Othello AI Tournament!

CS2: Intro. to Programming Methods
Weeks 9-10
Friday, March 7, 2014

Administrative notes

- Next assignment is due Tuesday, March 11 at 17:00
- Tournament cutoff is Monday, March 17, at 23:55
  - TAs need some time to set things up
  - We may accept tournament submissions after that, but there's no guarantee

Administrative notes

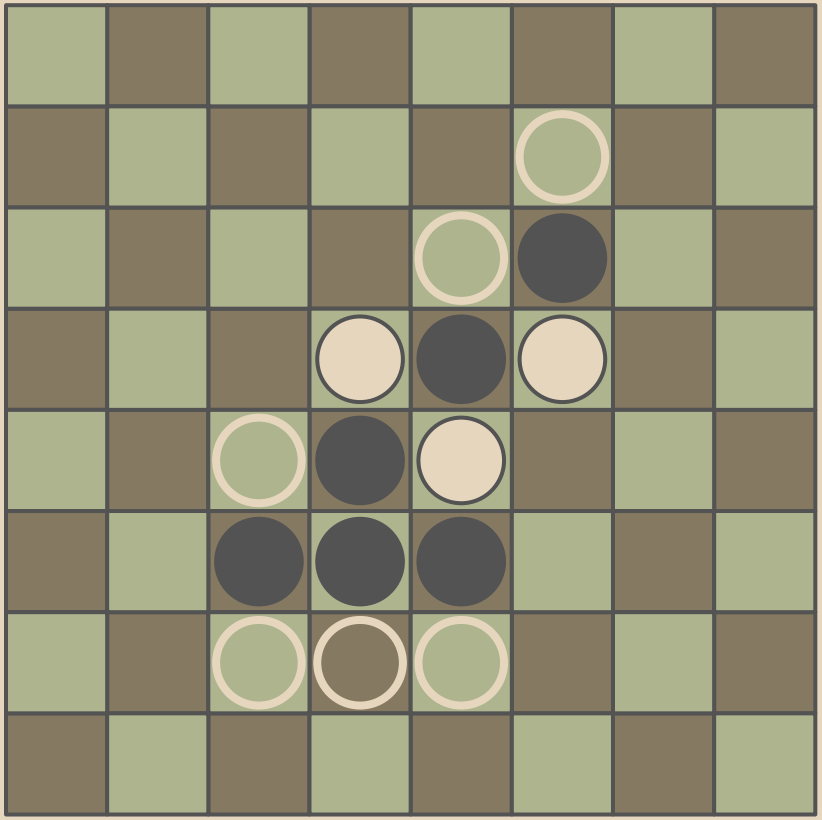
- The tournament itself will be held in Annenberg 104 (the lab)
- Tournament starts Tuesday March 18 at 17:00
- The games themselves will be displayed on the lab computers as they are played
- Come by and watch!

Othello++: additional considerations

- Mobility
- Frontier squares
- Alpha-beta pruning
- Transposition tables
- Iterative deepening
- Opening books

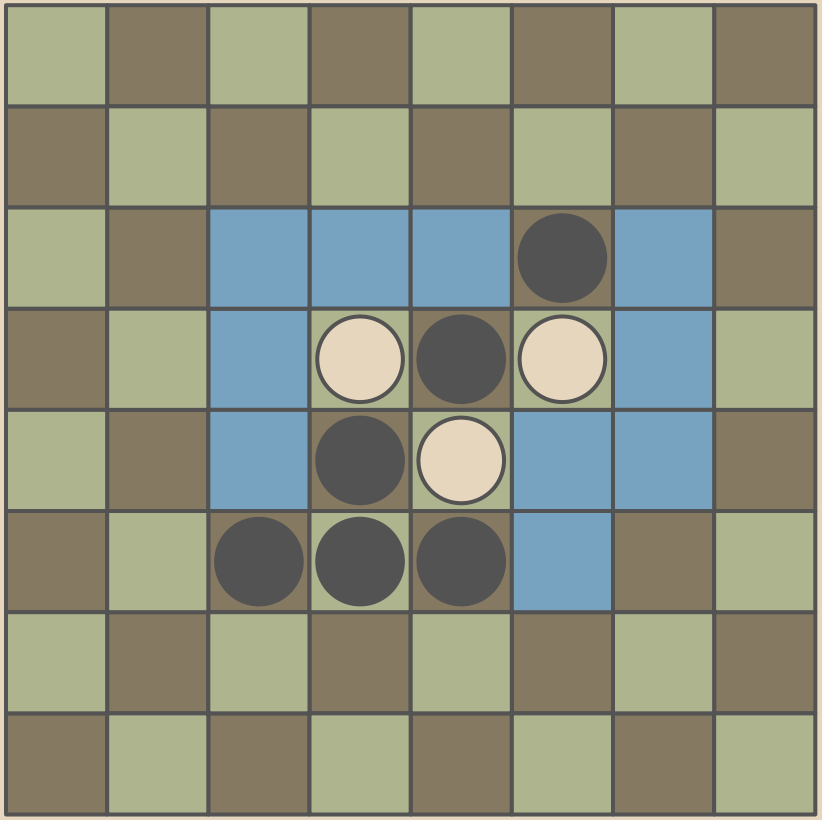
You are the battlemaster; test your skills.

Mobility



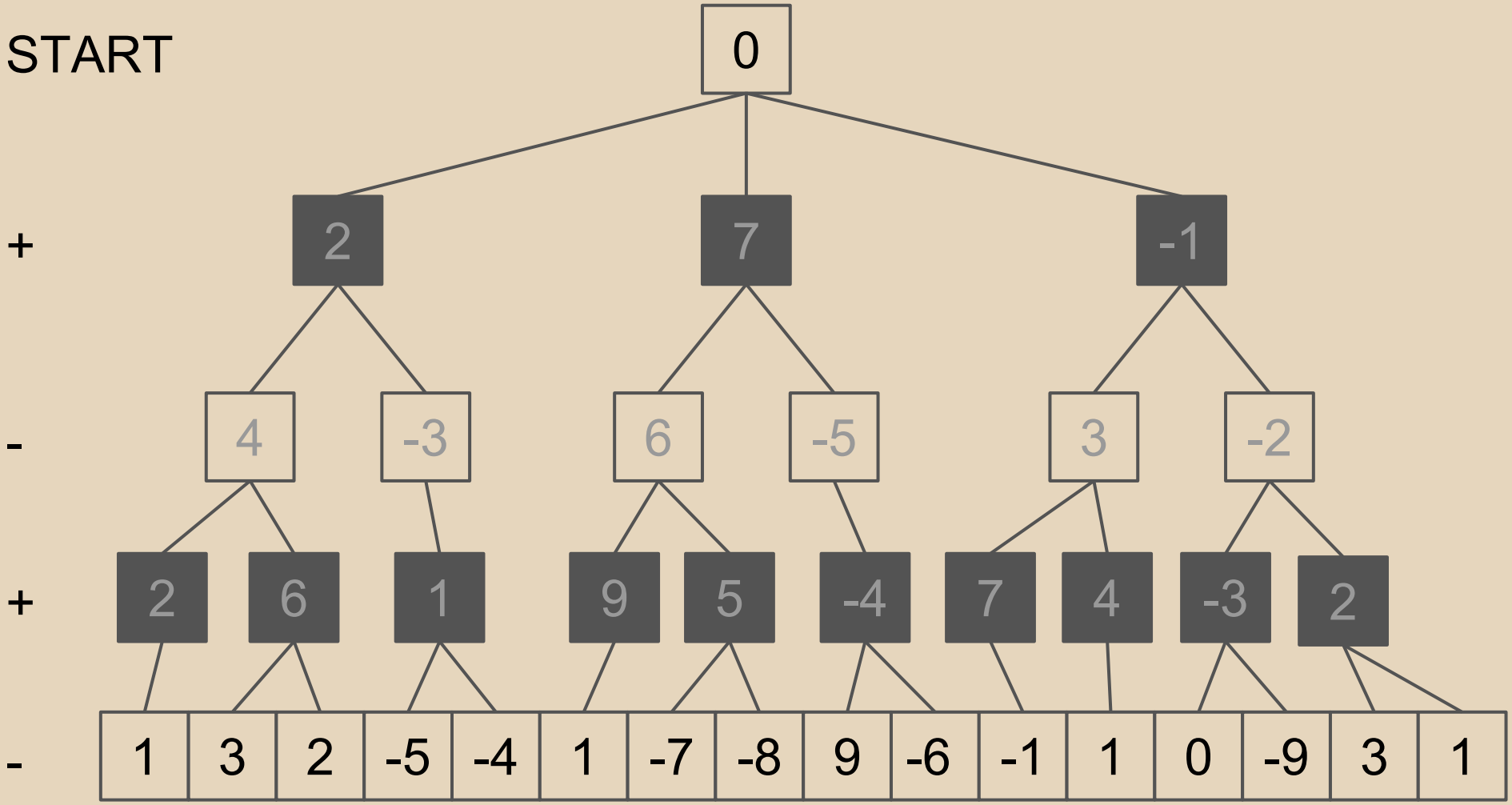
- The number of moves available
- Generally a good thing
  - more choices = better chance of a good choice
  - maximize for self
  - minimize for the other player

Frontier squares



- The number of open squares adjacent to our own pieces
- Generally bad for us
  - more frontier squares = more potential points for attack
  - minimize for self
  - maximize for opponent

Minimax again!



