

The background of the slide is a dark blue circuit board with intricate white lines representing traces, pads, and various electronic components like capacitors, resistors, and integrated circuits. A semi-transparent blue horizontal band is positioned across the middle of the image.

Parallel Game Tree Search

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Background Knowledge

Game Trees

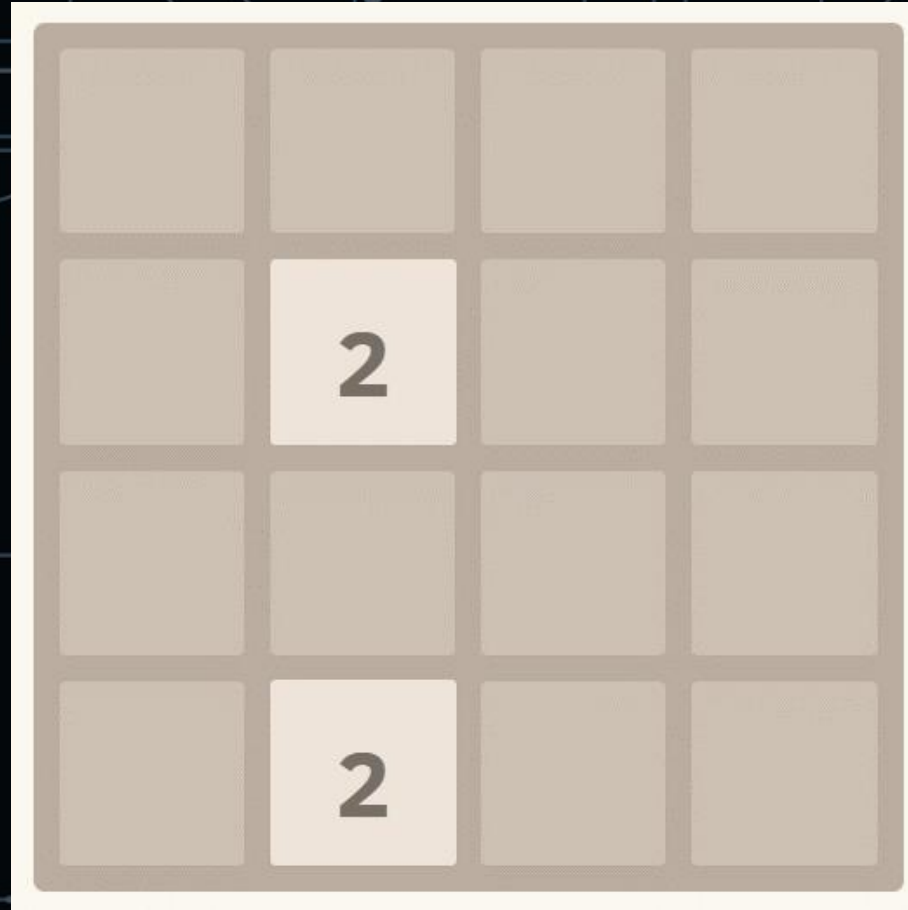
- A game tree is a directed graph where each node indicates a gamestate and each edge indicates an action.
- A game tree is complete if it contains all possible actions from each possible state.
- Game trees can be incredibly large for simple games.
- Game trees are highly parallelisable as each subtree can be seen as disjoint trees and so can be searched individually.

The Game of 2048

- 2048 is a single-player simple, deterministic block sliding puzzle game.
- The rules are as follows:
 - The game is played on a square grid, i.e. 4x4 or 8x8 grid.
 - Every turn the player will choose a direction for the blocks to move, either up, down, left or right.
 - Tiles will slide as far as possible until stopped by the edge of the grid or another block.
 - If 2 tiles have the same number while colliding then they will combine into a single block and the new value will be the sum of their values.
 - After each action, a new tile will appear on the grid with a value of 2.
 - The game is won when a tile with value of 2048 appears on the board.

Background

Example of a 2048 Game



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Technology Used

Technology

- The game was implemented using C++.
- The tree search was implemented in C++ and parallelised using Nvidia Cuda and Open MPI.
- HTML and CSS were used for the demo.



Strategies Used

Serial Approach

- We used a user controlled stack in order to build the tree.
- From the root node, all possible children are pushed to the stack.
- Then for each node at the top of the stack:
 - Each child is checked to see if its a dead state or if it is a solution state
 - A dead state is one where there are no possible moves left.
 - If not dead state or solution state then it is pushed to the top of the stack
 - If a solution is found then store it for later processing.
- However, since the game tree is so big for 2048, the tree is limited by the number of nodes.

