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Evaluation Function

How good is this state

→ What is it?

An evaluation function is used to estimate the value or "goodness" of a game state when the search hasn't reached the end of the game.

In simple words:

"If the game stopped right now, how likely am I to win from this position?"

Why is it needed?

searching all the way to the end of the game takes a lot of time (especially in games like chess). So we cut off the search early, and use an evaluation function to estimate how good that state is.

NO Date

Example (Tic Tac Toe)

You might give score like this:

→ +10 if the AI wins
→ -10 if the opponent wins
→ 0 if it's a draw
→ otherwise, count how many 2-in-a-rows the AI has.

Cutting-off search

When do we stop looking further?

What is it?

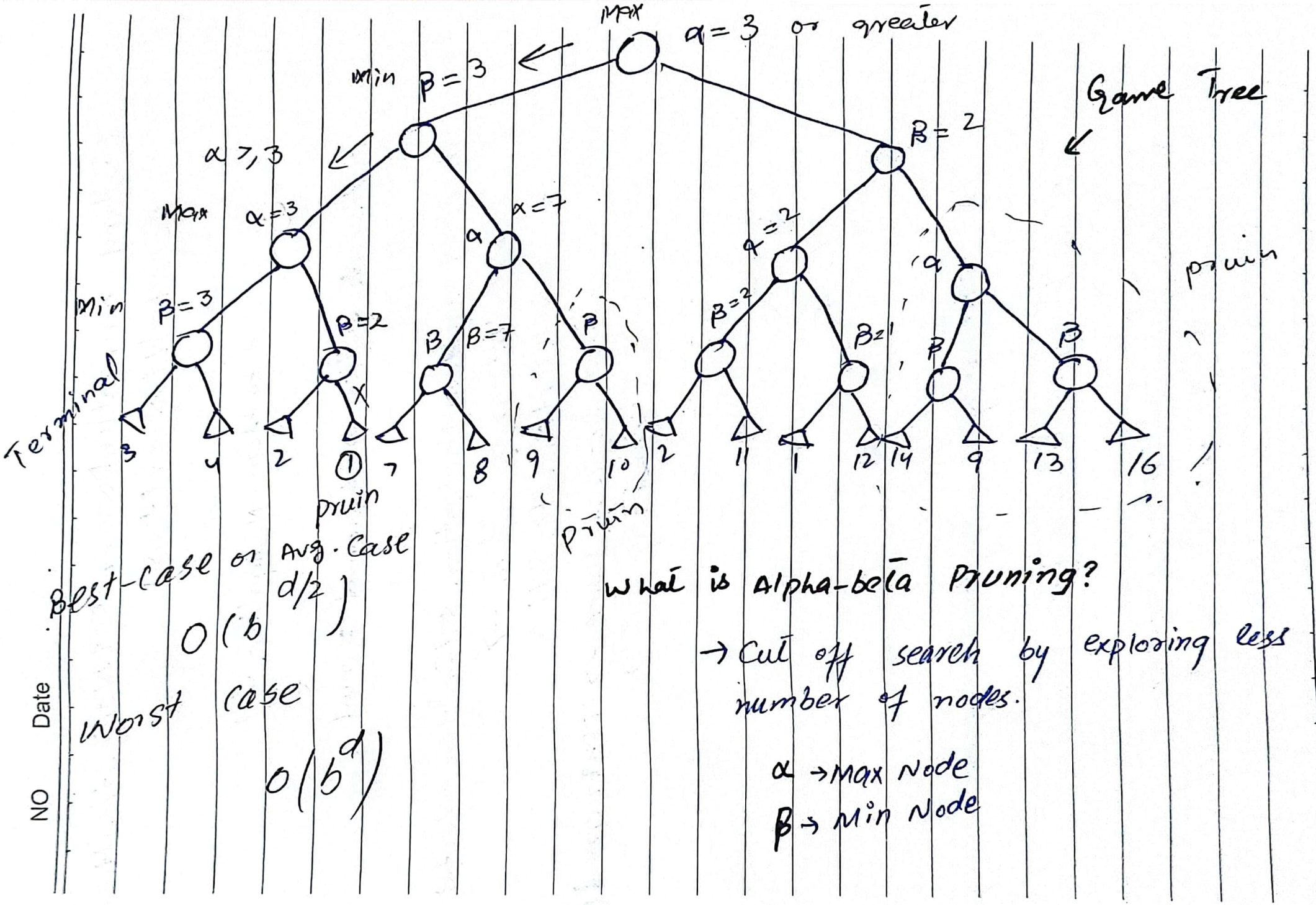
Instead of going all the way to the terminal state (like win/loss), we cut off the search at a certain depth or time.

In simple words:

"Stop search after 4 moves ahead. Evaluate the state using evaluation function."

Why do we cut off?

Deep search is slow and expensive. So, we stop at a certain depth level or Time limit and then evaluate the state.



Best-case or Avg. Case

$O(b^{d/2})$

Worst case

$O(b^d)$

What is Alpha-beta Pruning?

→ Cut off search by exploring less number of nodes.

α → Max Node

β → Min Node

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Why Alpha-Beta Pruning is Effective?

Benefit	Result
• Cut-off bad branches	• Fewer nodes to evaluate
• Save computation	• Runs faster
• Can search deeper	• Better game decisions
• Same result as full minimax	• But much more efficient.
• $O(b^d)$ to $O(b^{d/2})$	• Reduce time complexity