Alpha-beta pruning

- We can do better than exhaustive search.
- Store two numbers (alpha and beta) for each node as we're doing our depth-first search
  - Alpha: the maximum score we are assured of so far
  - Beta: the minimum score our opponent is assured of so far

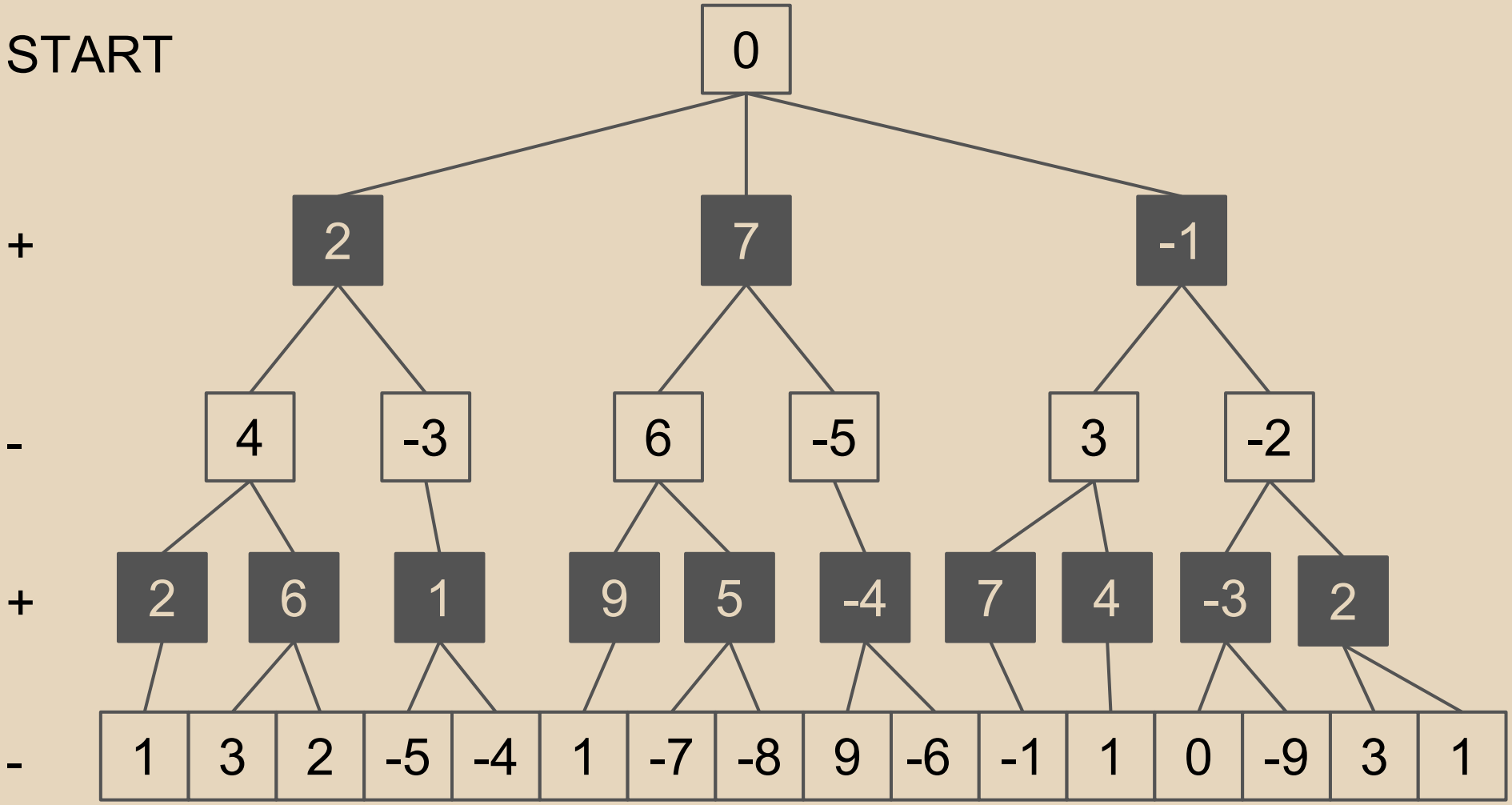
Alpha-beta pruning

- What if we can make a move such that alpha > beta?
  - Then the opponent should never have let us get here in the first place
- What if opponent can make a move such that beta < alpha?
  - Then we should never have let the opponent get there in the first place
- In either case, we can stop evaluating the current subtree

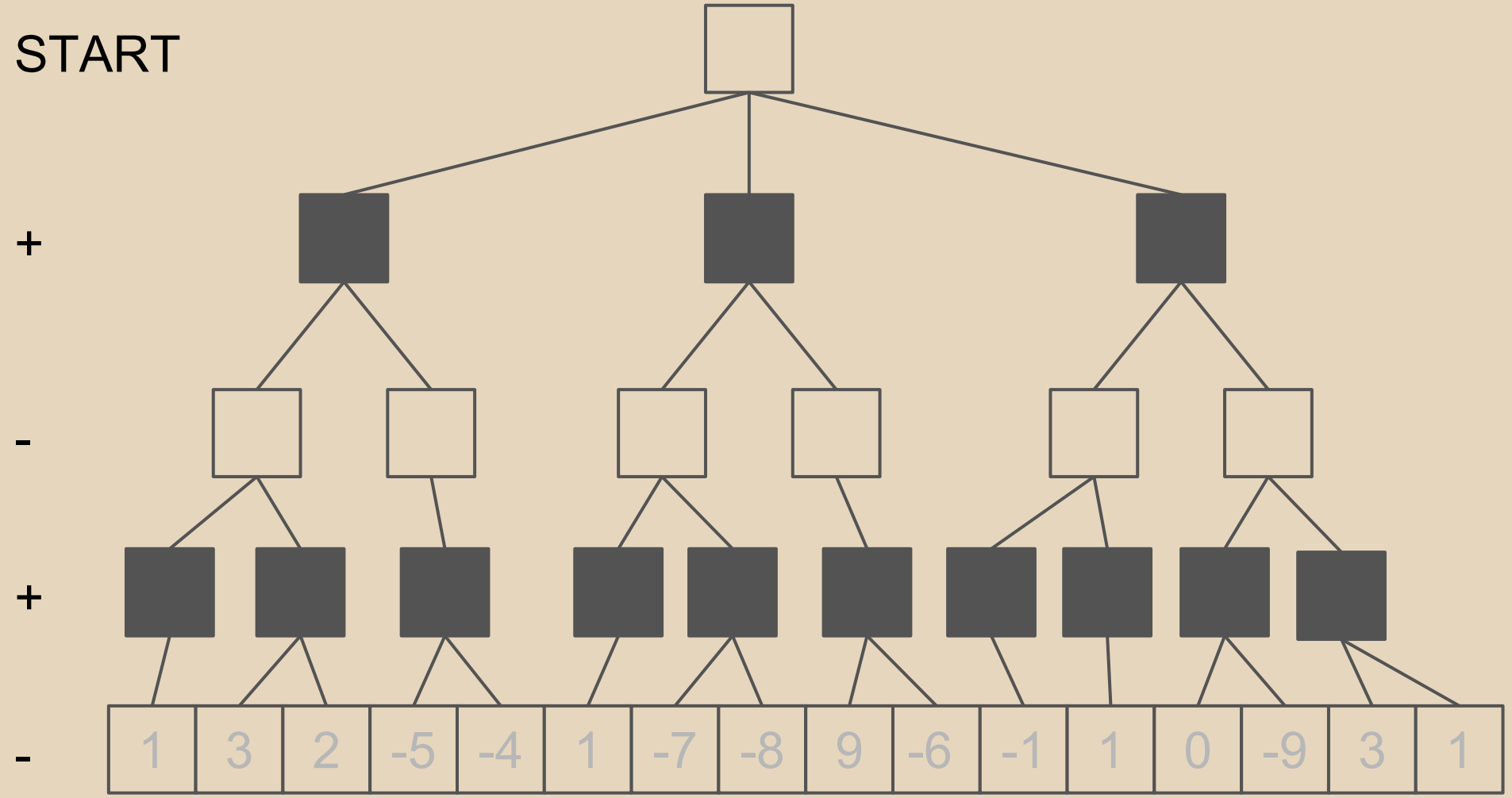
Computing alpha-beta in practice

- My turn?
  - I'm trying to maximize
  - Return alpha = max(alpha, beta $\forall$ children)
- Opponent's turn?
  - Opponent wants to minimize
  - Return beta = min(beta, alpha $\forall$ children)
- Recursive algorithm
  - If it's my turn for a given node, it's the opponent's turn for all the children
  - Inherit alpha/beta values from parent
  - Base case: bottom of tree (where value is given)
  - Initial call: alpha, beta = INFINITY