MPI Approach

- The MPI approach is very similar to the serial approach.
- The root process creates a small subtree until the number of leaves is equal to number of processes used.
- Each process is sent its initial state
- Each process then creates a serial search from the initial state.
- Then each process sends back its local optimal solution depth to the root process.
- The root process compares them and chooses the minimum.

CUDA Approach

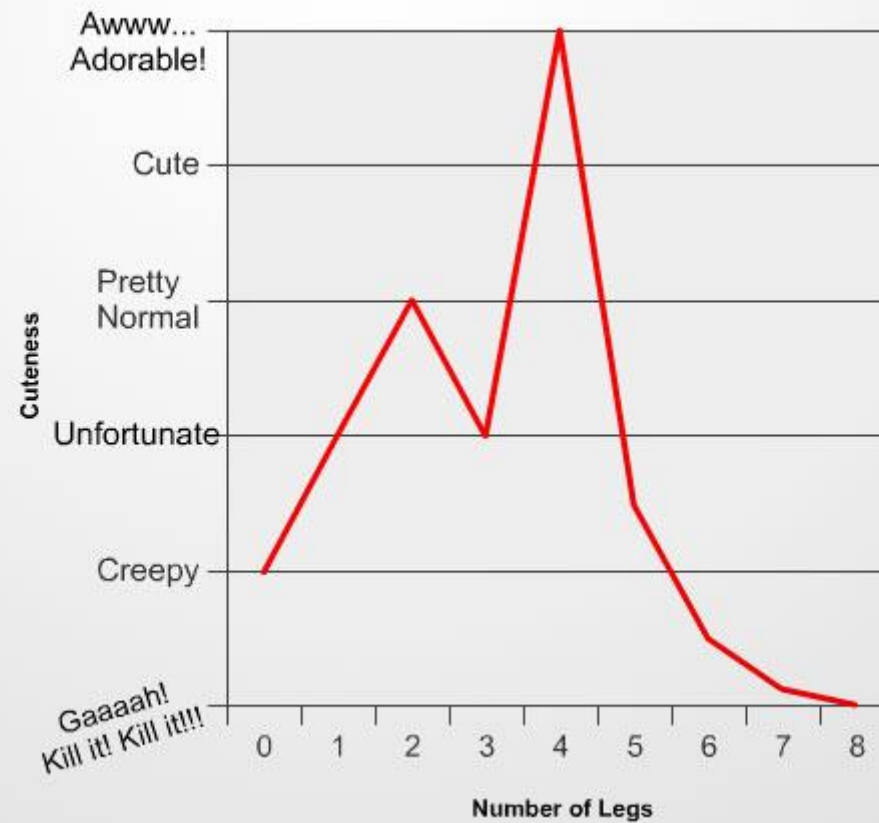
- The CUDA approach starts in a similar manner to the MPI approach.
- The host generates a small subtree and stores each initial state to be used in the first column of a matrix.
- Each row in this matrix is a subtree to be explored by a thread.
- For each entry in its row, each thread creates the nodes children and places them in the row of the matrix.
- For this approach to work, we must assume the tree is complete and symmetric.

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Results

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Cuteness vs. Number of Legs



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Problems Encountered

Problems

- Inplace DFS and Recursive DFS
- Enforcing terminating conditions for tree generation.
- Using strings instead of ints.
- Underestimated game tree size
- Trying to code in such a way that code can be re-used for all 3 approaches.
- Most code had to be re-done for CUDA.
- The CUDA implementation was very challenging.
 - Indexing
 - Class function used pointers
 - Random number generation
- Creating initial subtrees for MPI and CUDA.
- Co-ordinating processes with MPI

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Conclusions

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- MPI is a simple way to gain a massive speed performance over the serial approach.
- However, while CUDA may be a lot more complex to implement and may be slow, the limits of the tree size can greatly be expanded.

Works Cited

- Sager, J. (2015, October 1). Free PowerPoint Template. Retrieved 2016, from <http://sage-fox.com/>
- En.wikipedia.org. *2048 (video game)*. [online] Available at: [https://en.wikipedia.org/wiki/2048_\(video_game\)](https://en.wikipedia.org/wiki/2048_(video_game)) [Accessed 17 May 2017].
- NVIDIA Developer. *CUDA Zone*. [online] Available at: <https://developer.nvidia.com/cuda-zone> [Accessed 17 May 2017].
- Open-mpi.org. *Open MPI: Open Source High Performance Computing*. [online] Available at: <https://www.open-mpi.org/> [Accessed 17 May 2017].
- Softonic. *2048 Game*. [image] Available at: <https://features.en.softonic.com/how-to-win-at-2048> [Accessed 17 May 2017].