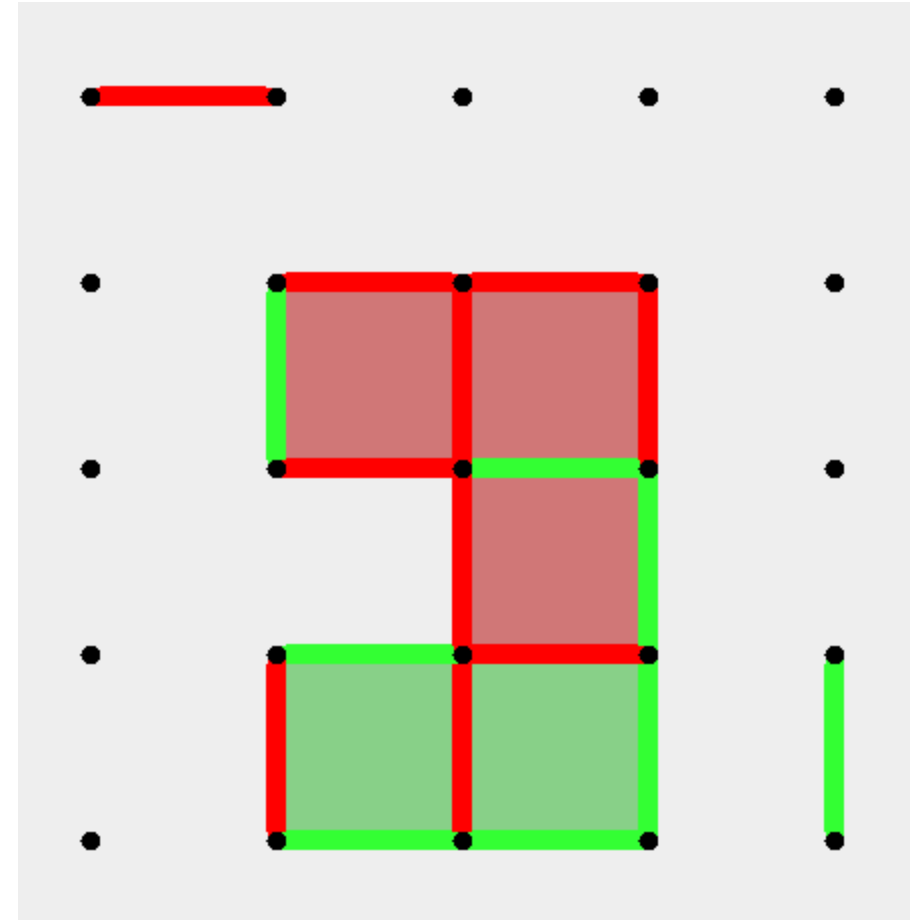# Parallelized Minimax on Dots and Boxes

By Russell Ferrall, Isai Tinoco Gutierrez, Curtis Bradley, Samiksha Gollamudi Karimbil

Dots and Boxes

- 2 Player Game

- Goal is to complete more boxes than opponent

- Players take turn drawing lines

- Completing a box gives an extra turn

Motivation: GamePigeon

- I want to dominate my friends in dots and boxes

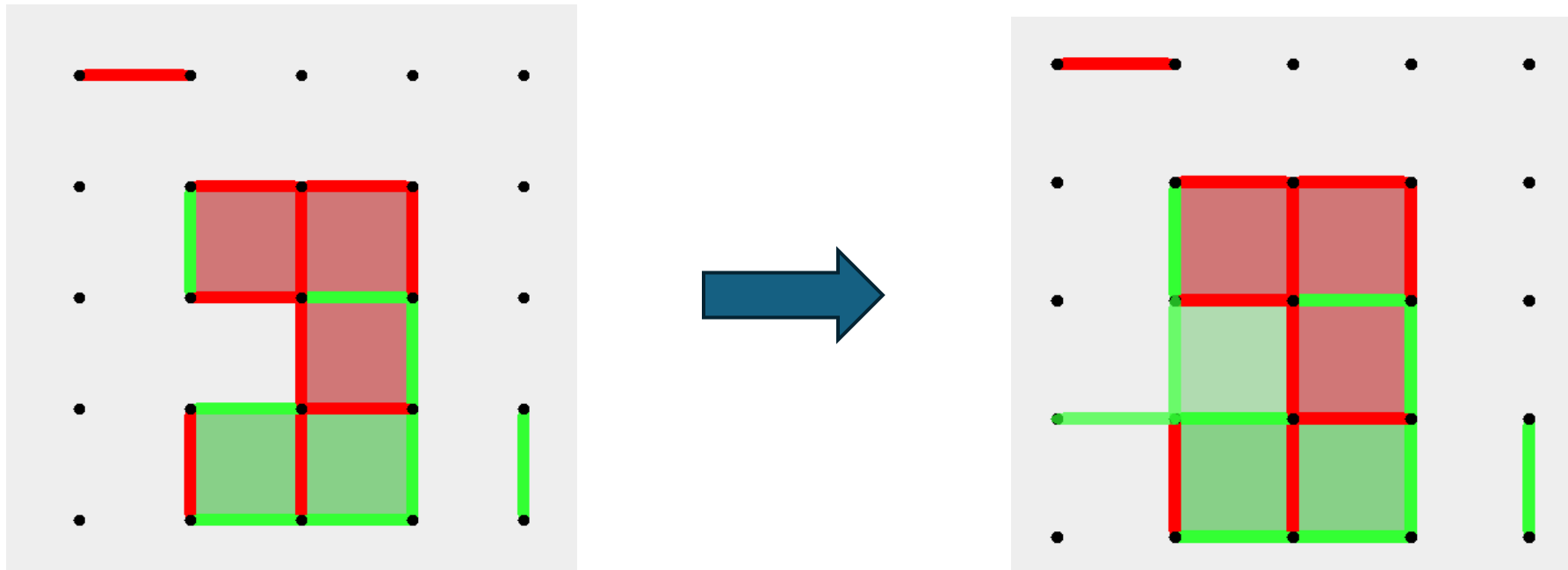- Playing against a computer will give me practice for the games that matter.

