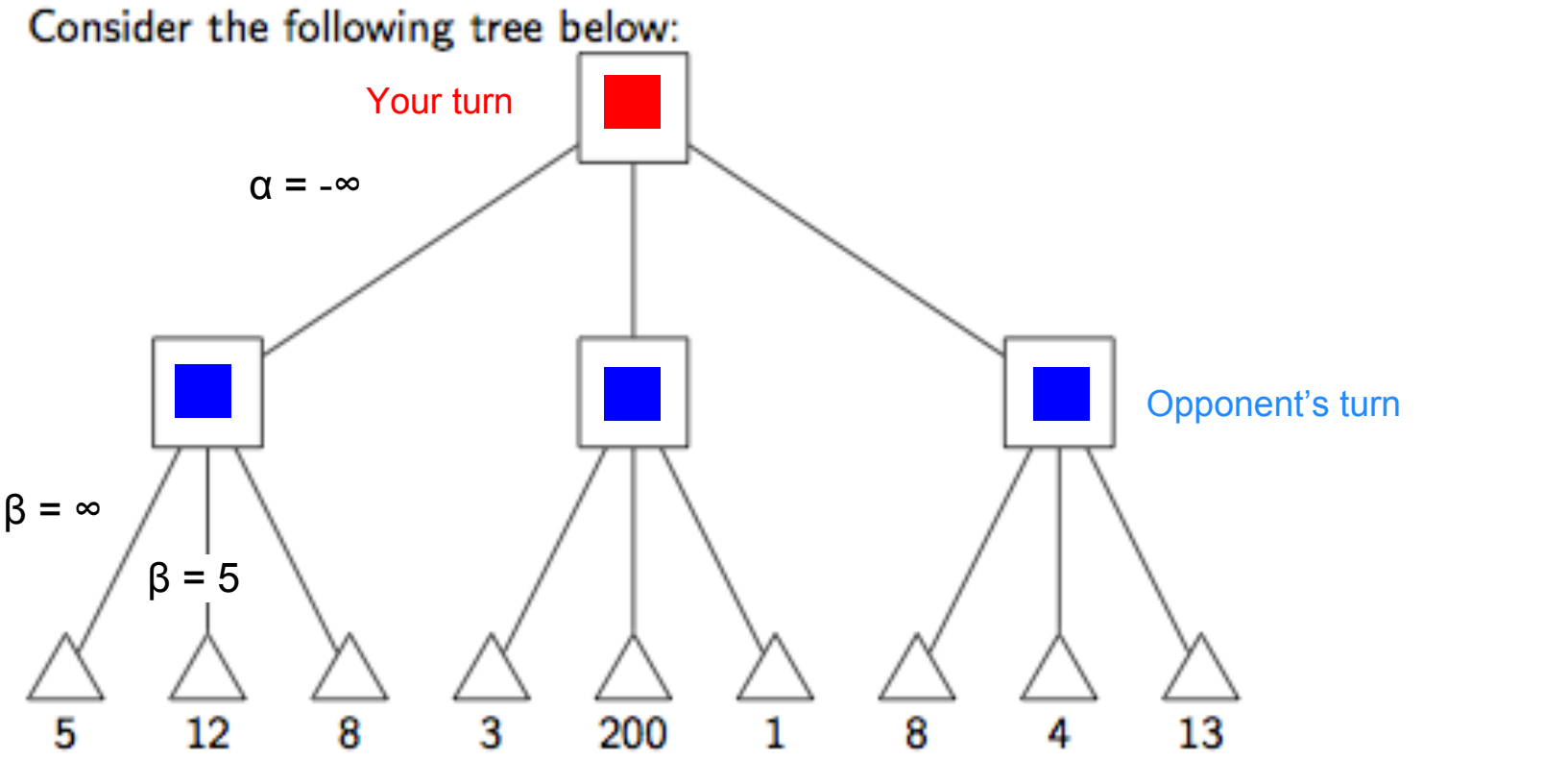

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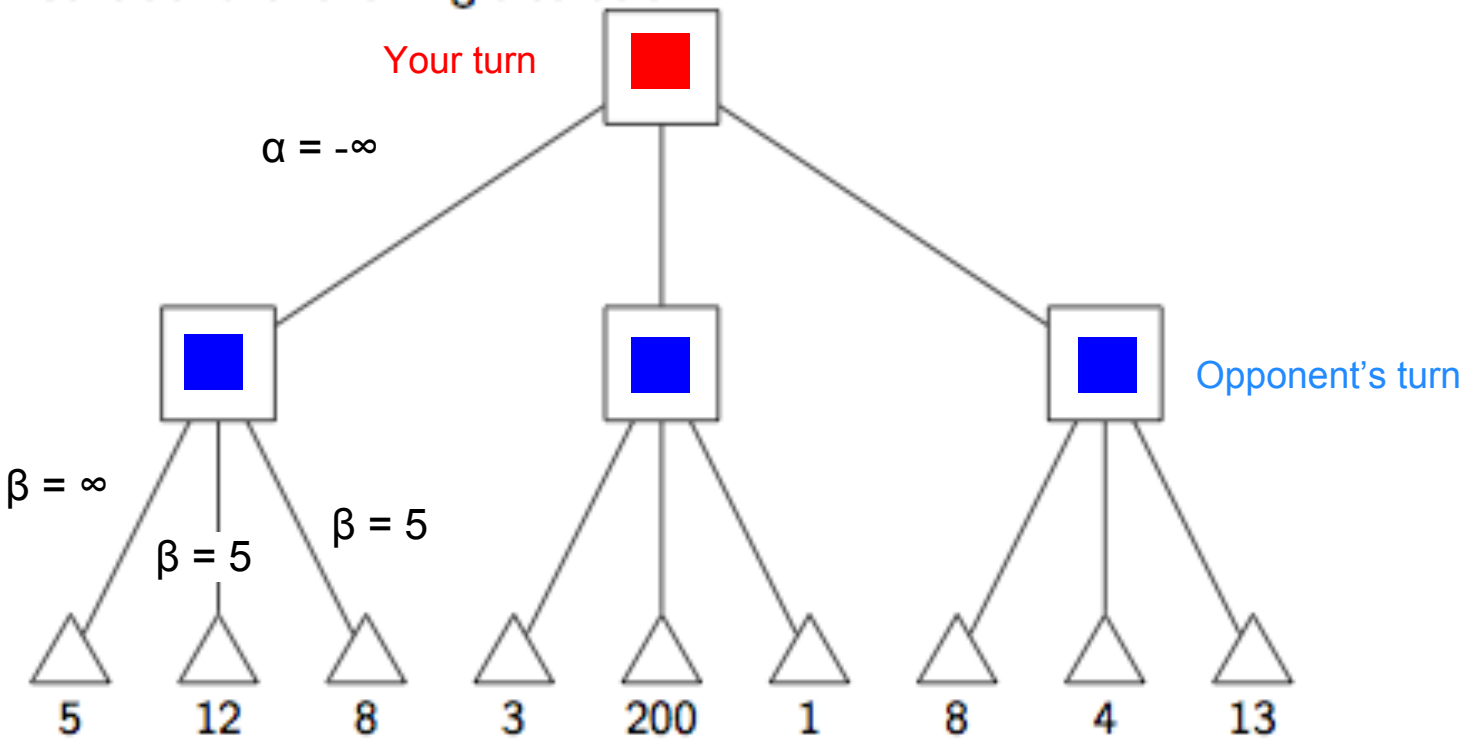