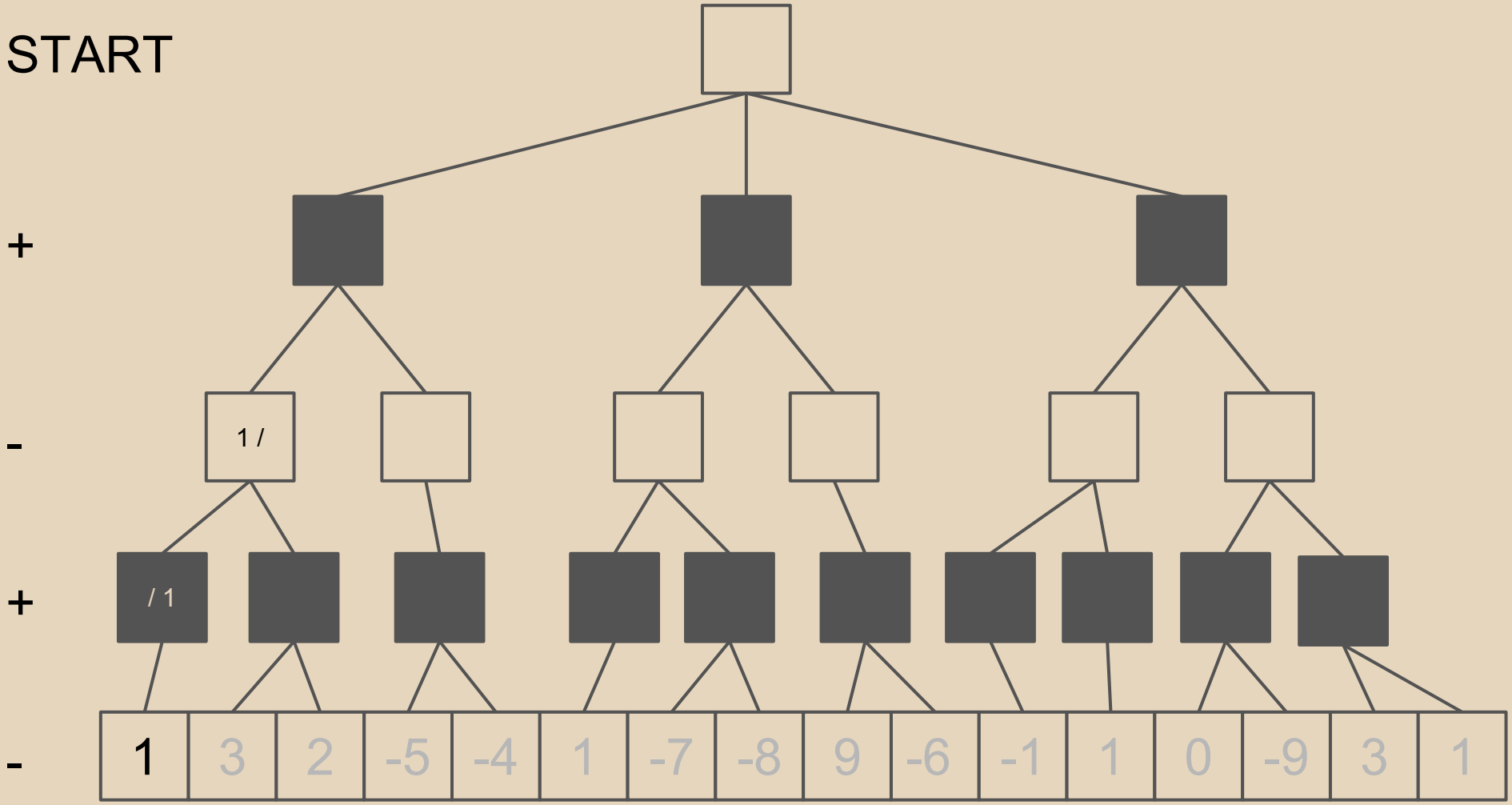
Alpha-beta example



First ignore all intermediate scores



Now start searching...



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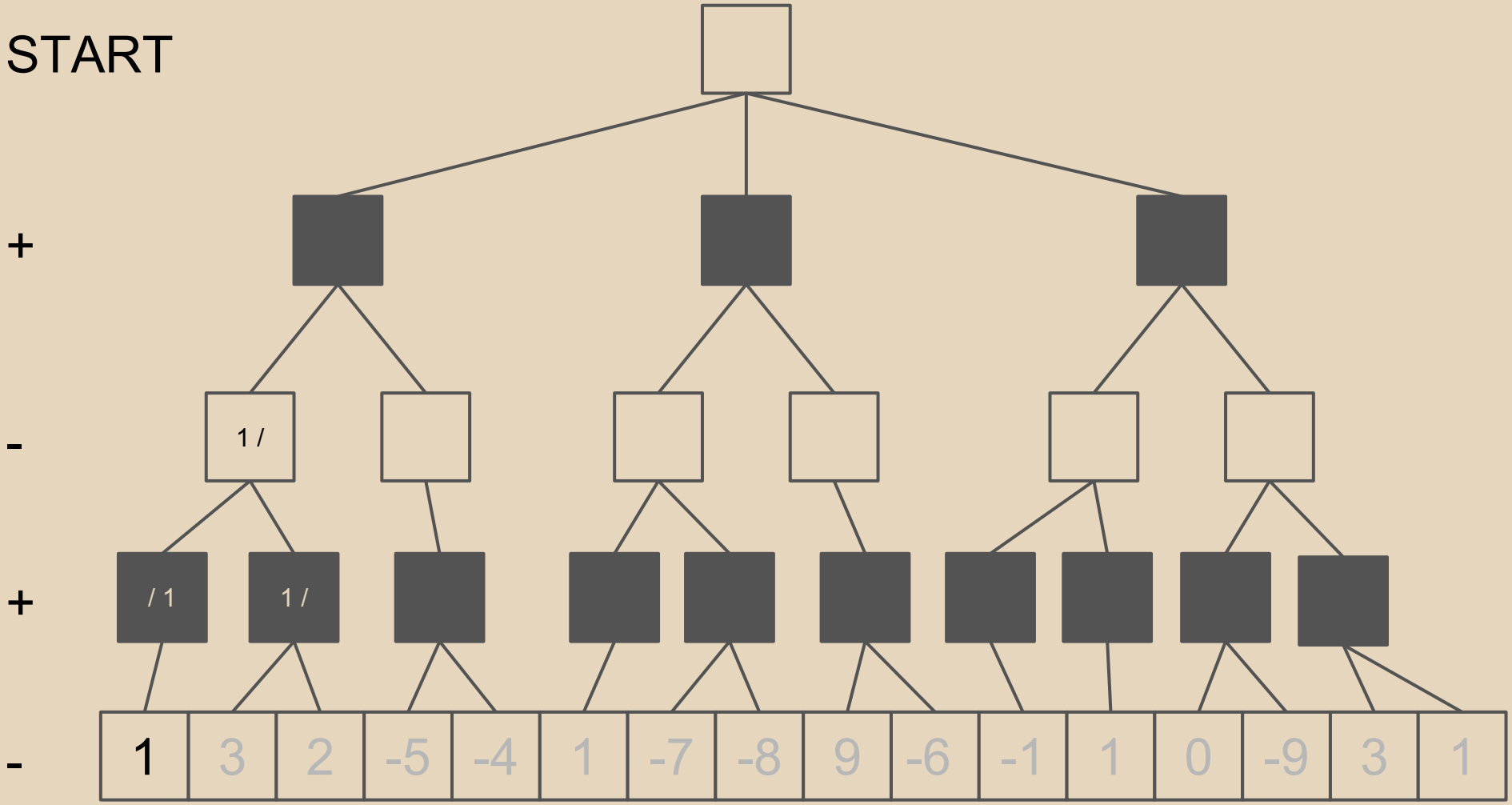

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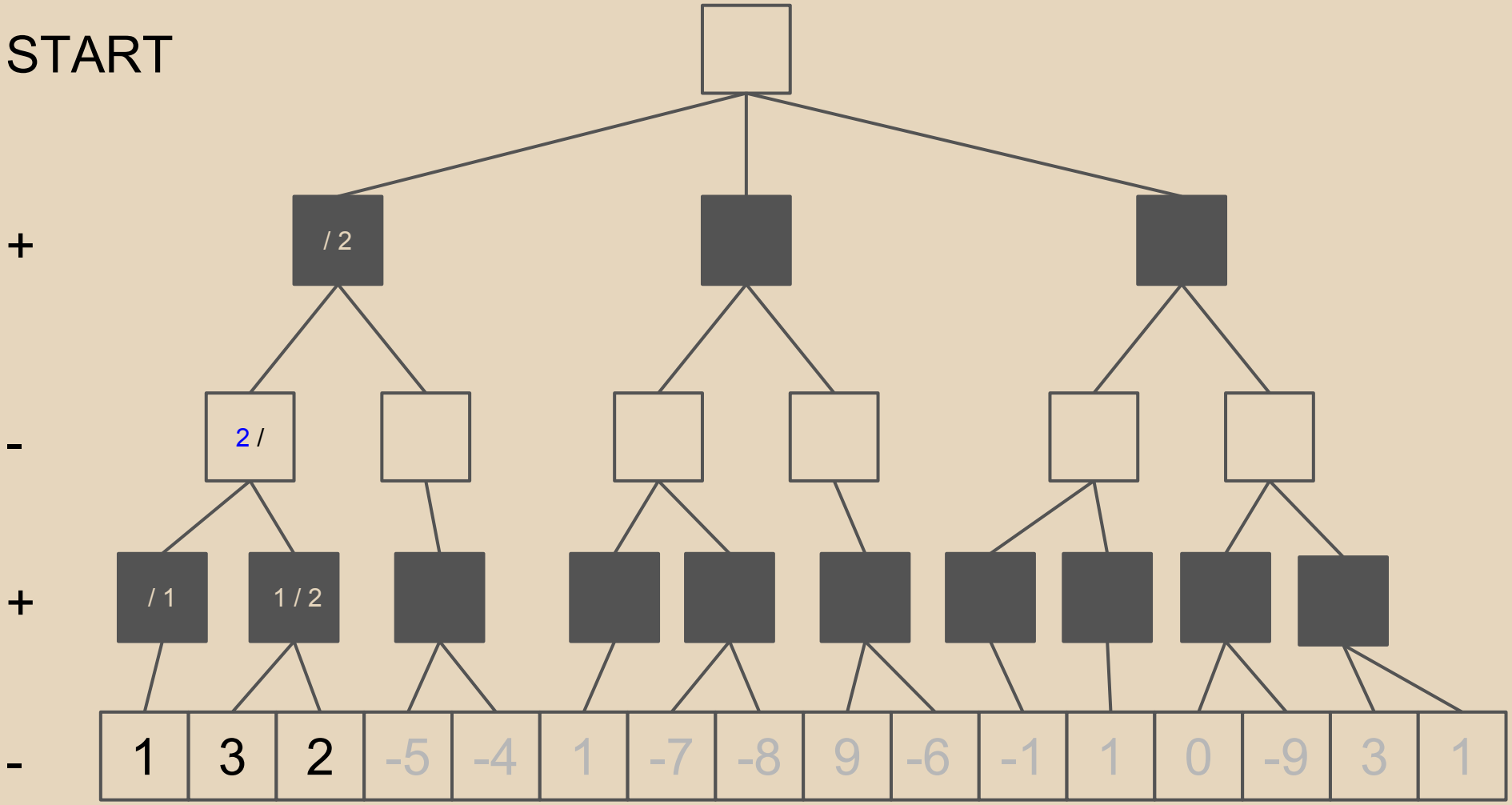