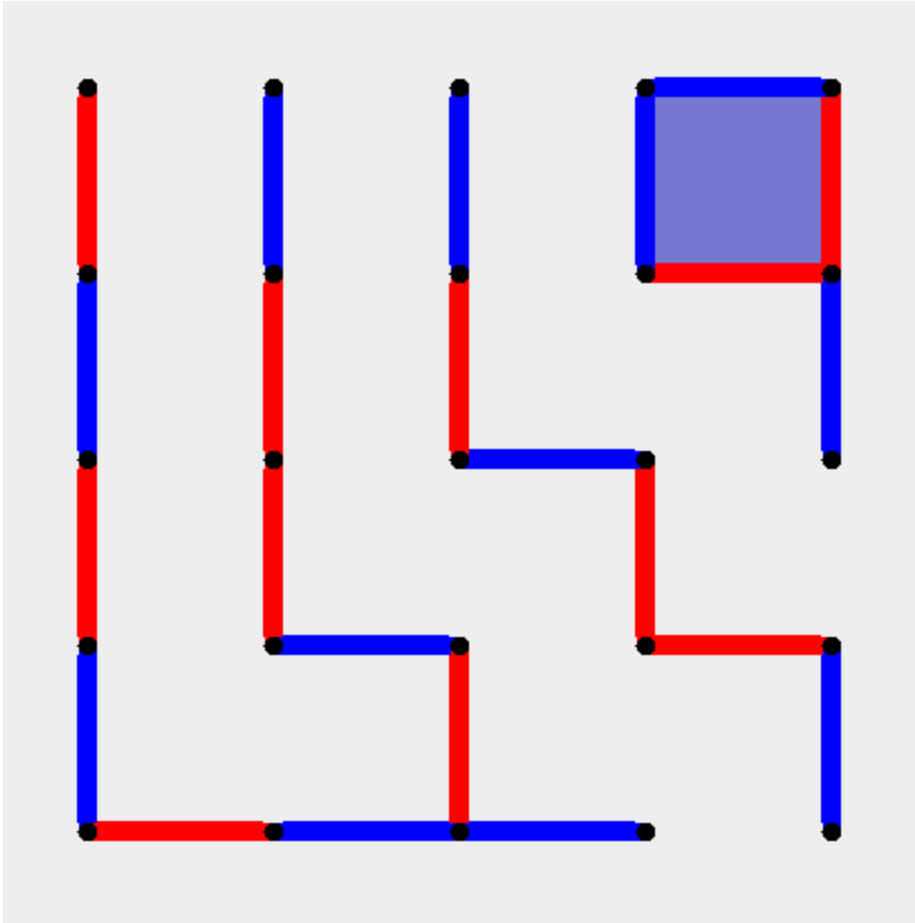# Designing an agent to play dots and boxes
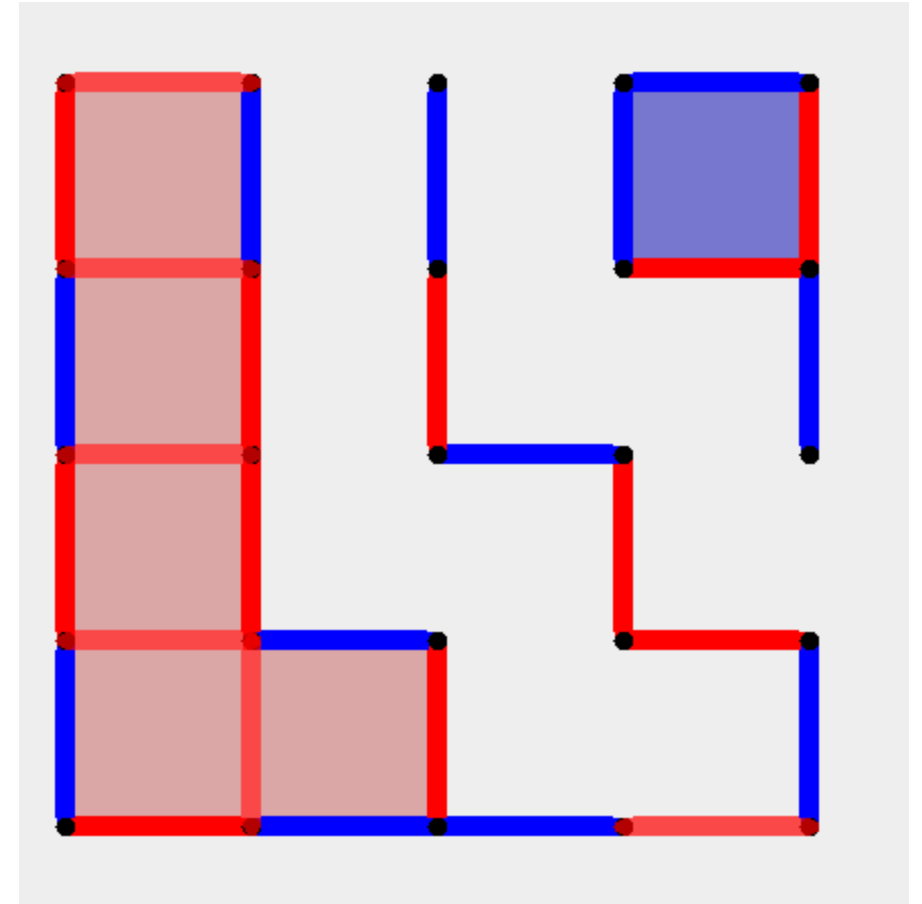
Naïve Solution – Greedy Bot

- When given a board, play the move that captures the most boxes.