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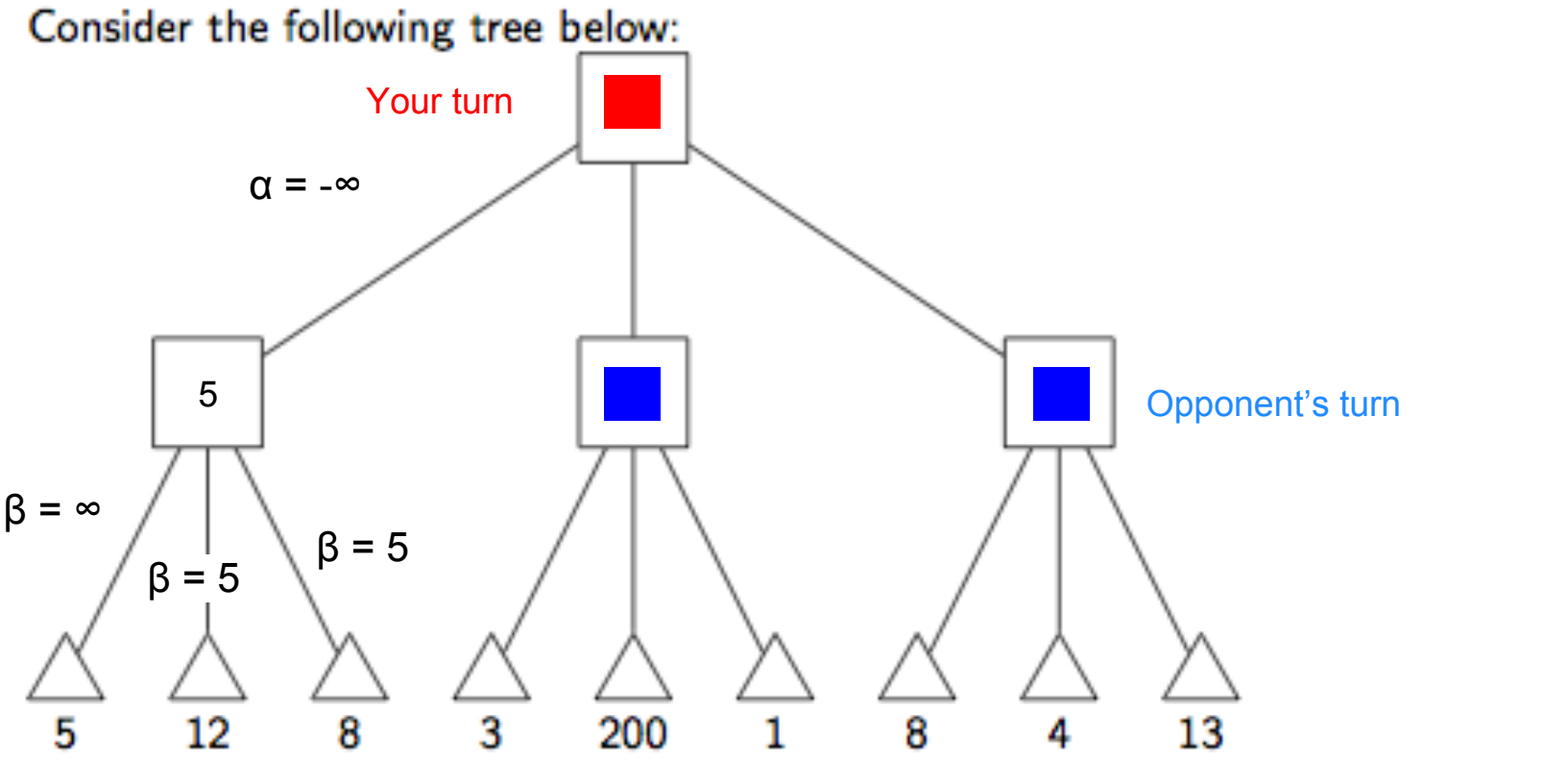

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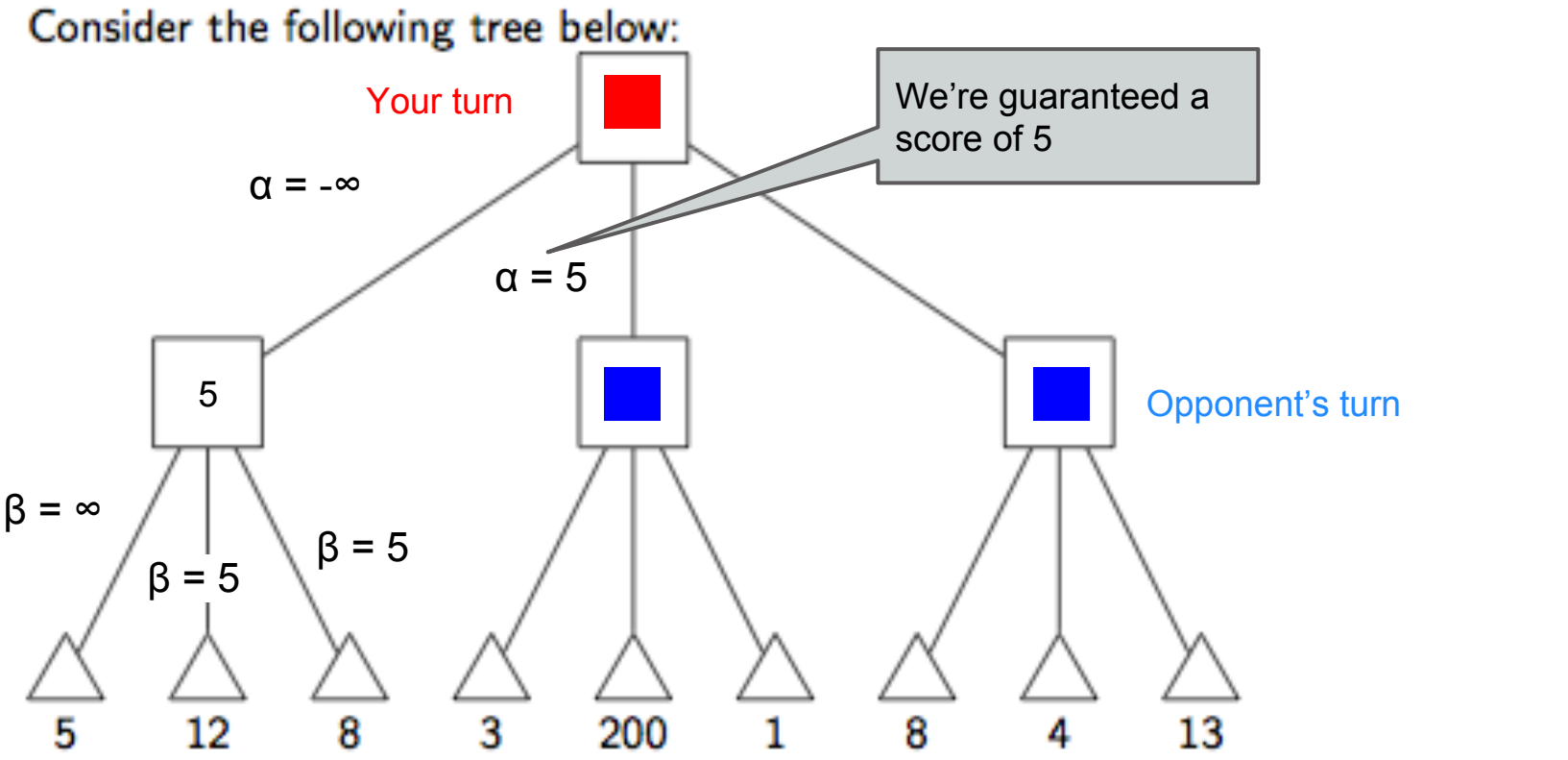

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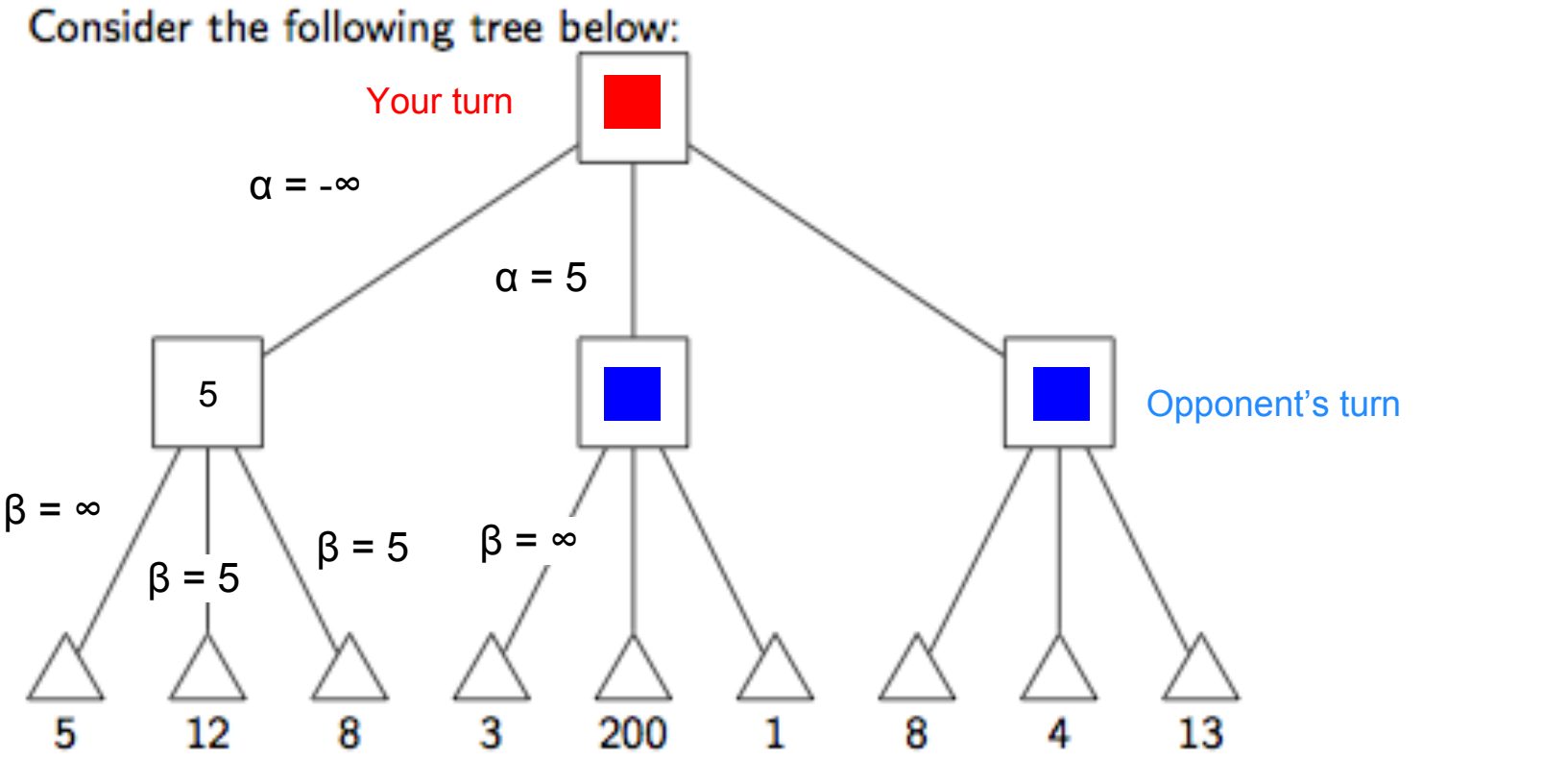