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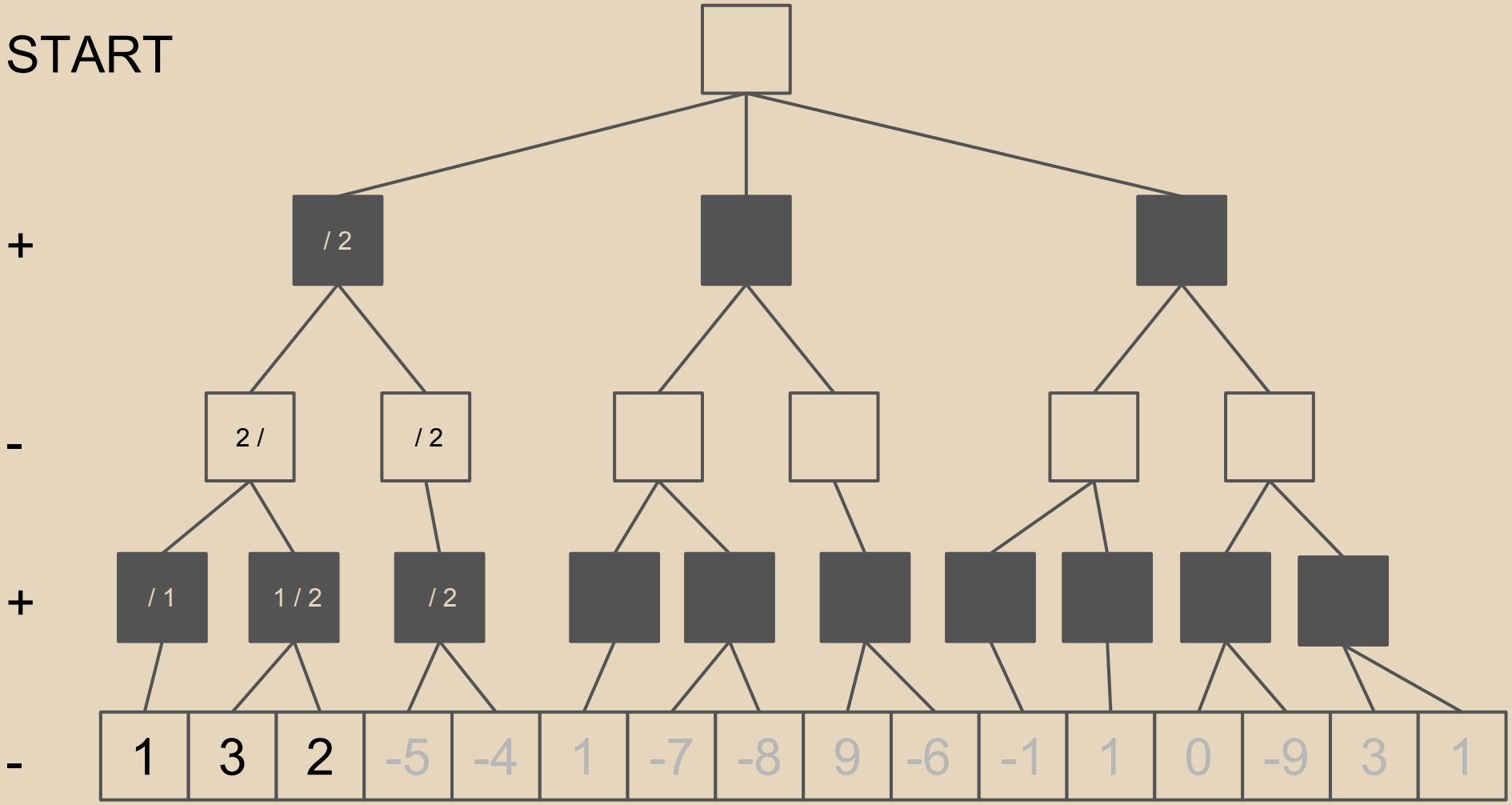

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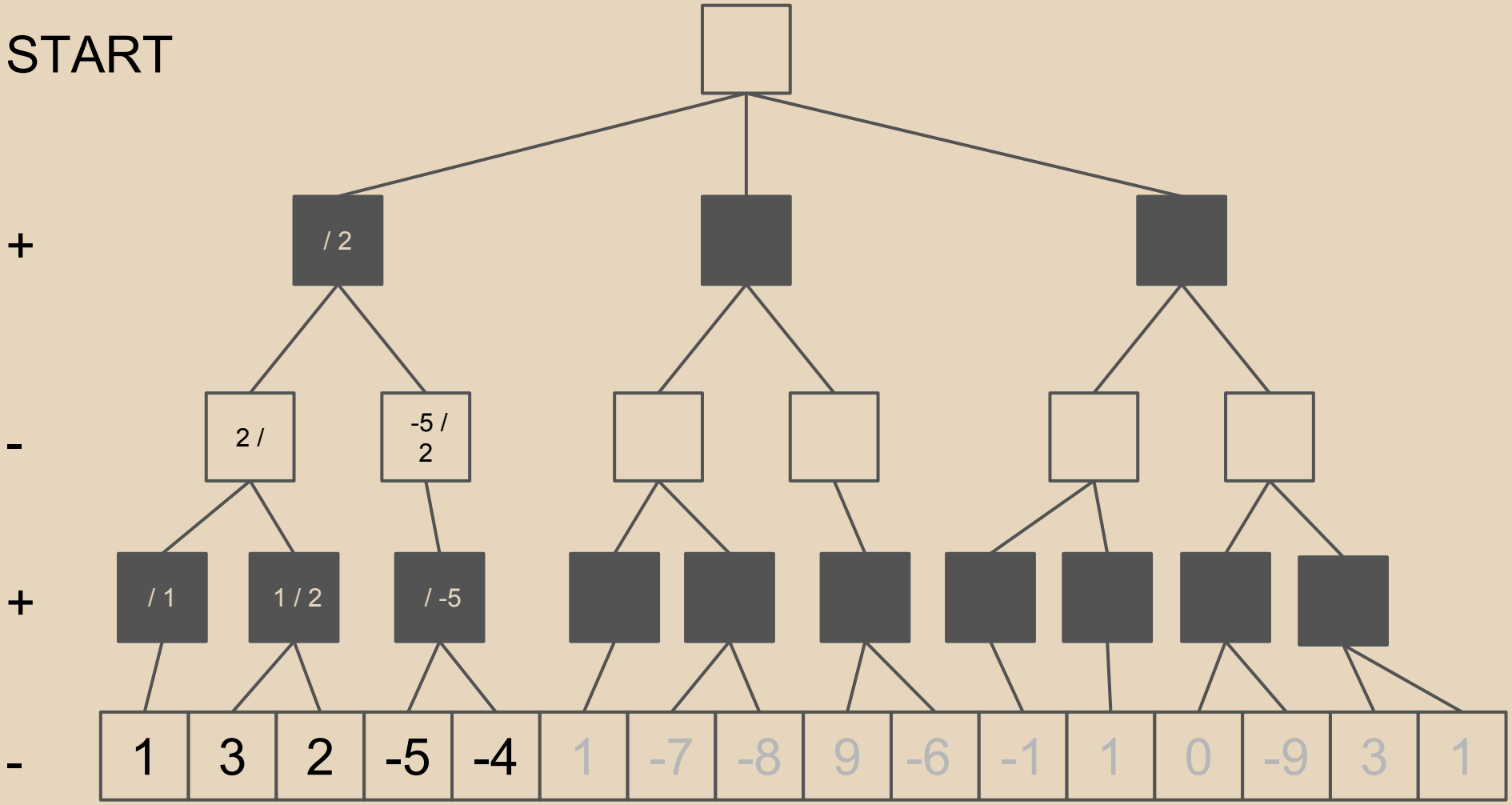

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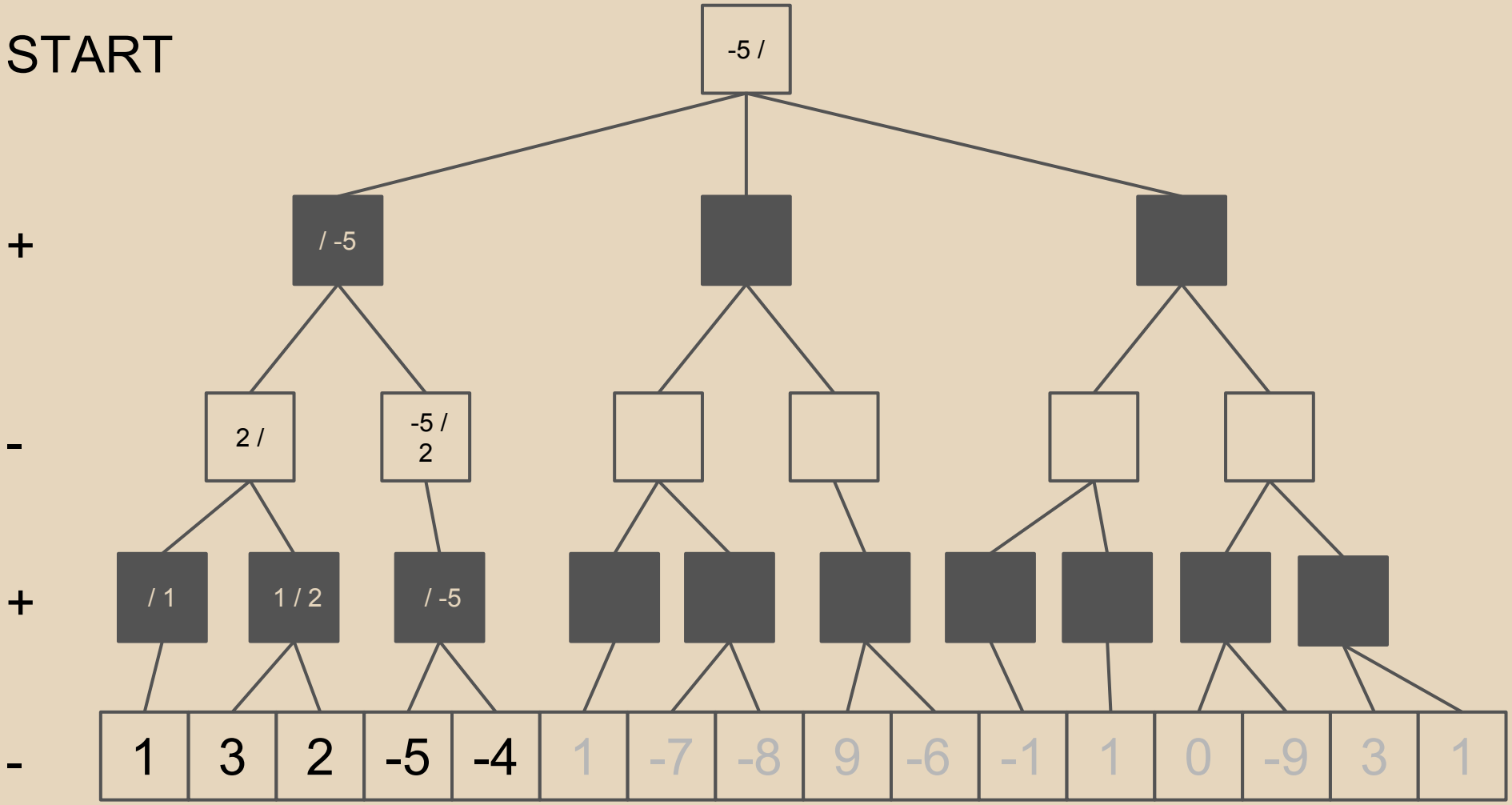