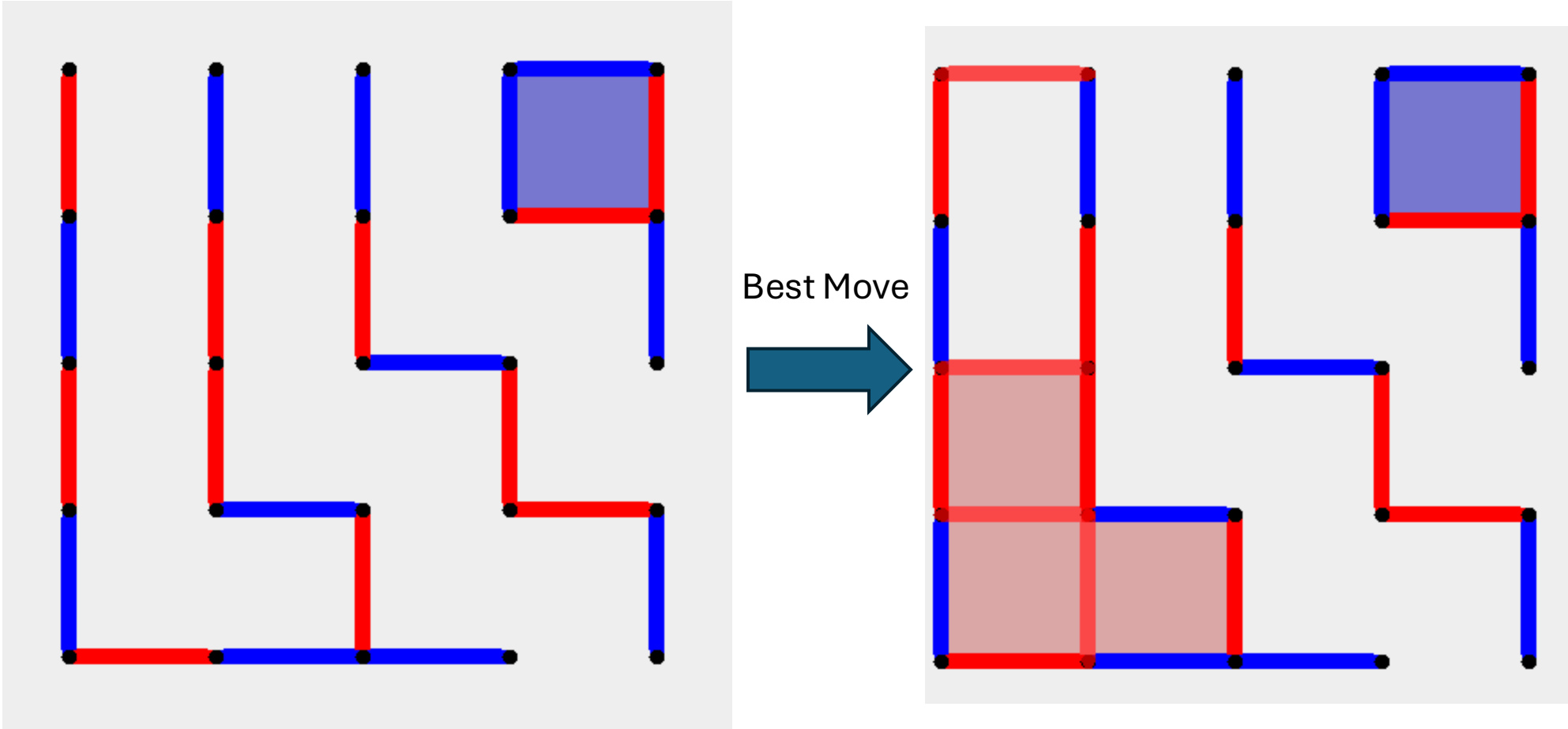- Beats a random move agent 85% of the time.

Issue – Being Greedy is not Optimal

GreedyBot

Issue – Being Greedy is not Optimal

Best Move

Excerpt from Elwyn Berlekamp's *Dot's and Boxes – Sophisticated Child's Play*

Now Amy's strategy suggests the following policy:

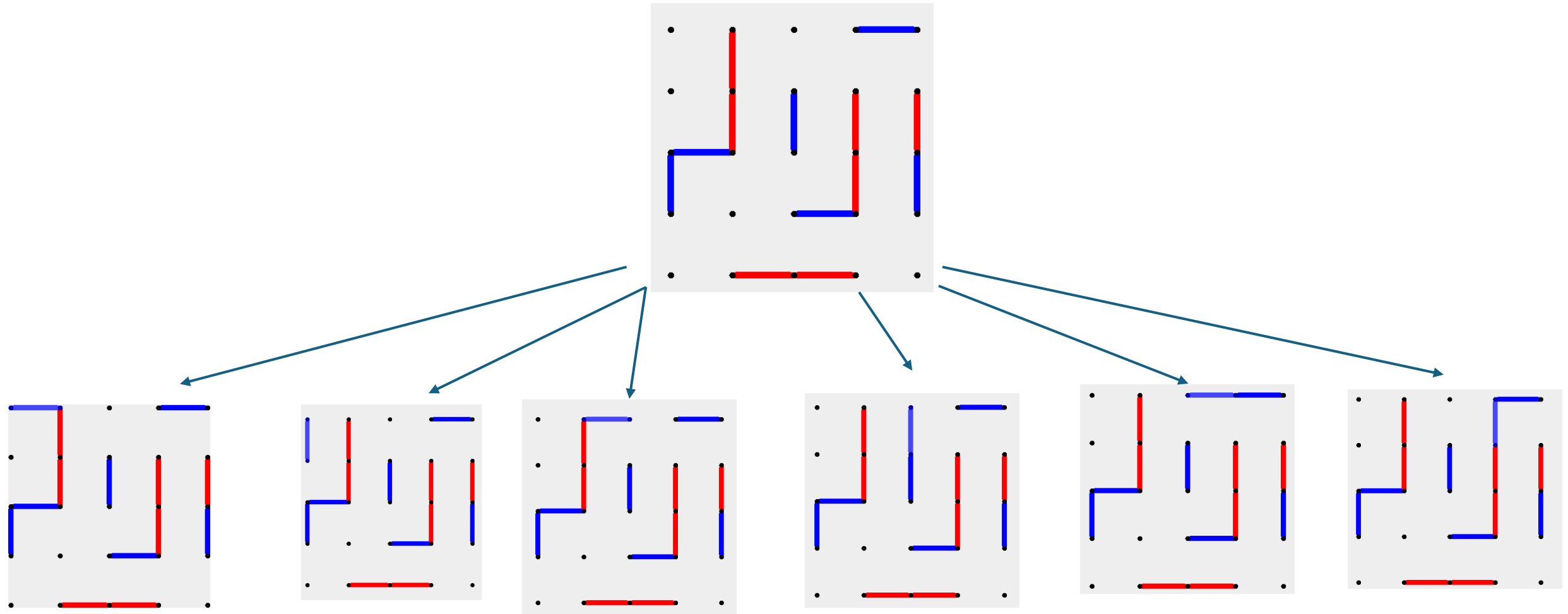> Make sure there are long chains about and try to force your opponent to be the first to open one.