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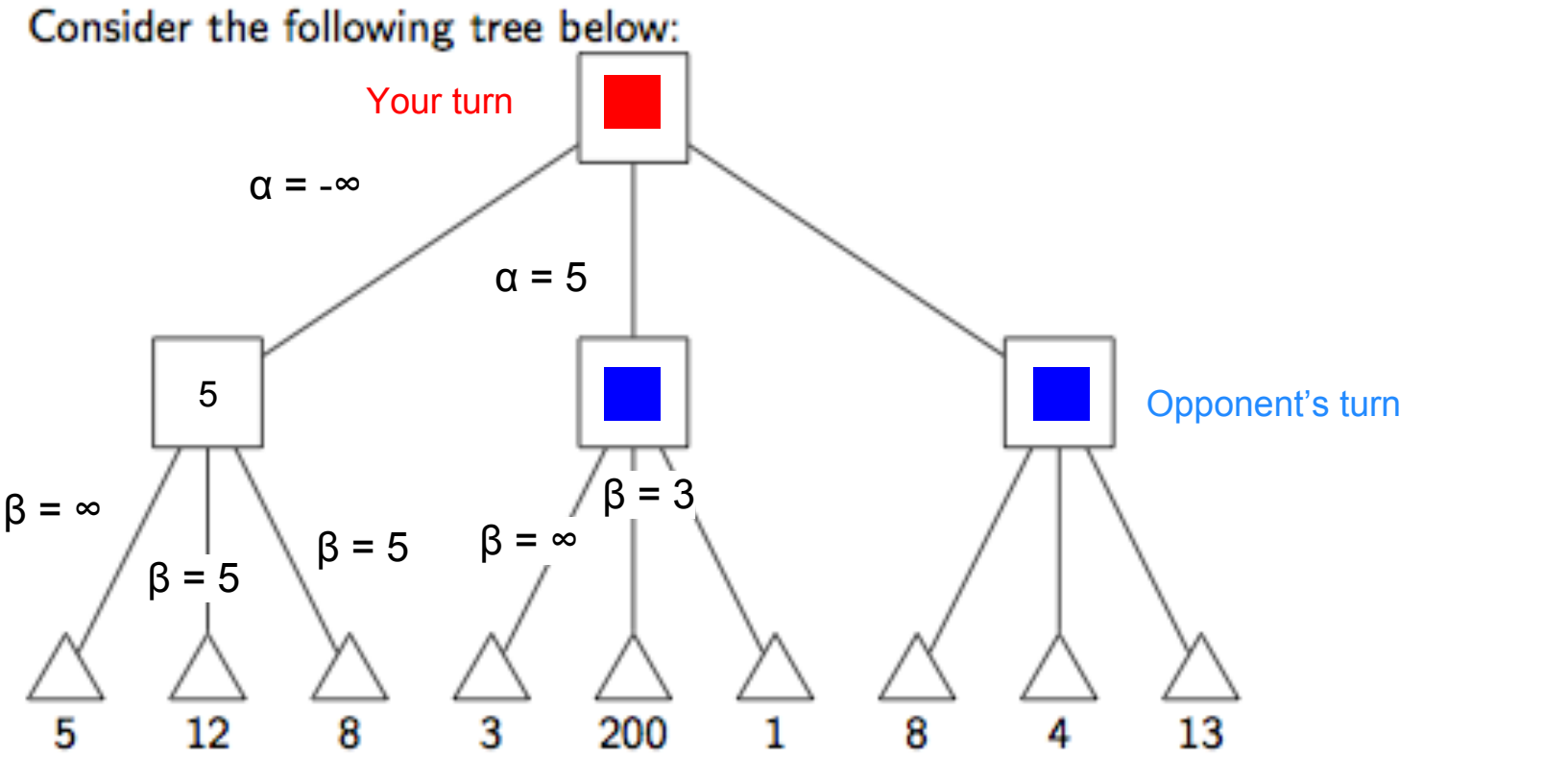

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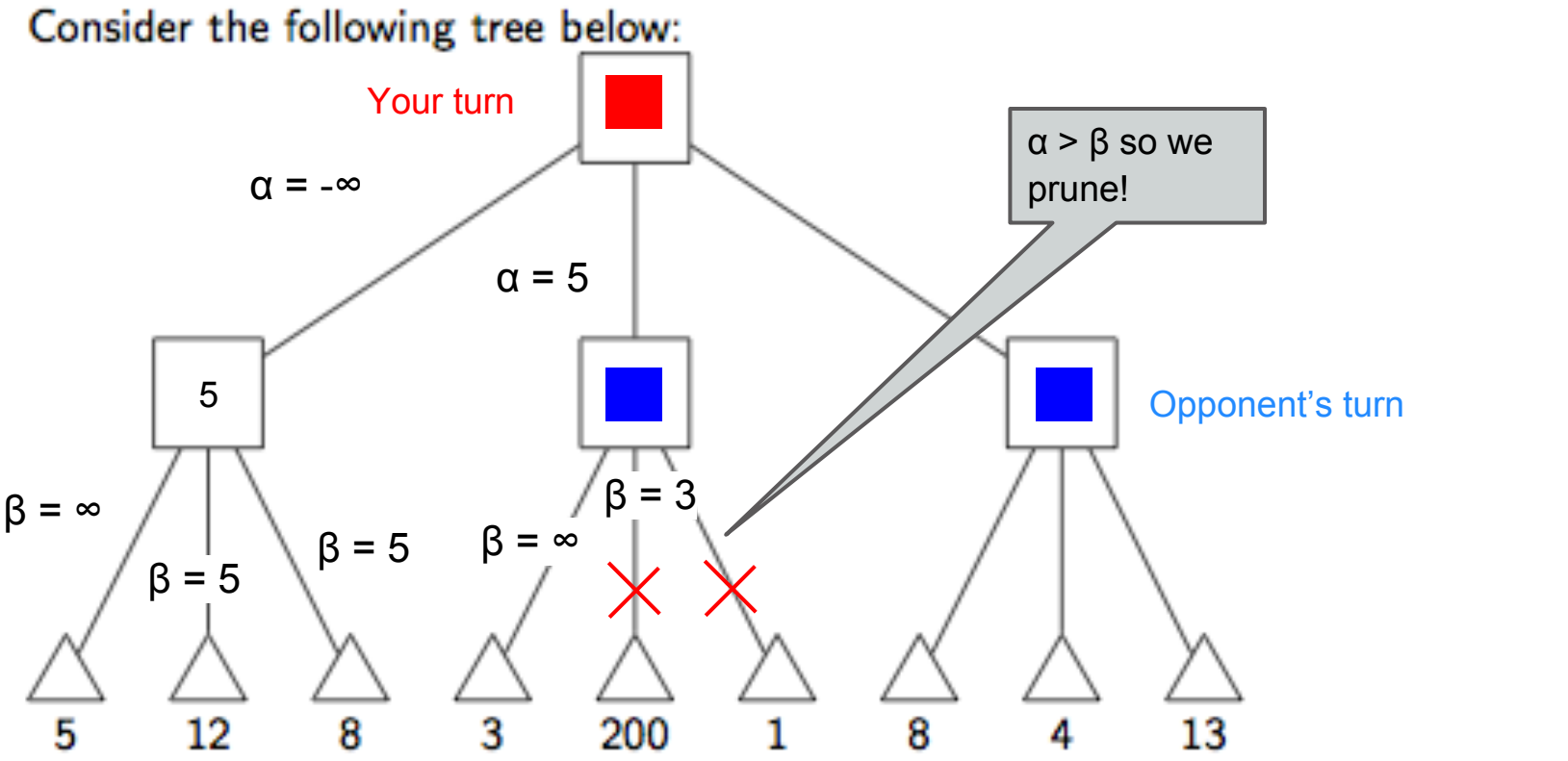