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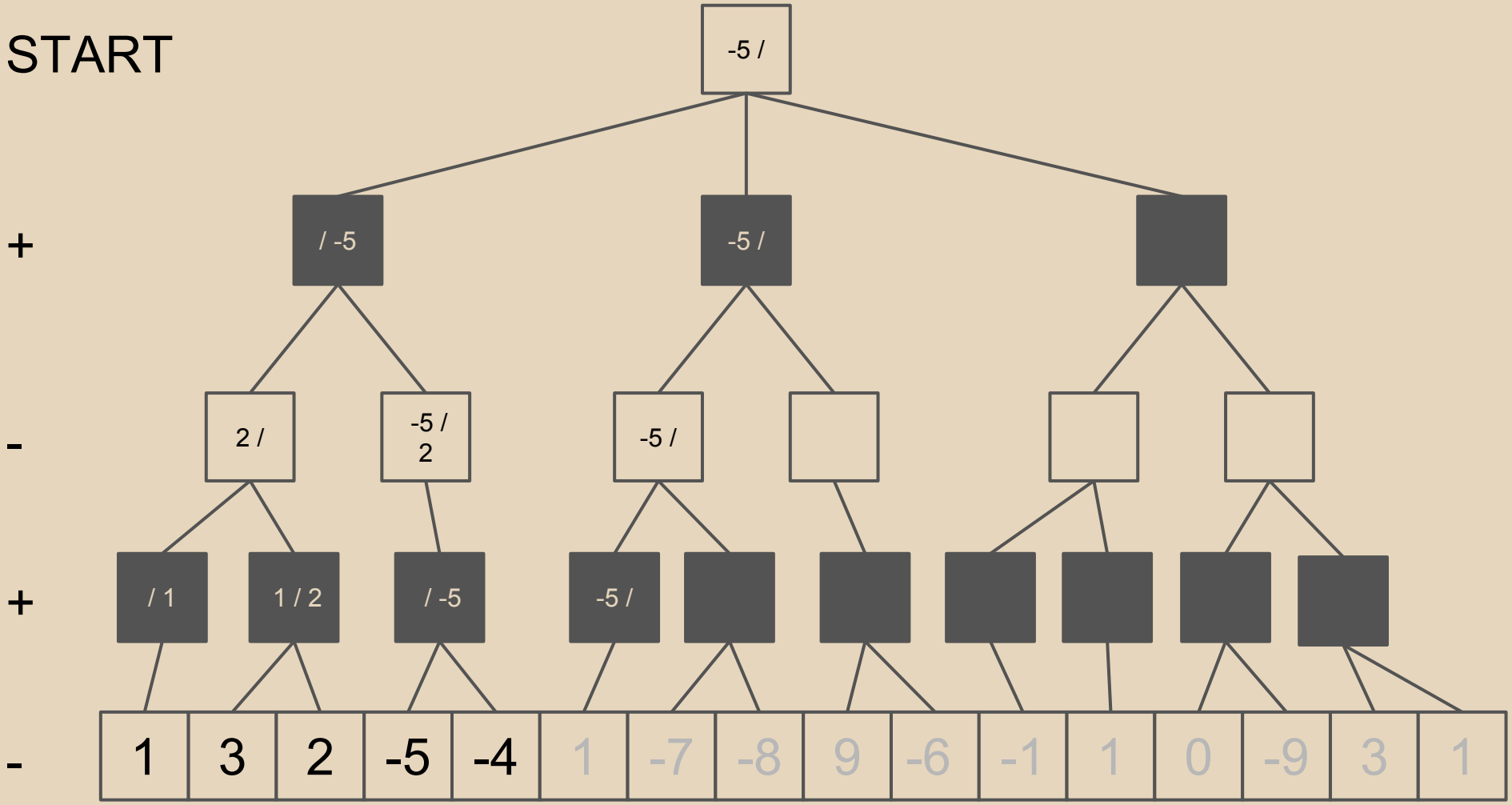

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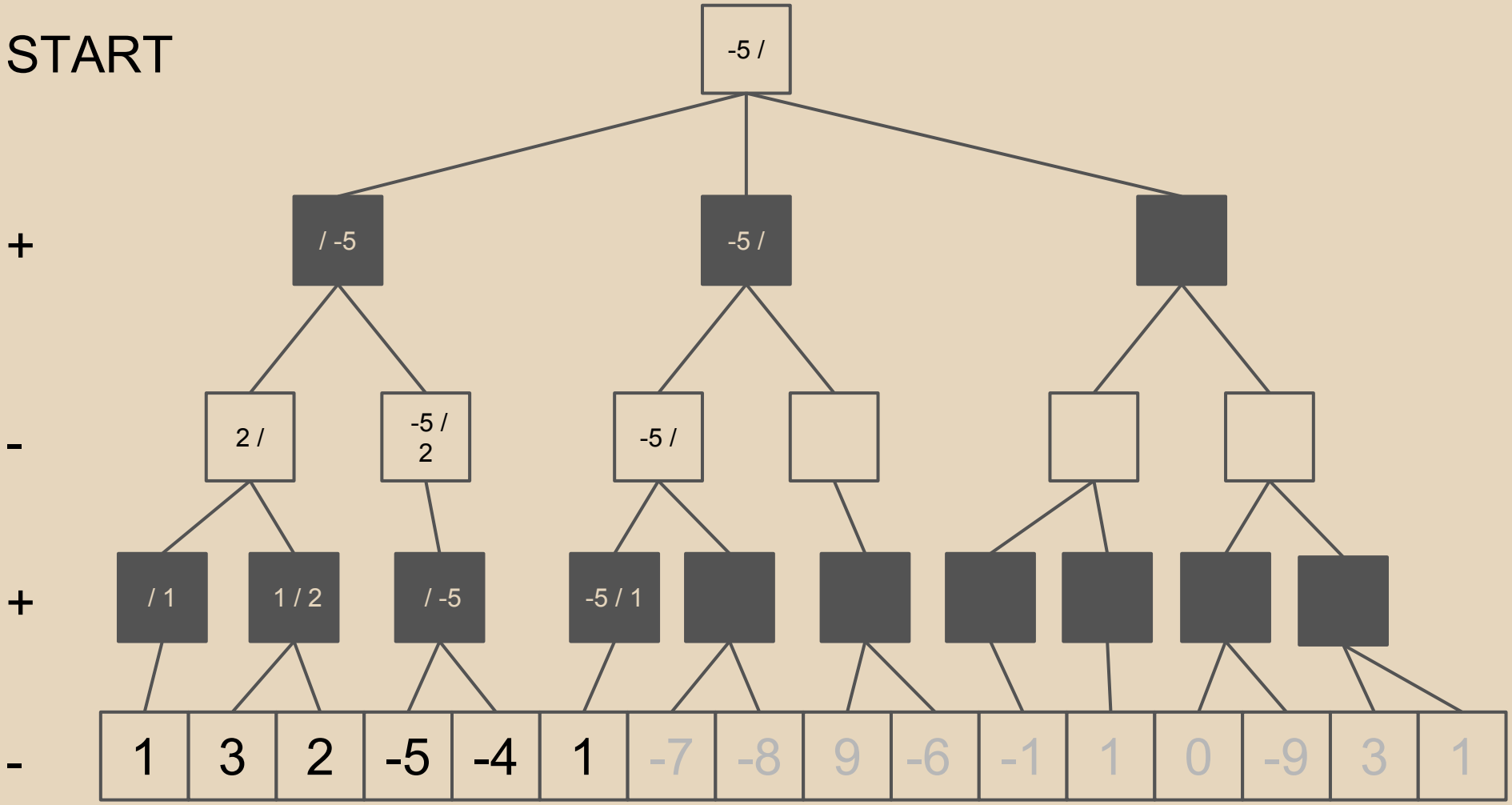