Try To Get Control…

We'll say that whoever can force her opponent to open a long chain has *control* of the game. Then:

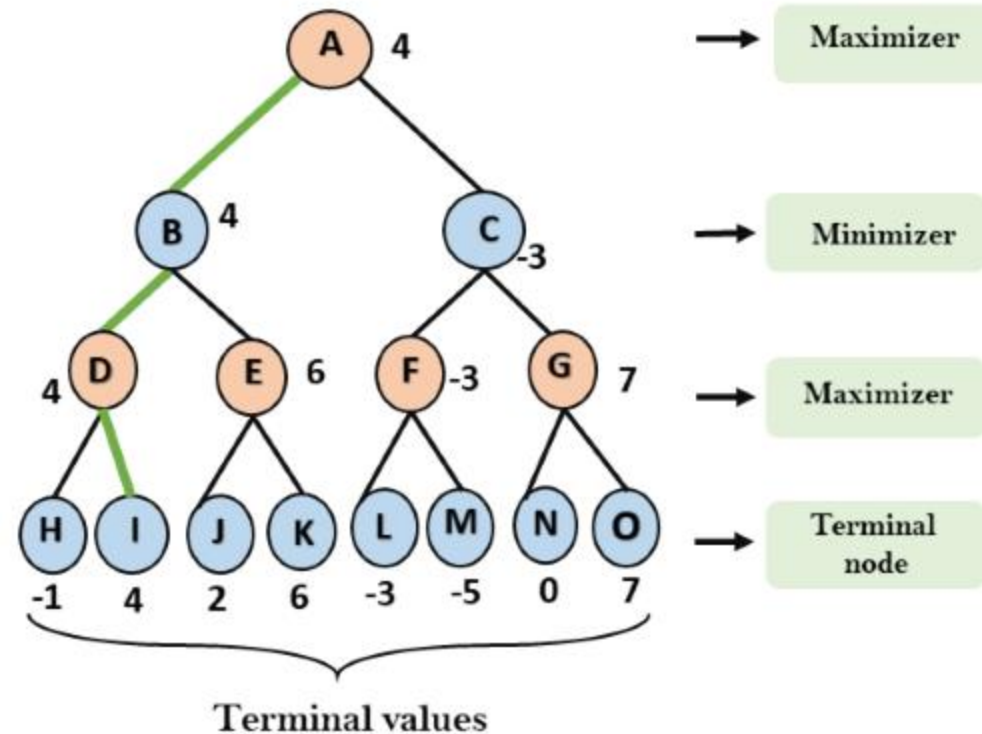> When you have control, make sure you keep it by politely declining 2 boxes of every long chain except the last.

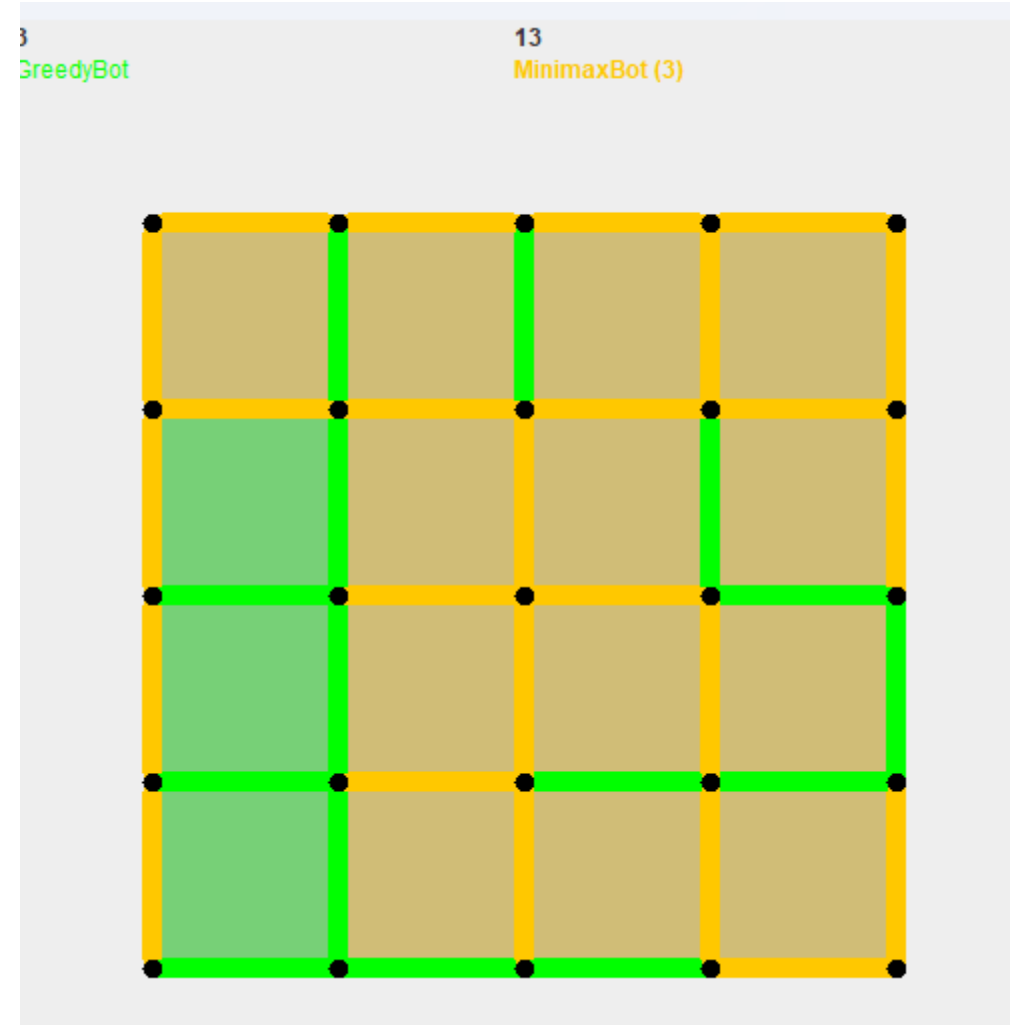… And Then Keep It.