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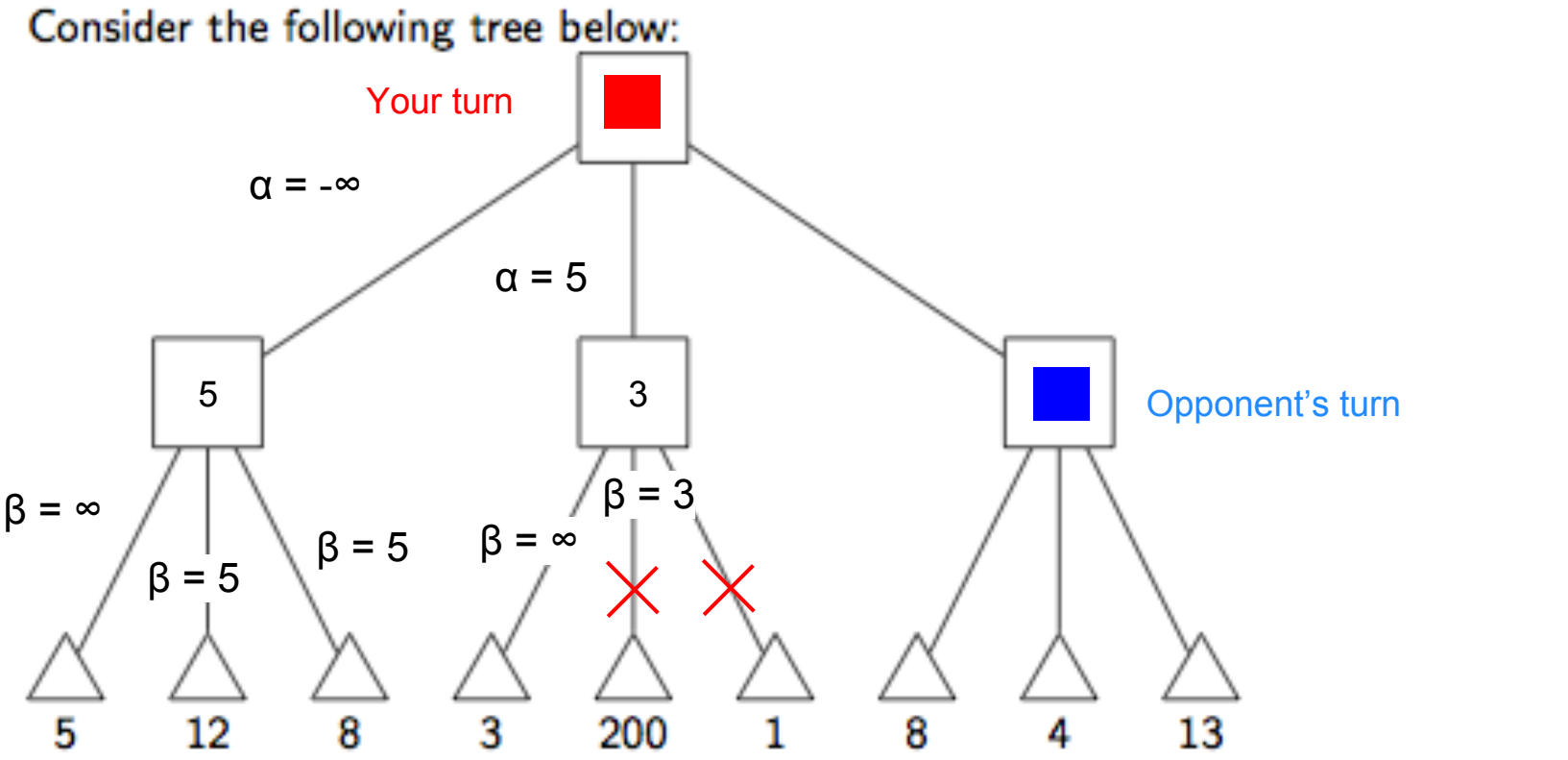

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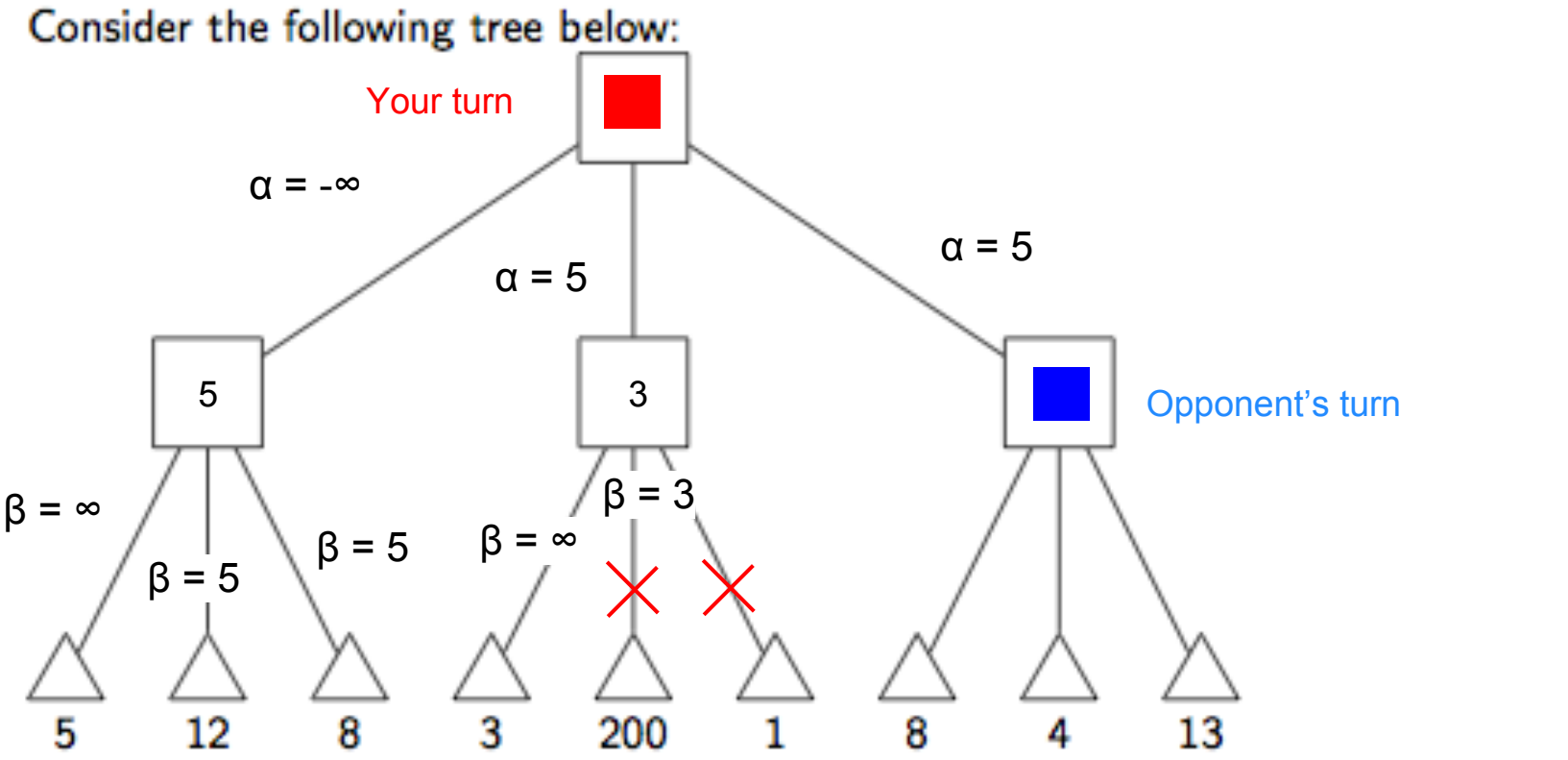