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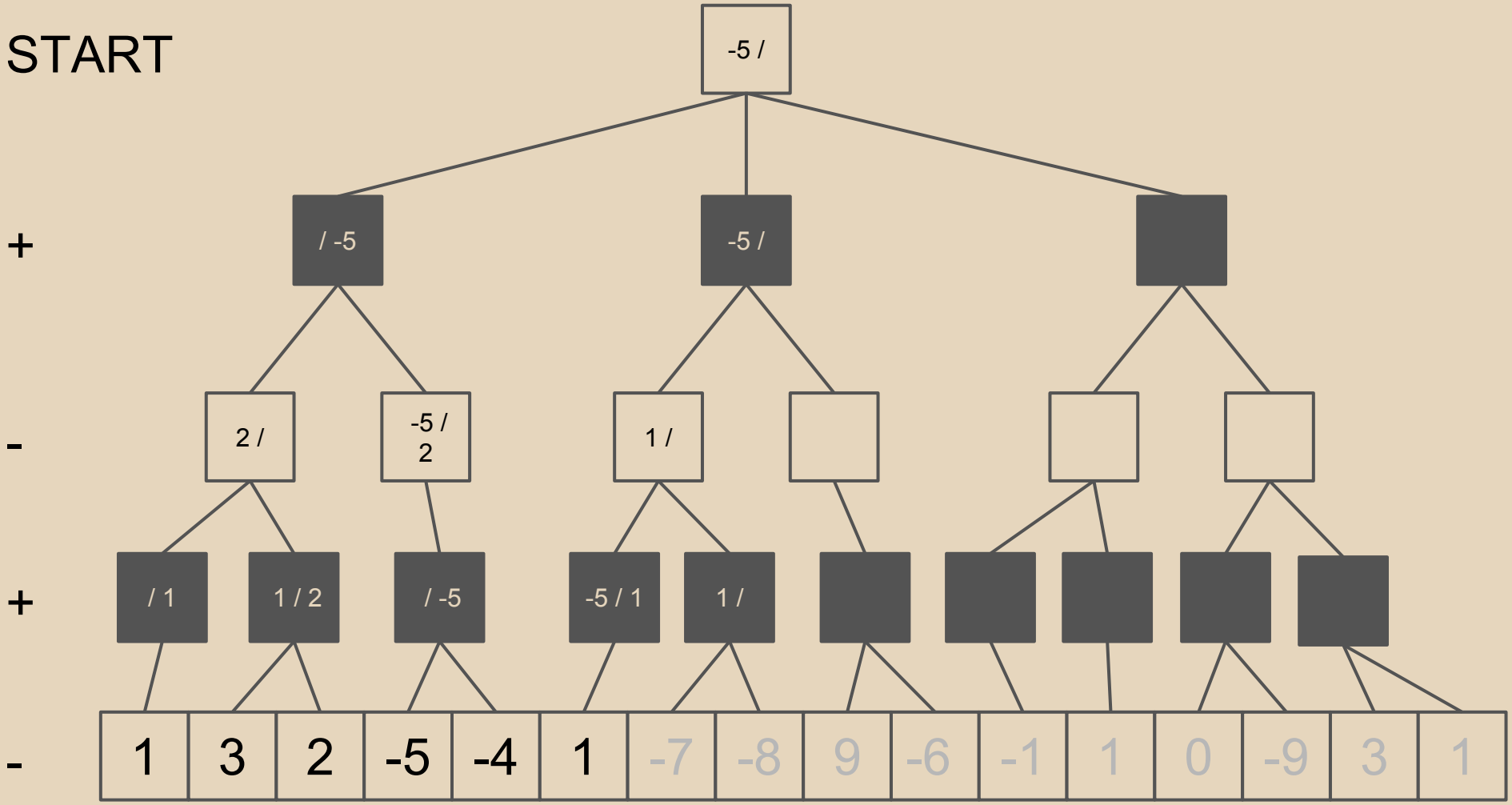
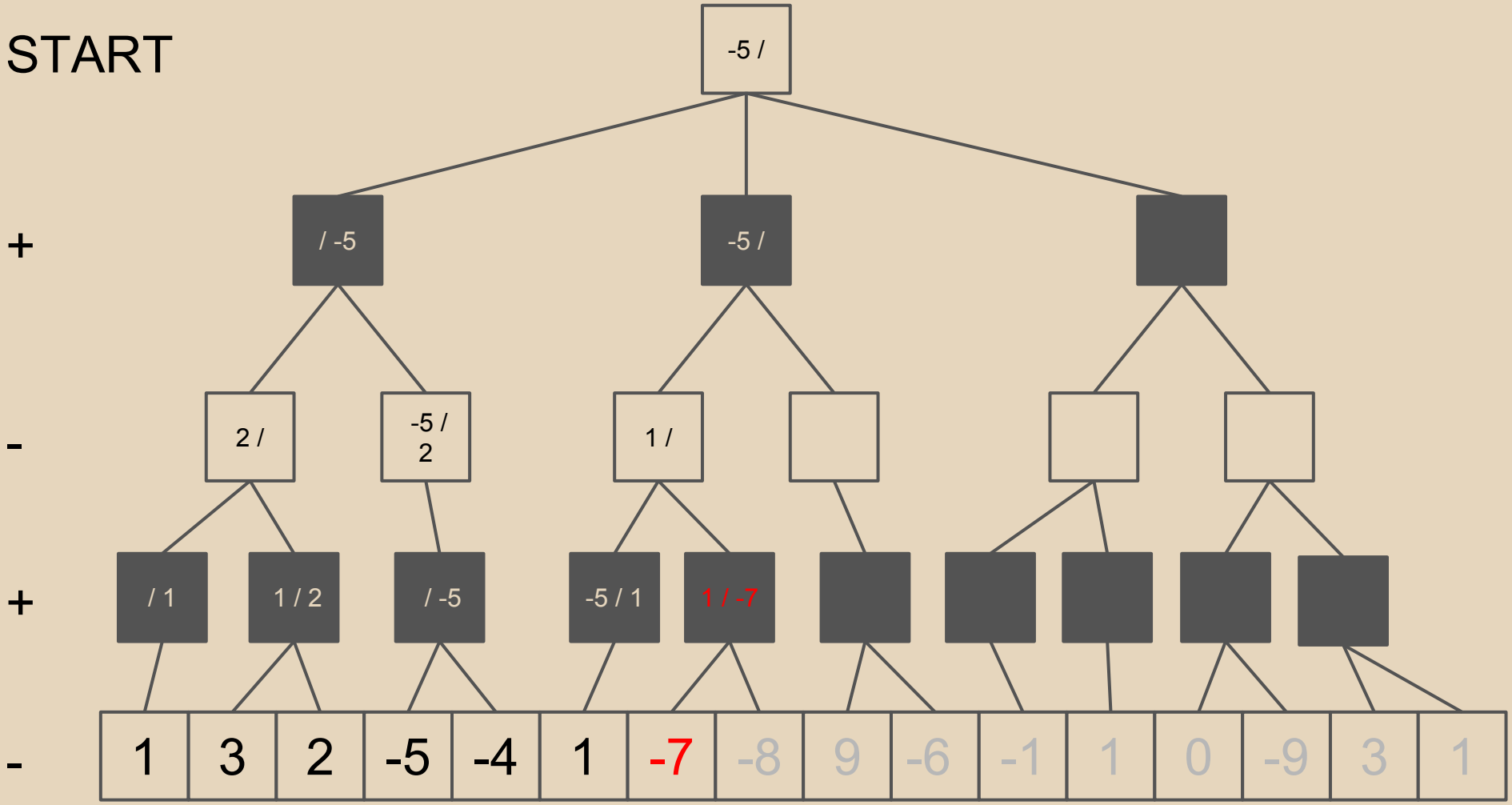


Cutoff!



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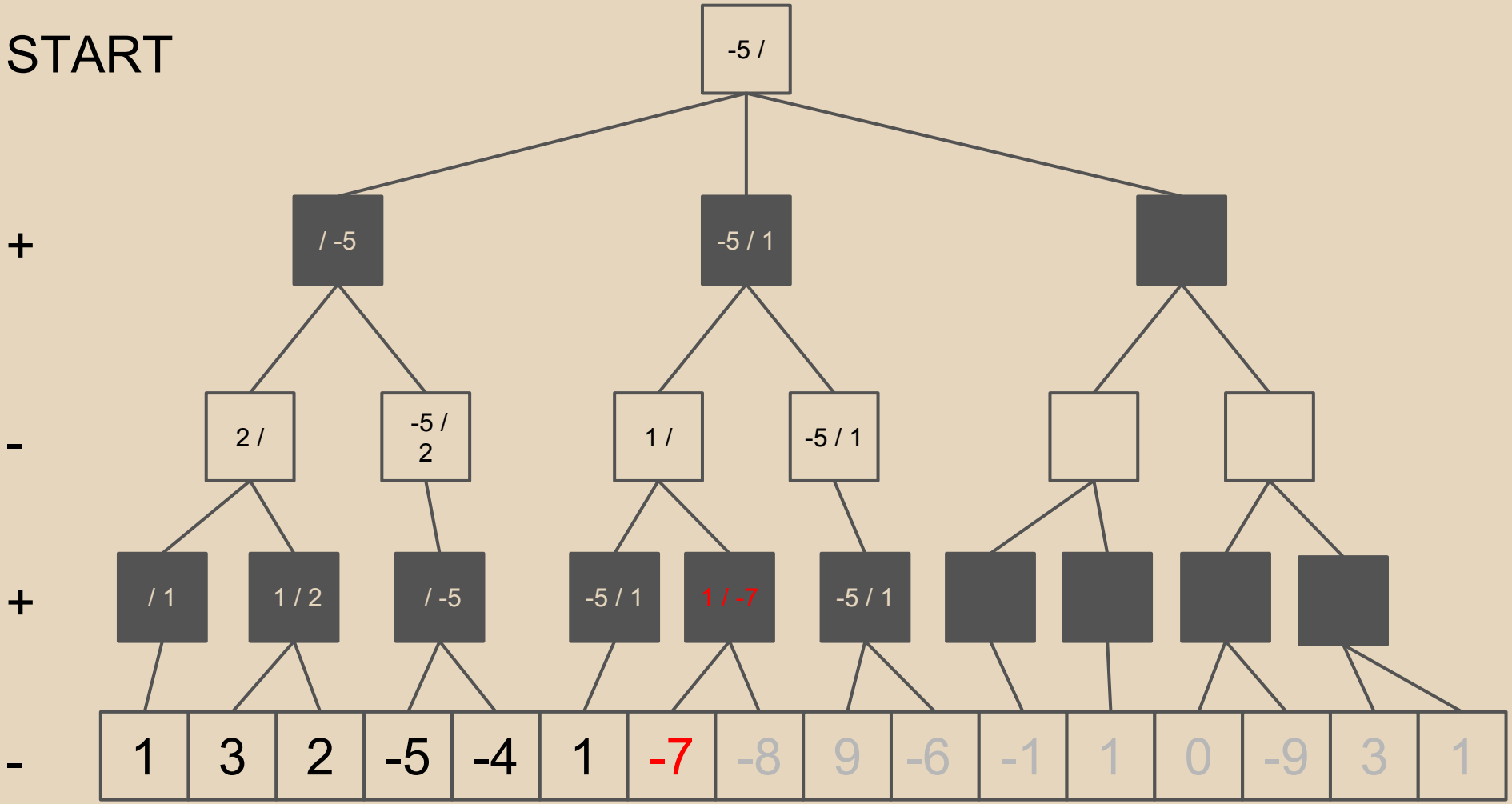