Complete Solution: Minimax
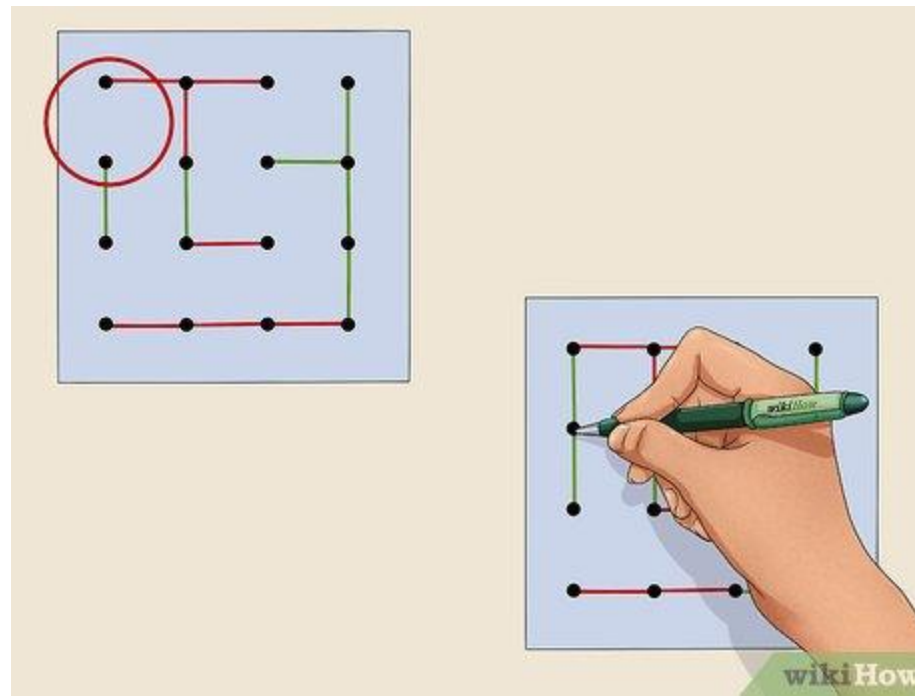
Minimax Algorithm

- Player A will choose the moves best for them (maximizer)
- Player B will choose the moves best for them (minimizer)

Testing Minimax

- When minimax is run at depth of 3 pips, it beats GreedyBot 92.5% of the time in 1000 trials in a 5x5.

Parallelizing Minimax

Decomposition

Coarse-Grained Exploratory Decomposition

- Game tree is the search Space

- Splits each root move into a task

- Initial 5x5 board there are 40 possible edges, 24 for 4x4, 12 for 3x3
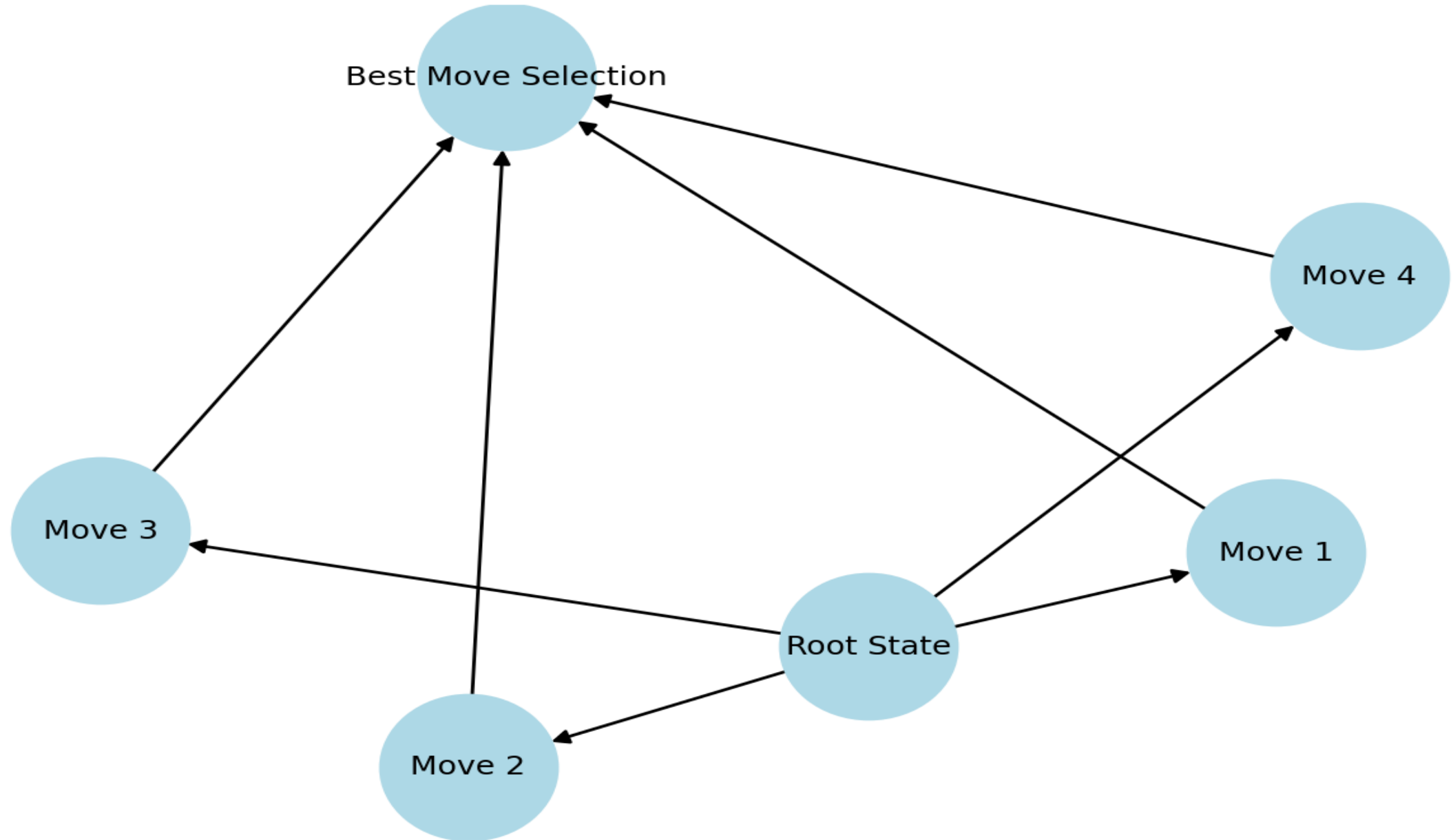
- Branches are independent until best move is found