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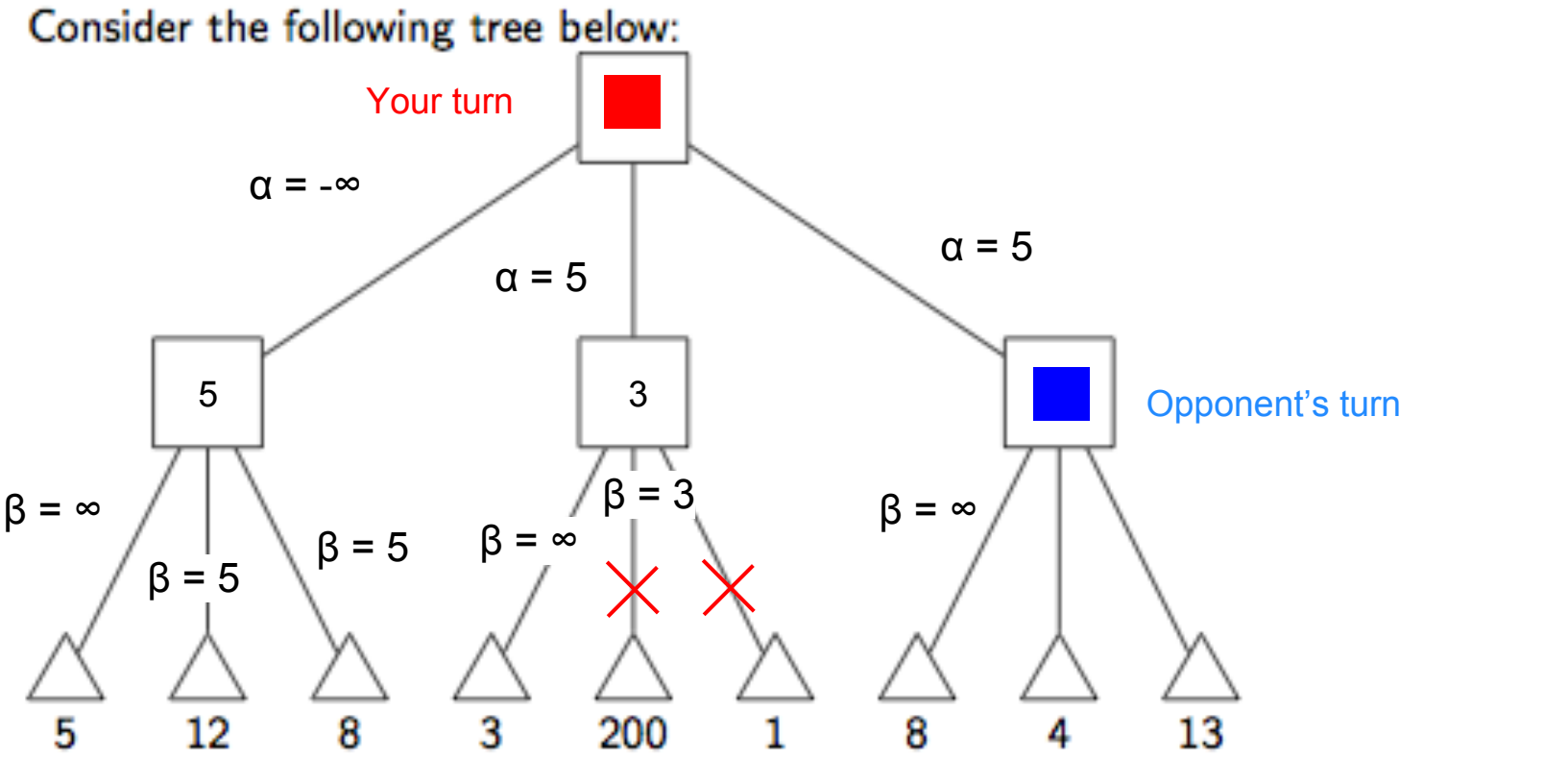

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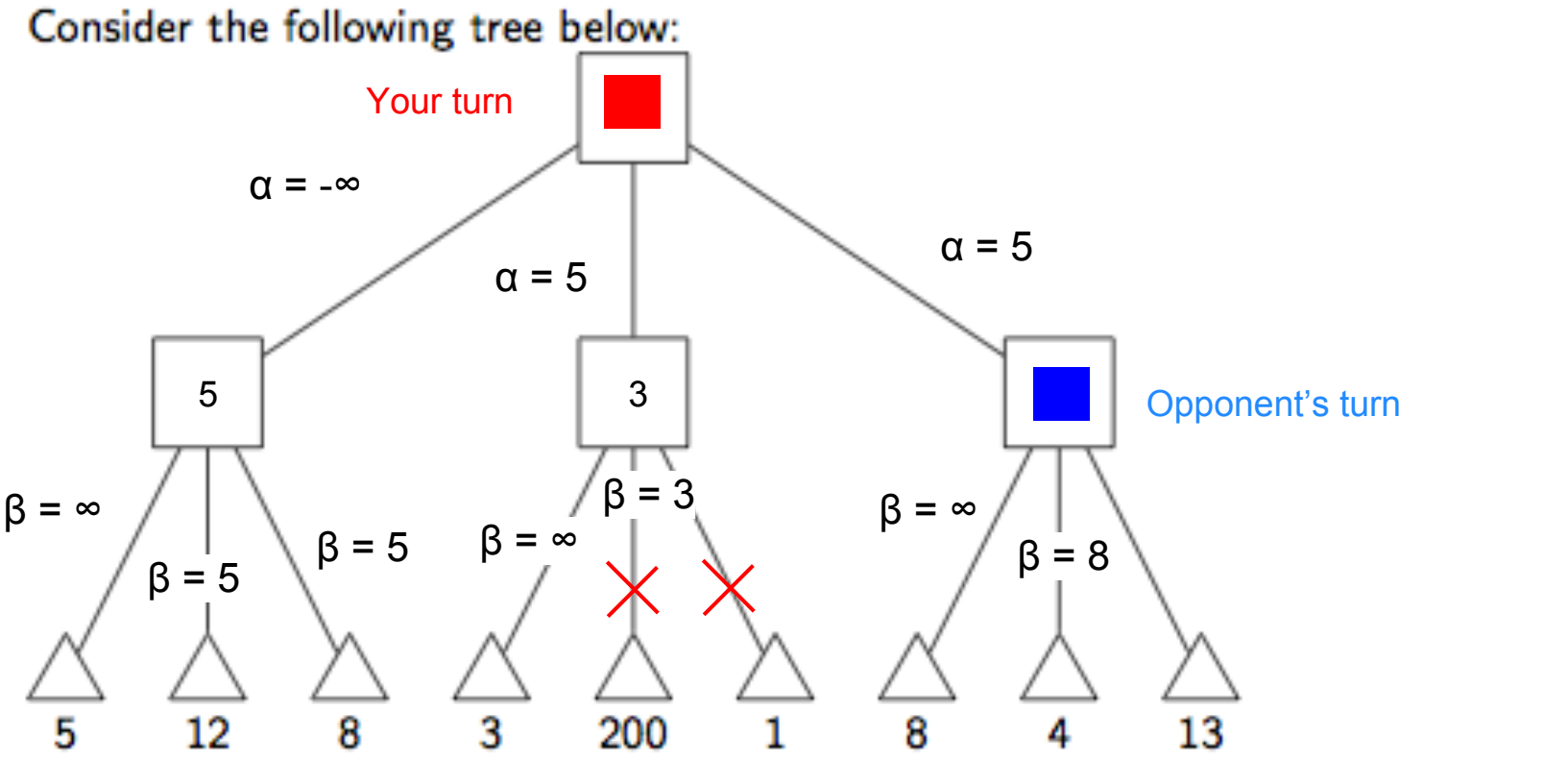