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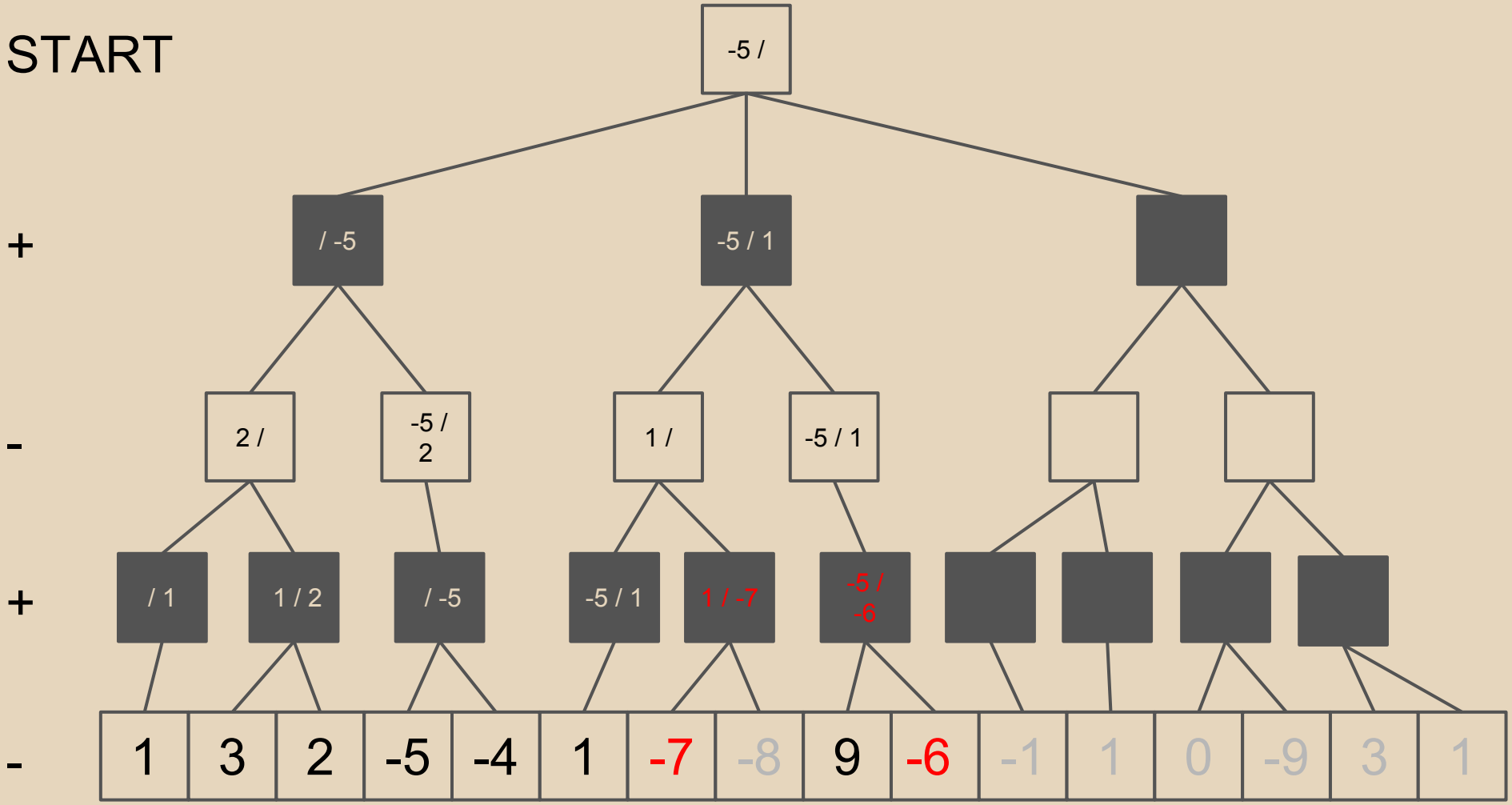