Threads

- Uses ExecutorService with fixed thread pool
- One task per possible root move
- Tasks run Minimax on independent branches
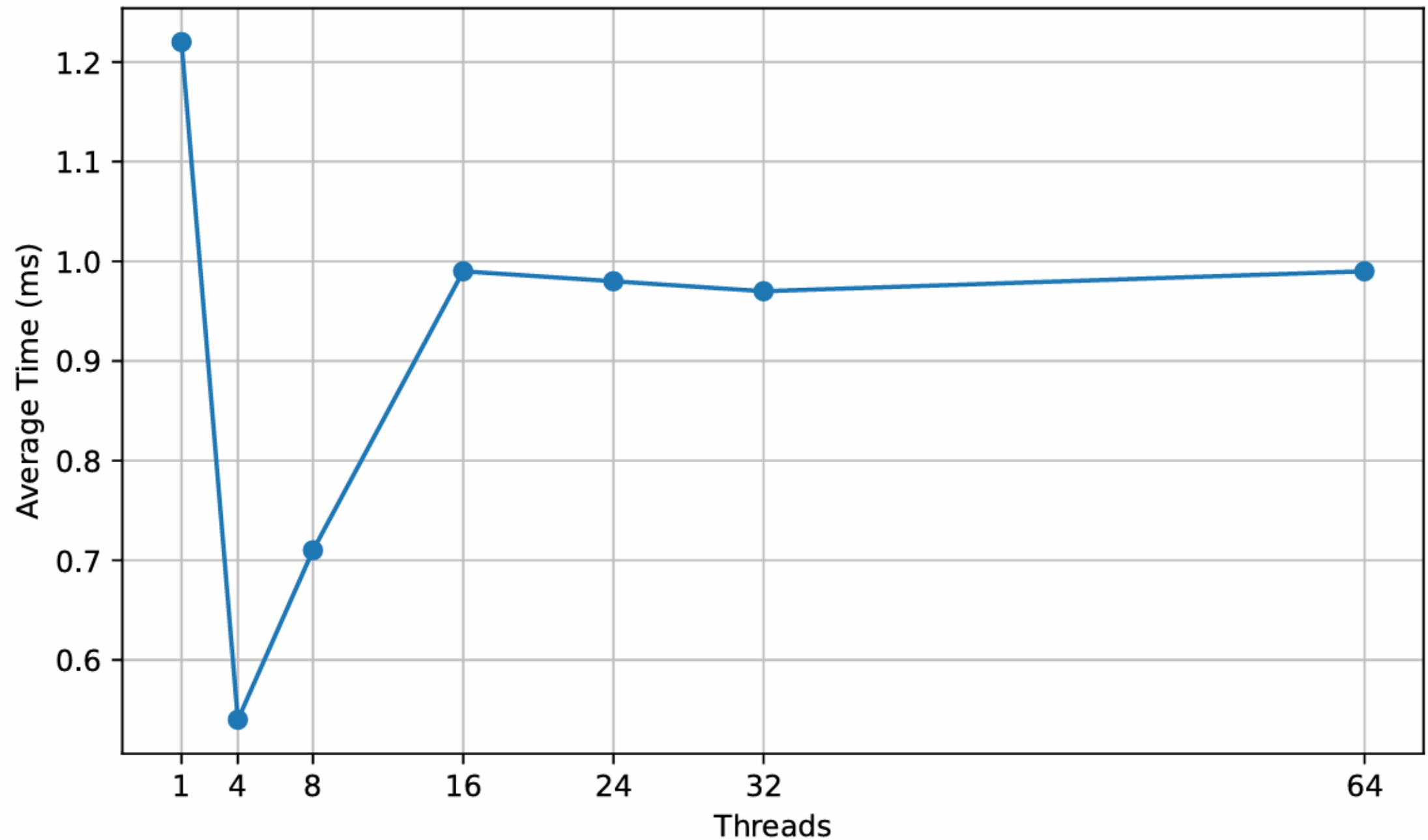- Results collected and best move selected