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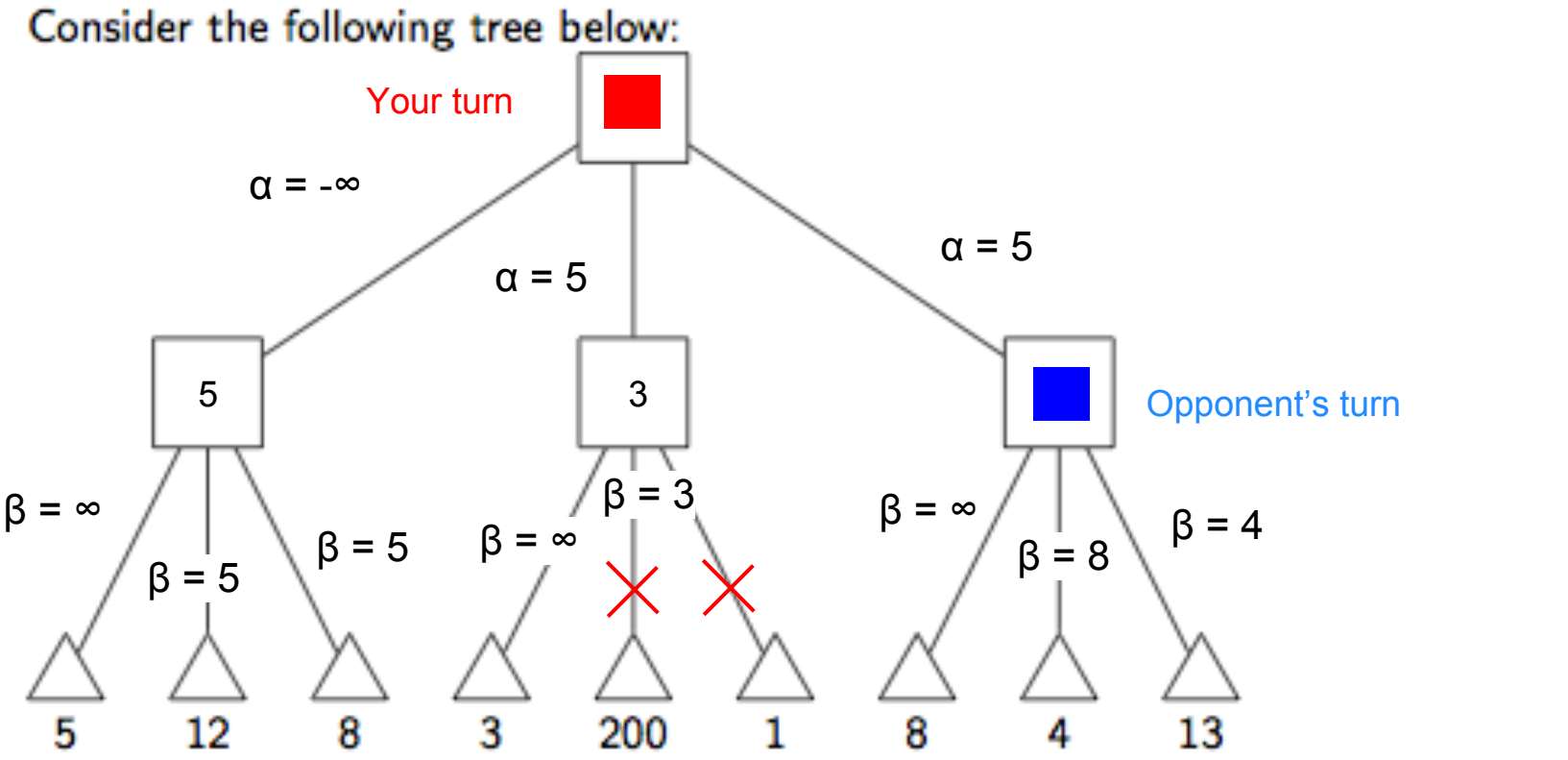

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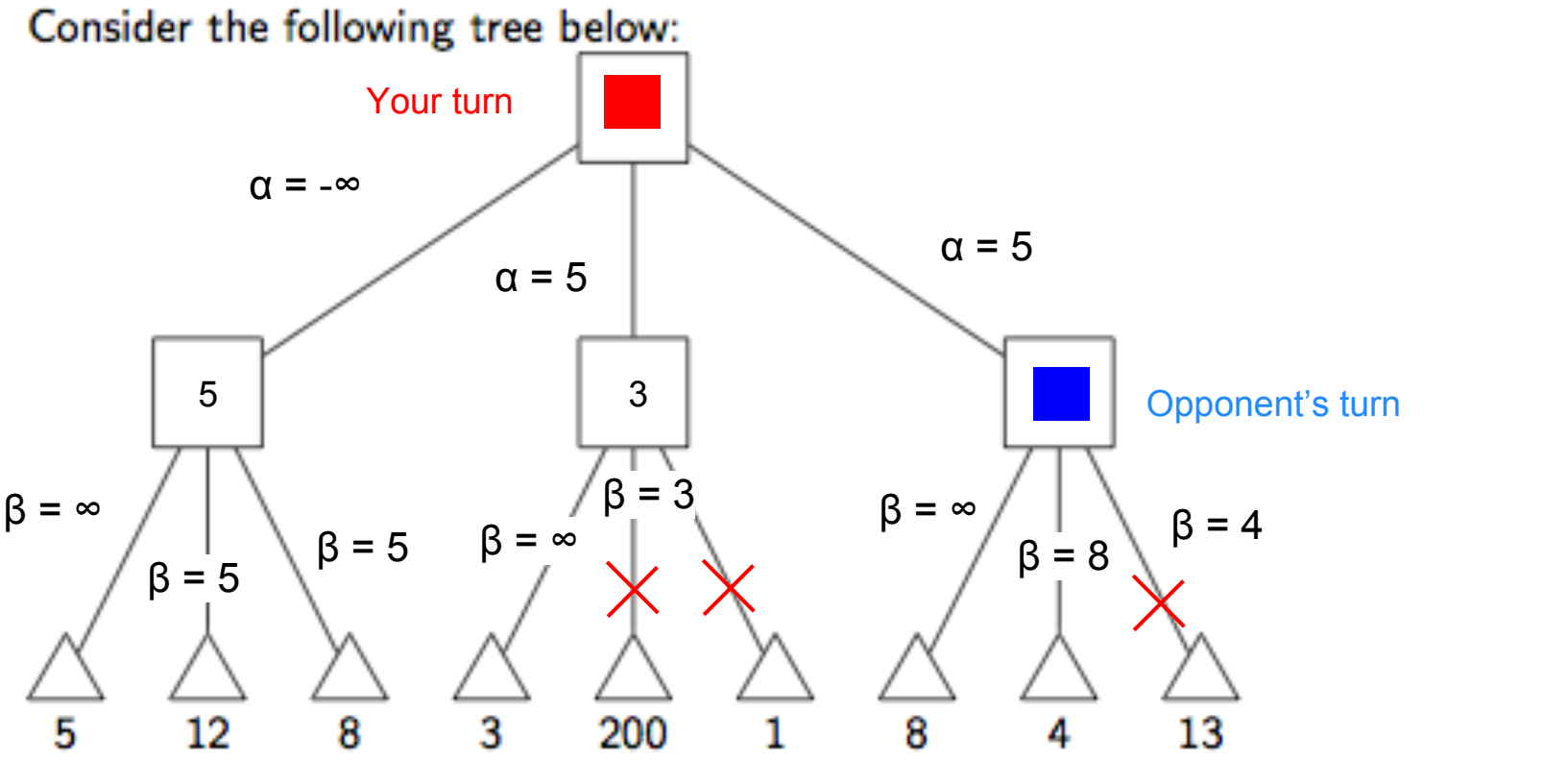