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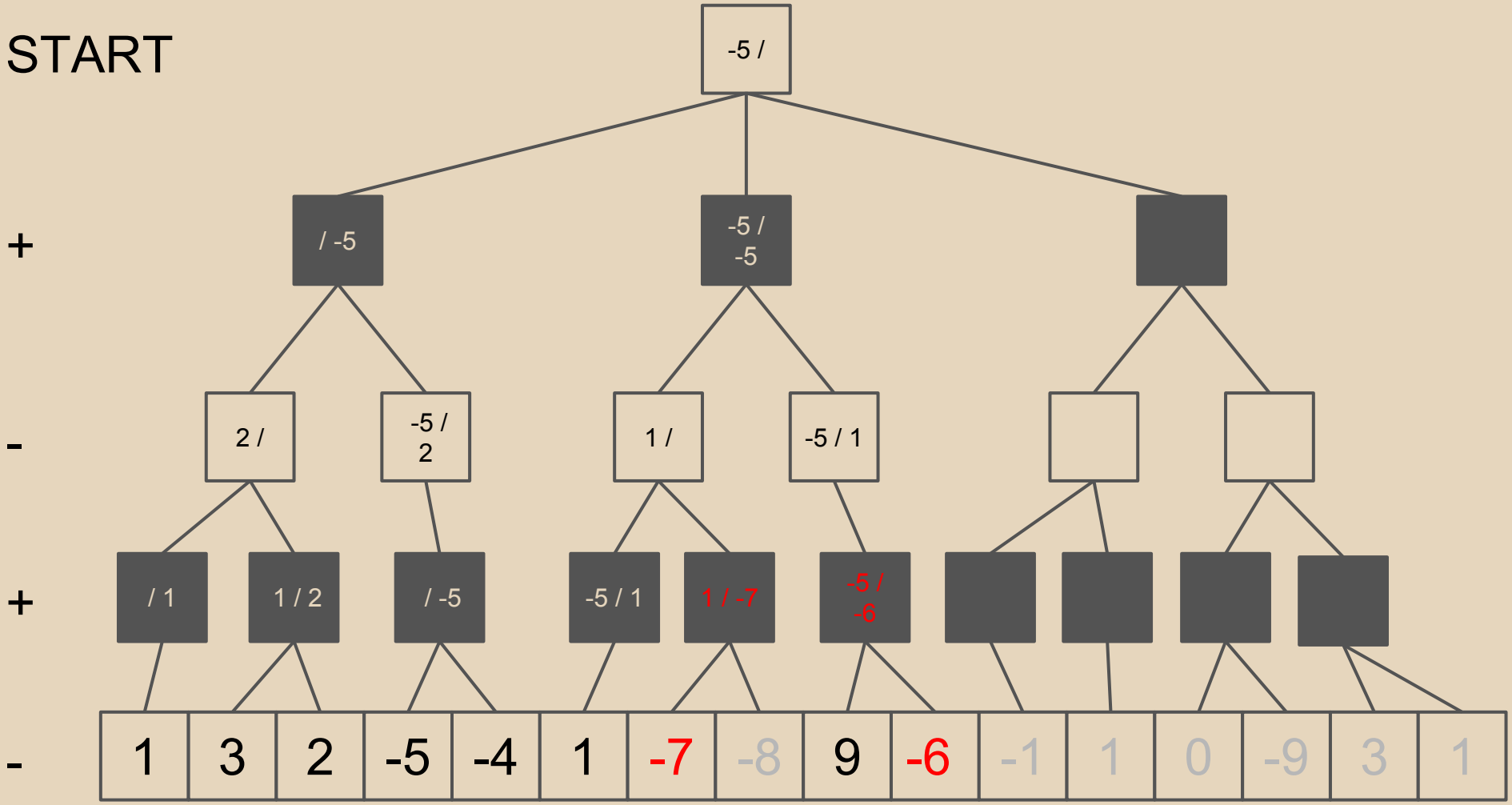
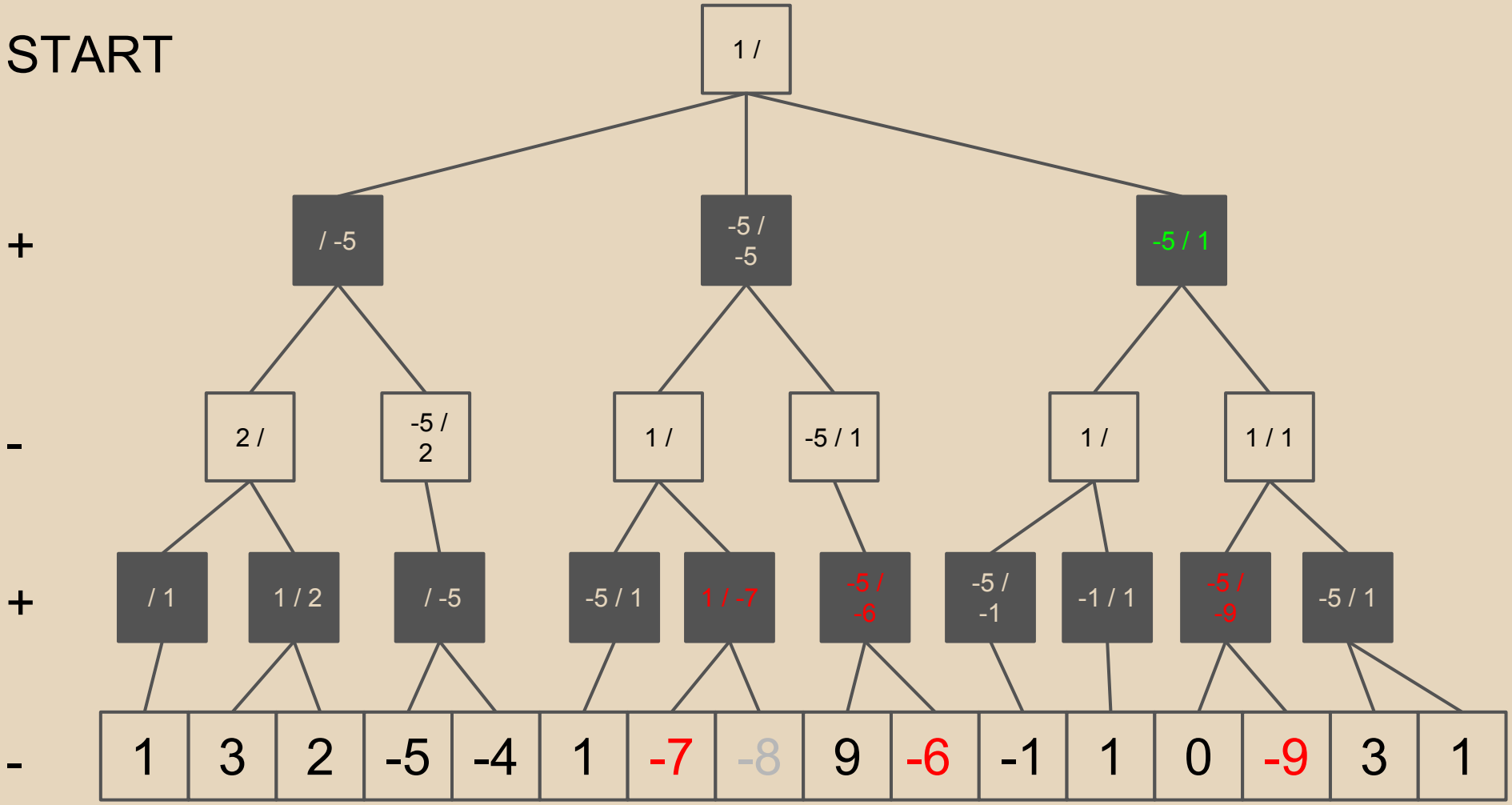
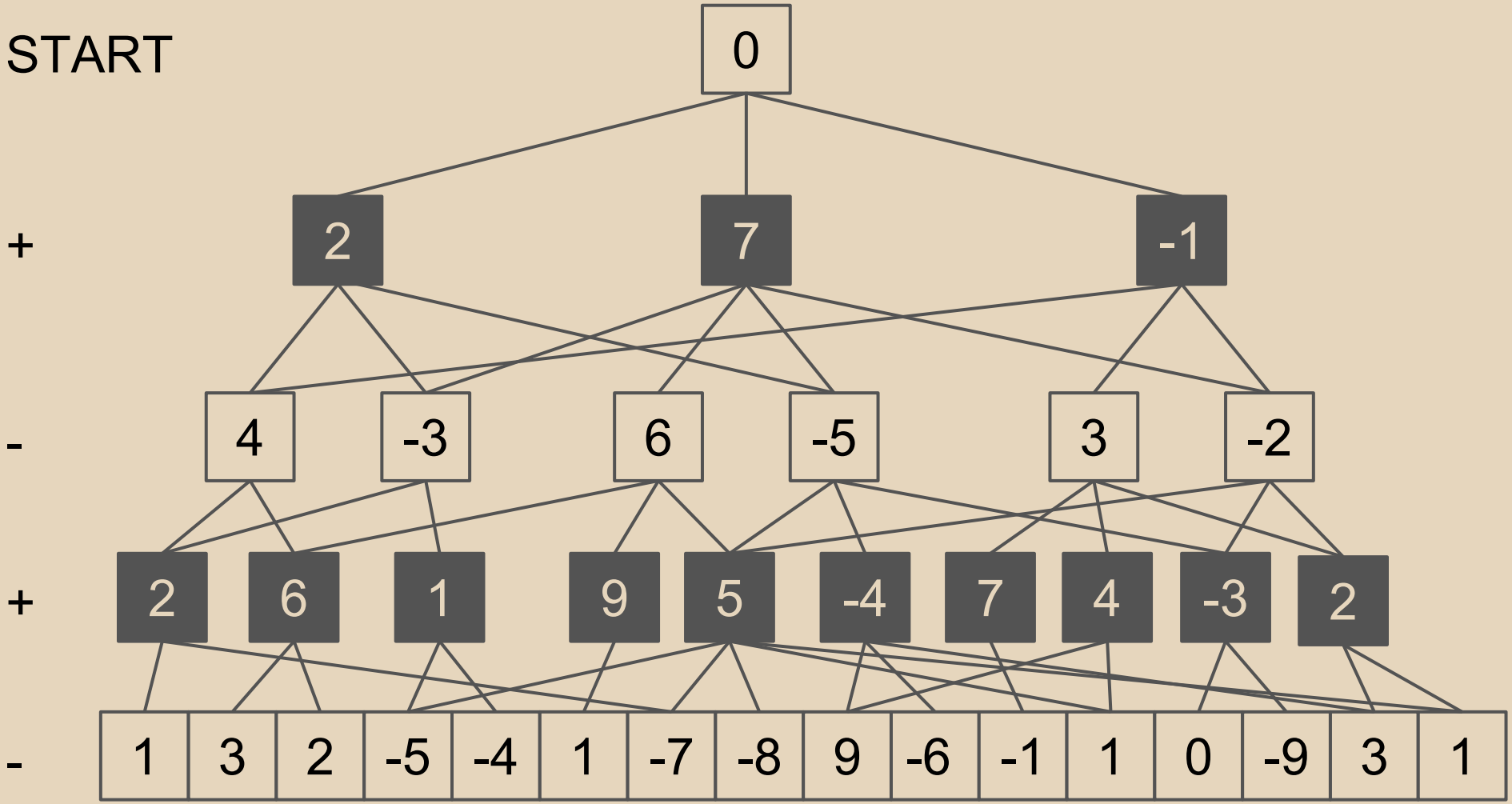


You get the idea...



Game trees can contain duplicate positions...



Transposition tables

- Basically add memoization to our search
  - Remember dynamic programming?
  - Hmm... looks like the seam carving problem!
  - If the same position comes up (with the same parameters) and we've already analyzed it, we don't want to reanalyze it
  - Better to look up the solution we already have
- Best way to do this is by hash table
  - Convert board position to a 'hash'
  - (almost) Constant-time lookup then

Transposition tables

- Caution: There are lots of possible positions
  - >> 10^20 legal positions
  - *Cannot* store all of them!
  - Store only the positions that are the most 'popular'
  - Could simply overwrite filled buckets, or keep some sort of popularity metric within each bucket (for multi-slot buckets)

Iterative deepening

- Your time is limited!
  - Up to 16 minutes
  - Want to use our time as efficiently as possible
  - Follow paths that result in fast cutoffs
- Want to be able to do decently even if we run out of time or are interrupted

Iterative deepening

- Start search at a shallow depth
- Store some information about the results
  - Which moves might force alpha-beta cutoffs early?
  - Evaluate the best moves first.
- Repeat search at a deeper depth
- Continue in this vein for as long as needed
  - until we can't afford to spend any more time
- If interrupted, can use the result from an earlier depth rather than from an incomplete search

Opening books

- Precalculated responses to early moves
  - Records the best series of responses to particular moves in the early game (down to some small depth)
  - Reduces amount of calculation necessary in the early game
  - Again, dynamic programming / memoization is your friend!
- Often pre-generated
  - The best programs update their opening books after each game
  - We don't expect you to do that

Useful git commands: A shortlist

Useful commands to know:

- `git init`: Initializes an empty repository
- `git commit`: Takes a "snapshot" of current state
  - Actually a bit more complicated than that; think of saving a diff between each commit
- `git push`: Push new commits to a remote source (but not until first commit made)
- `git checkout`: "Roll back" to old version
- `git branch`: Start a new branch

Useful git commands: Stash

Suppose we want to save our current changes *without* committing (say, to pull from the remote repository)

- `git stash`: Stashes local changes without committing, reverts back to HEAD state
- `git stash apply`: Replays last stash change (does not commit)

Example: You've been working for hours and find out you need to fix a bug *NOW*. Don't want to lose your work -- so stash it!

Useful git commands: Branch

Sometimes we aren't quite sure what direction our code should take; or we want to try something out without destroying the main branch.

- `git branch`: Start a new branch
- `git checkout`: Switch to another branch
- `git merge`: Synchronize two branches
  - Can have "merge conflicts" to resolve before the merge is complete

Example: You fixed the bug in a branch, now sync with the main repo for your users.

Useful git commands: “Time travel”

Git is powerful because it lets us go back to *any* previous commit, and the code will be *exactly* as it was when committed. Great for when you’ve suddenly “broken” your code.

- `git checkout HEAD`: Go to the most recent commit state
  - Replace HEAD with a hash number to go back further; they can be found with…
- `git log`: Displays a log of all your commits with timestamps and messages

:)

Have fun!