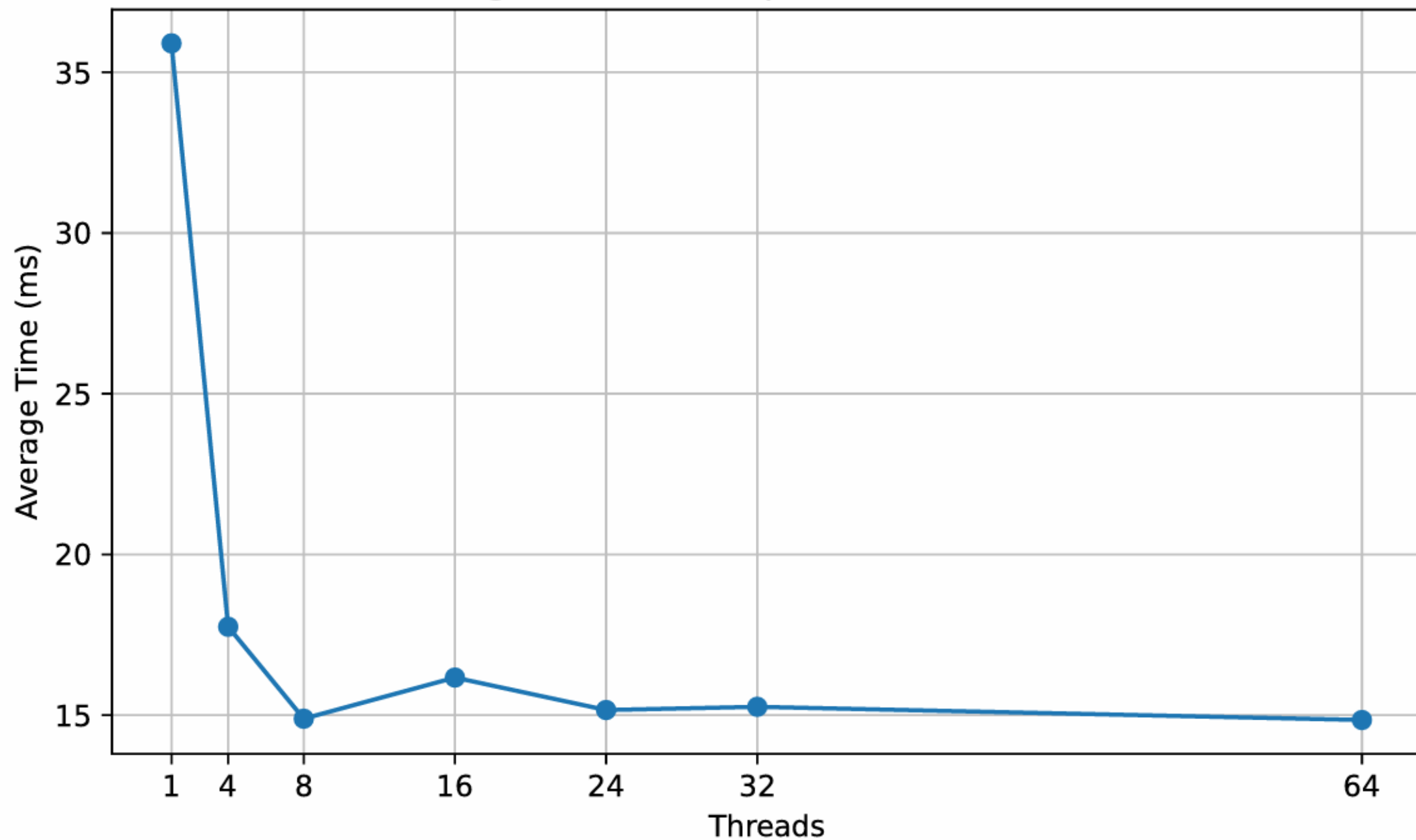
Interaction Graph - Parallel Minimax
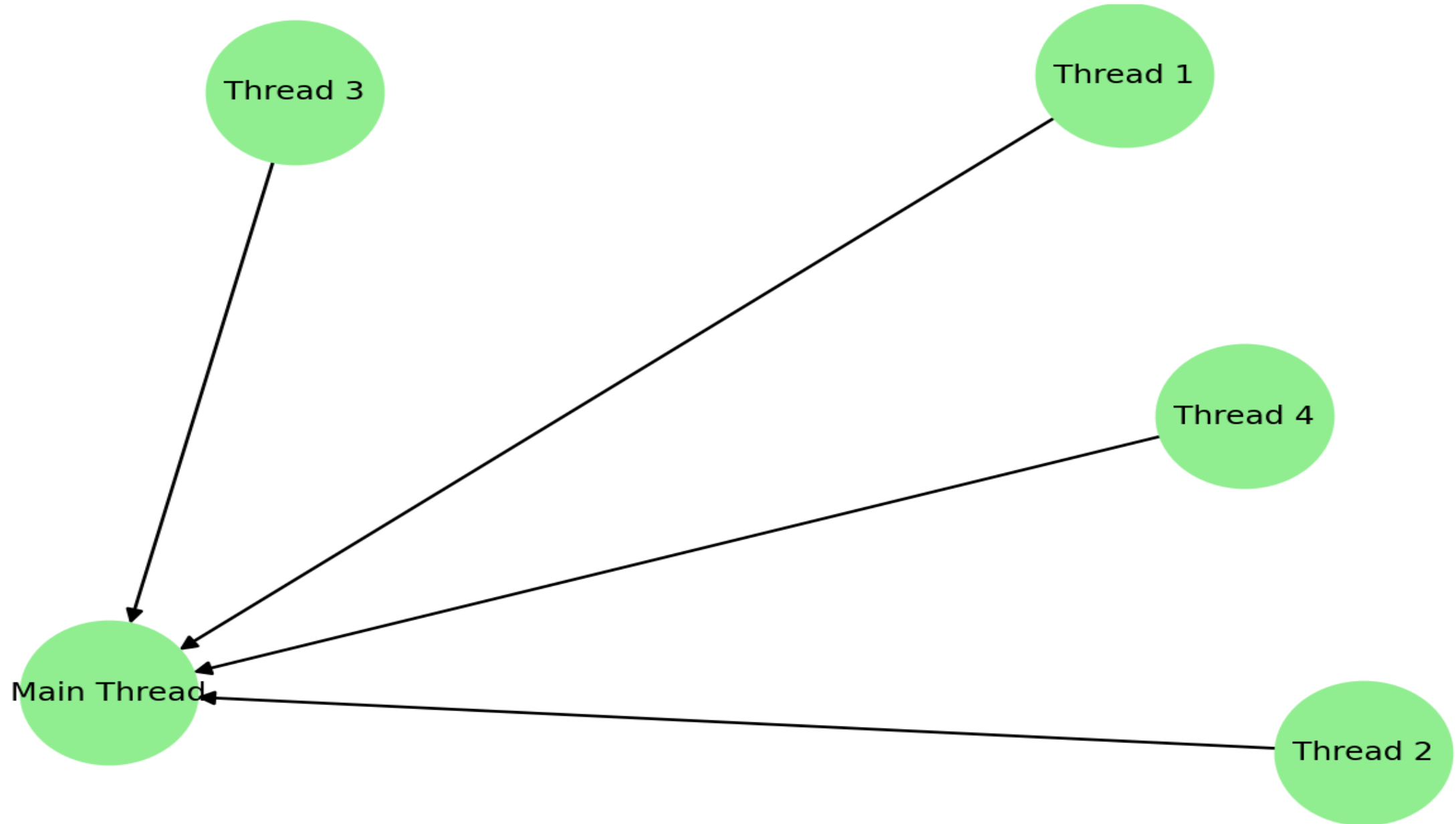
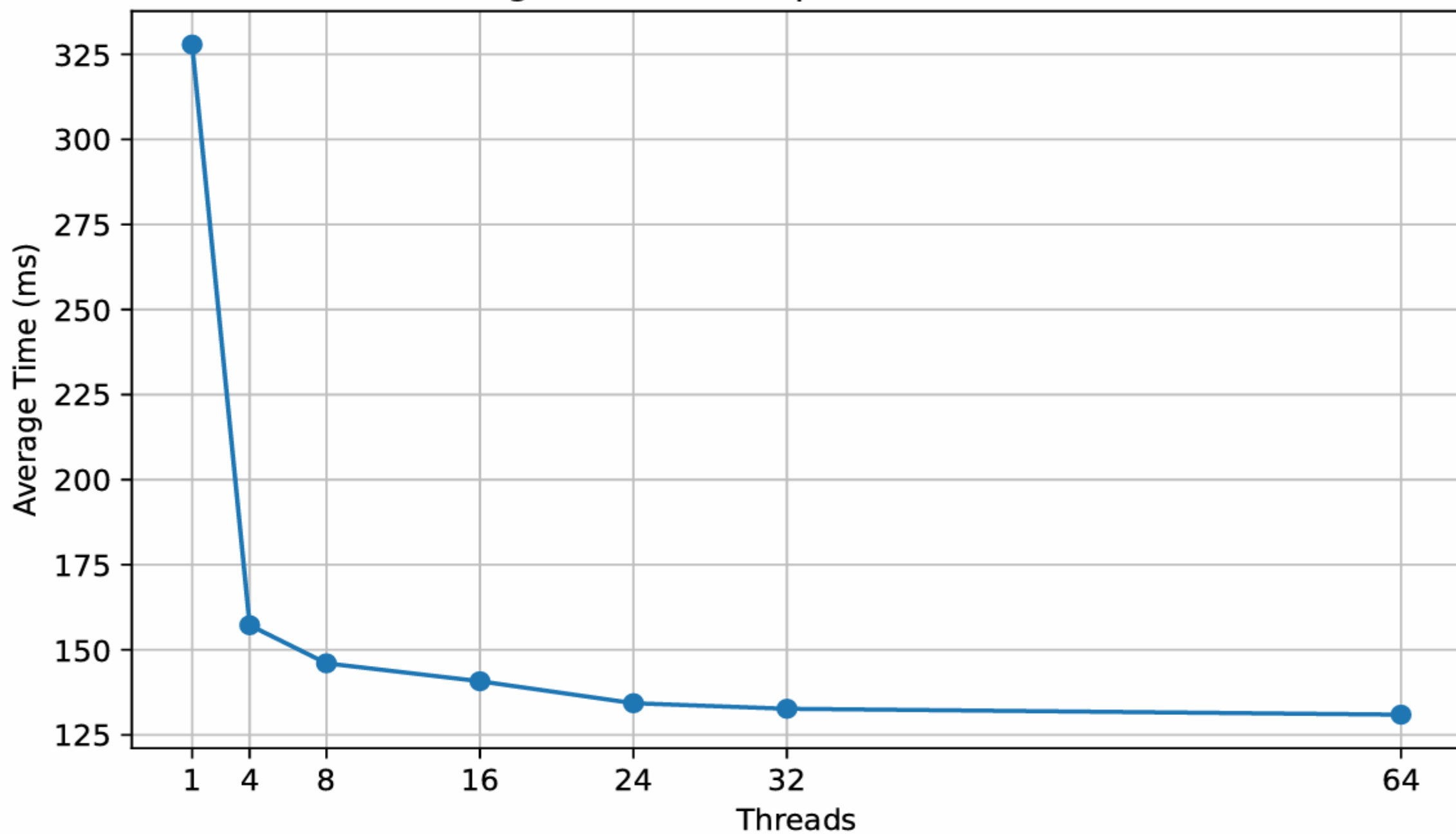# Dependency Graph - Parallel Minimax

Best Move Selection

Move 4

Move 3

Move 1

Root State

Move 2

3×3 Board – Average Time to Complete VS Thread Count (1000 runs)

4×4 Board – Average Time to Complete VS Thread Count (1000 runs)

5×5 Board – Average Time to Complete VS Thread Count (1000 runs)

Live Demo