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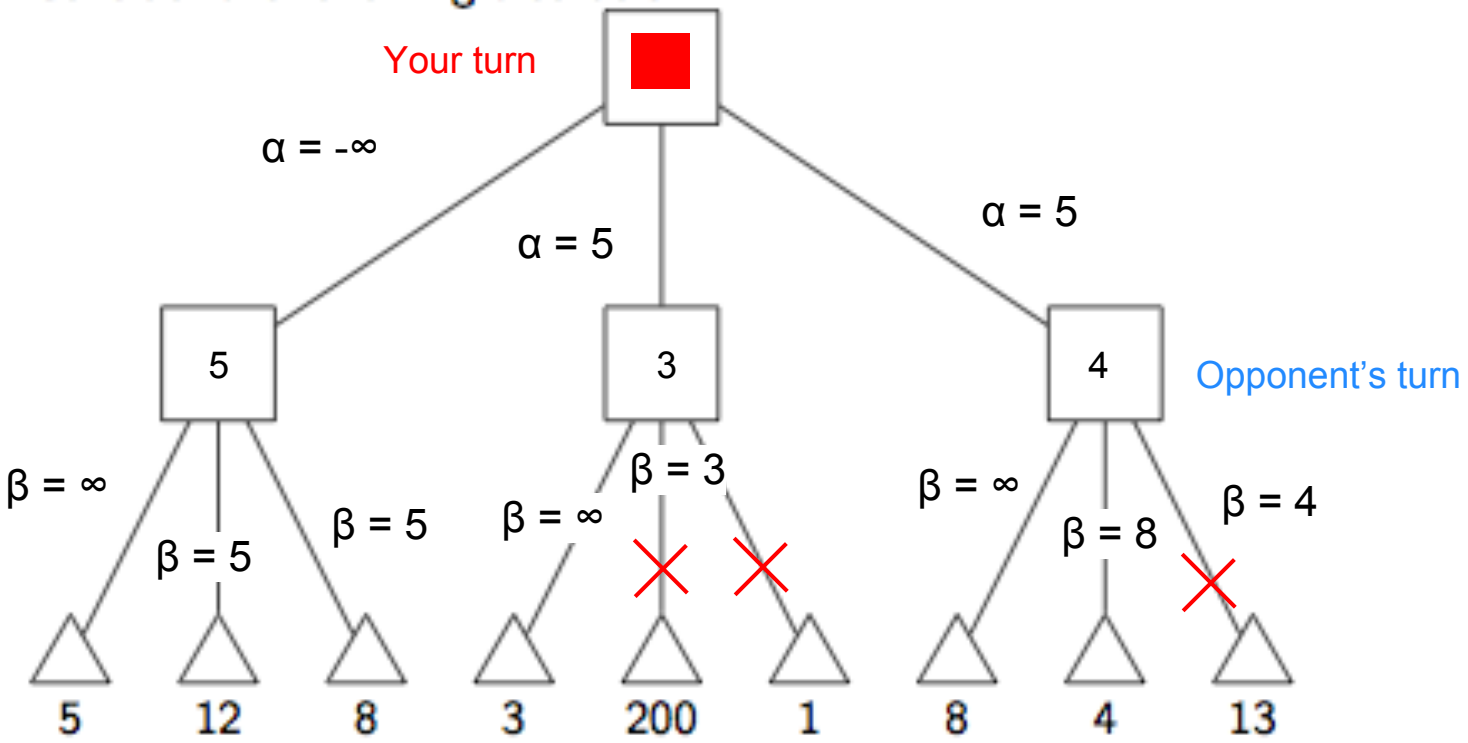

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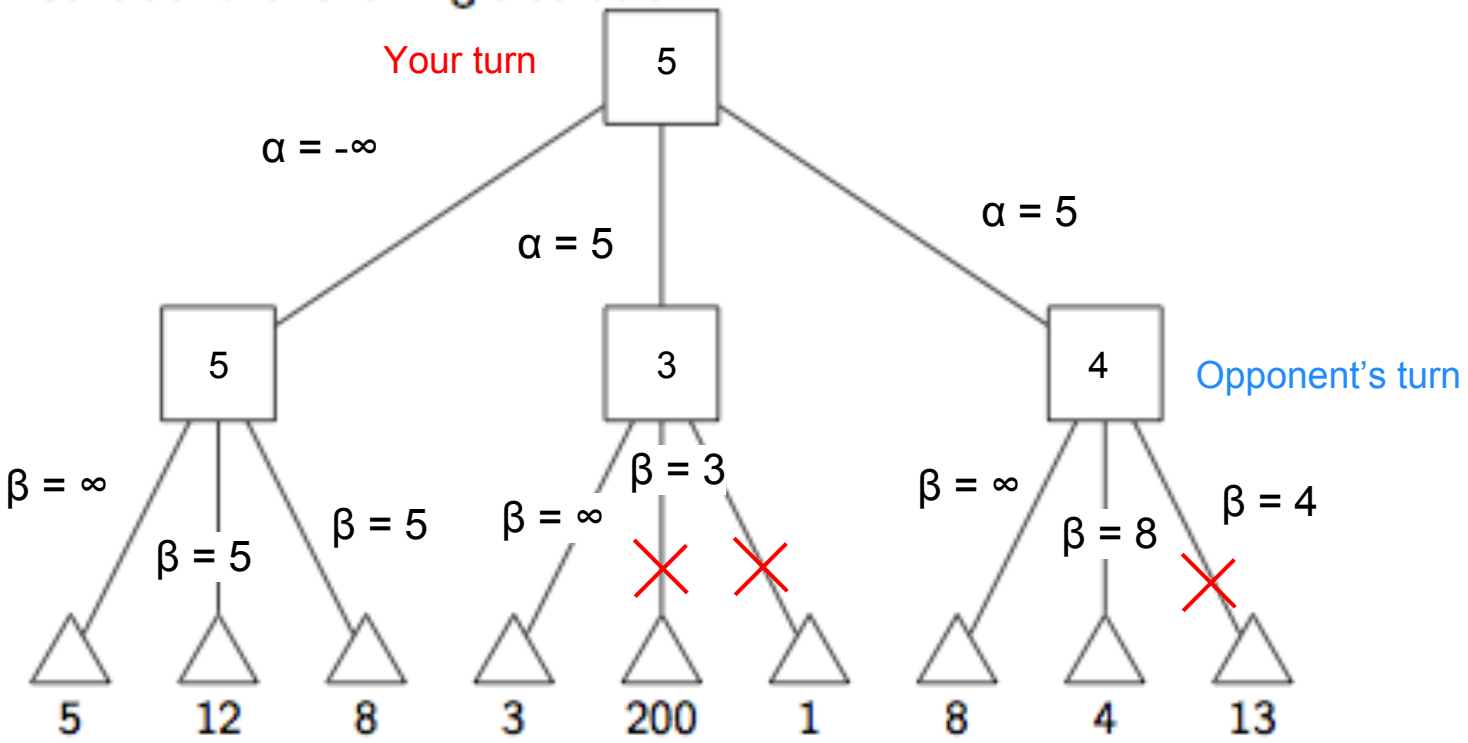

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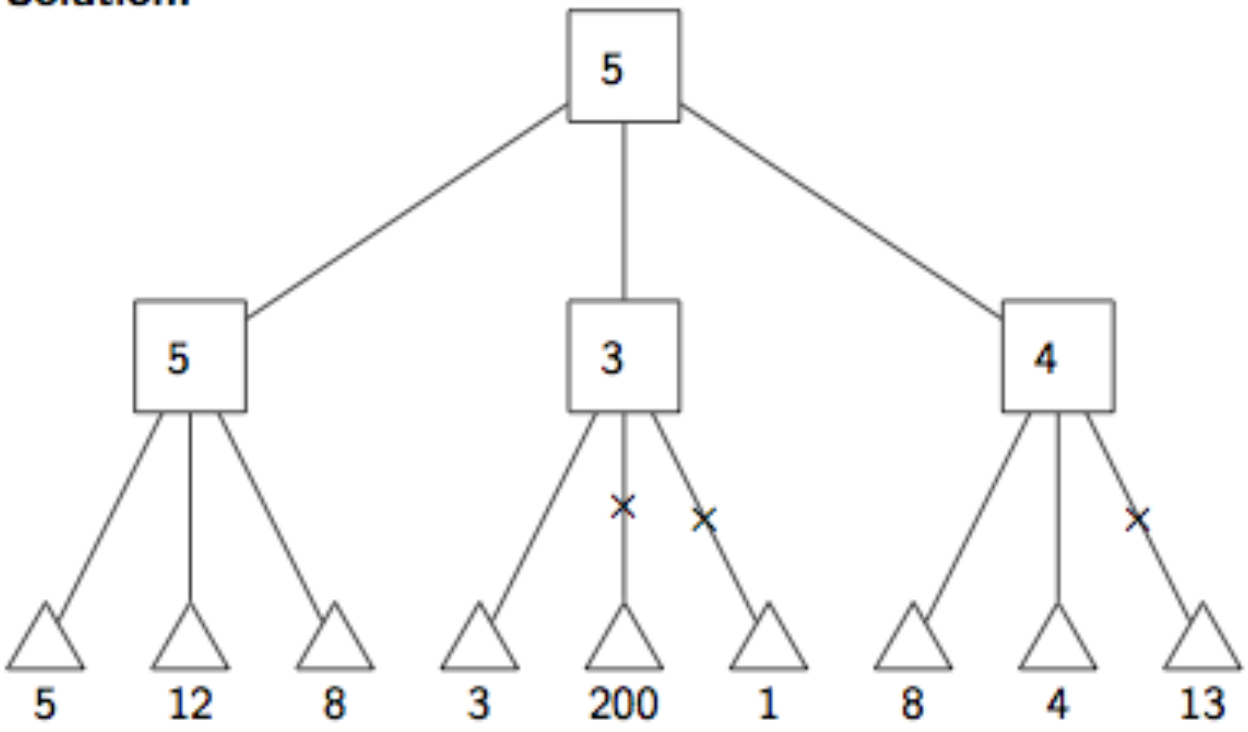
Alpha Beta Pruning

Solution:



Alpha Beta Pruning

True or False:

1. After alpha-beta pruning, the root maximizer node will never have the wrong value.

2. During alpha-beta pruning, none of the minimizer or maximizer intermediate nodes will differ from values found when using the normal minimax algorithm.

3. Alpha-beta pruning can have different prunings based on the order in which the algorithm traverses the tree.

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True -- what would have happened if we started with the middle minimizer's children first?

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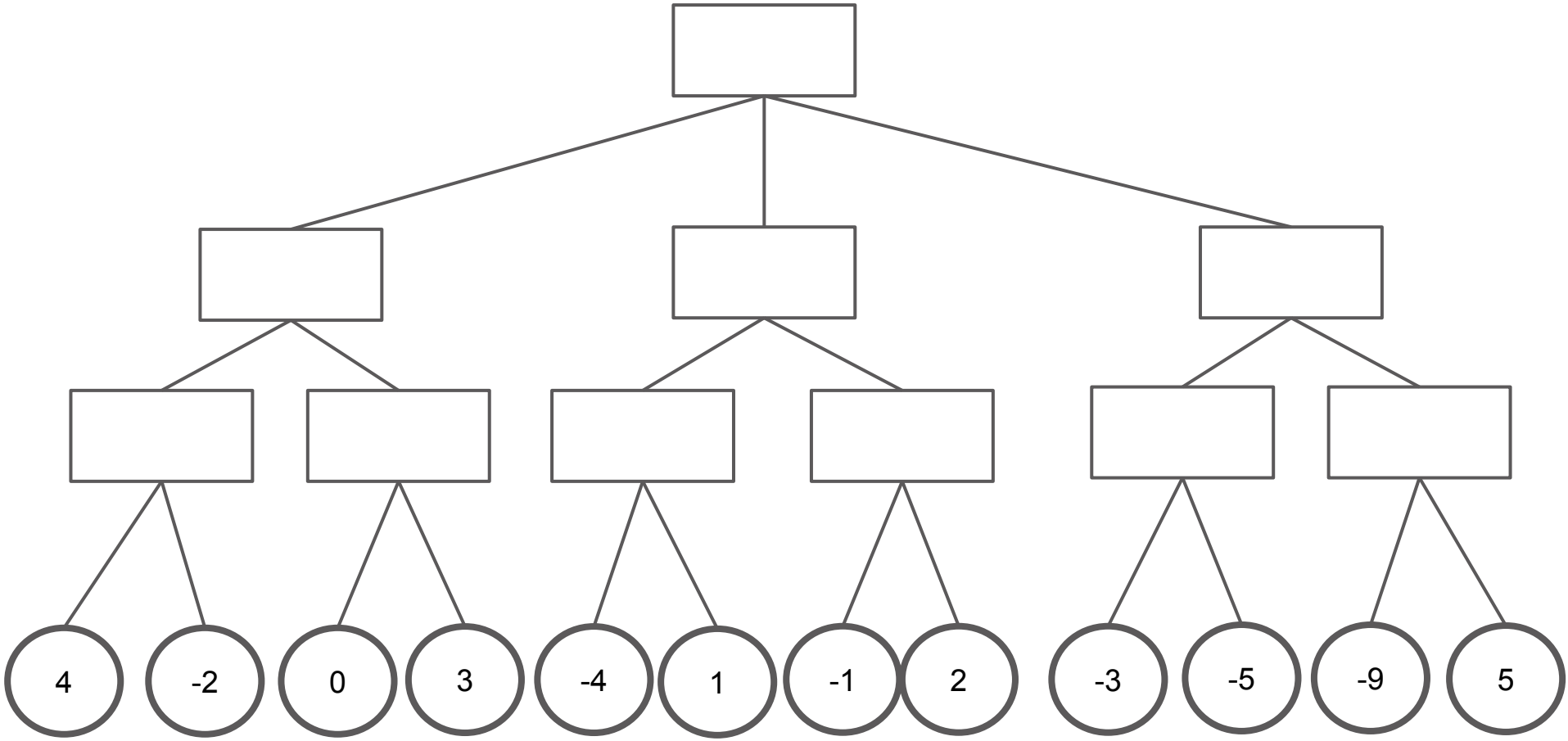

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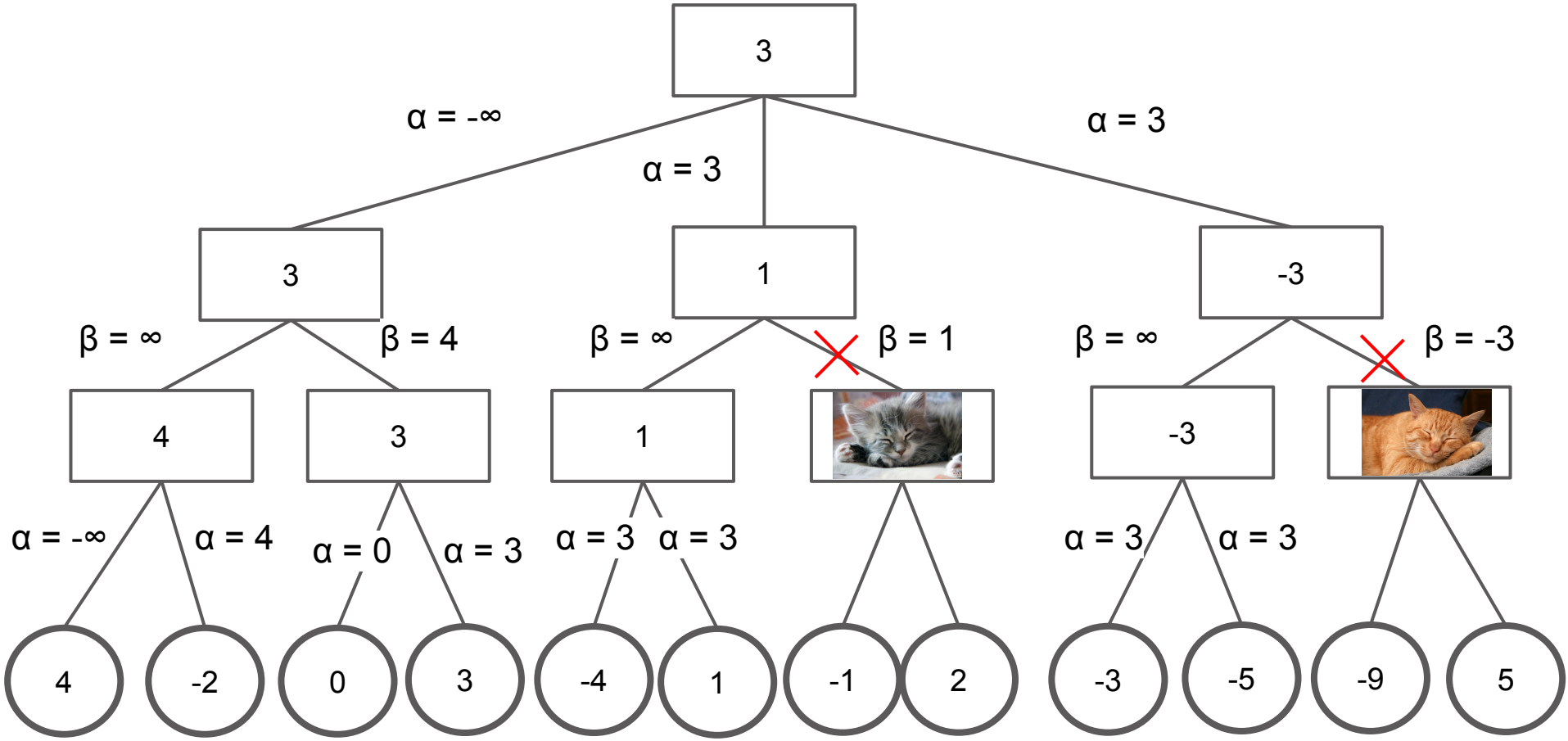

Alpha Beta Pruning Code

```
public Best chooseMove( boolean side, int
alpha, int beta) {
  Best myBest = new Best(); // My best move
  Best reply; // Opponent's best reply
  if (the current Grid is full or has a win) {
    return a Best with the Grid's score, no
move;
  }
  if (side == COMPUTER) {
    myBest.score = alpha;
  } else {
    myBest.score = beta;
  }
  //code continued on the next page
```

```
for (each legal move m) {
    perform move m; // Modifies "this" Grid
    reply = chooseMove( ! side, alpha, beta);
    undo move m; // Restores "this" Grid
    if ((side == COMPUTER) && (reply.score >=
myBest.score)) {
      myBest.move = m;
      myBest.score = reply.score;
      alpha = reply.score;
    } else if ((side == HUMAN) && (reply.score
<= myBest.score)) {
      myBest.move = m;
      myBest.score = reply.score;
      beta = reply.score;
    }
    if (alpha >= beta) { return myBest; }
  }
  return myBest;
}
```