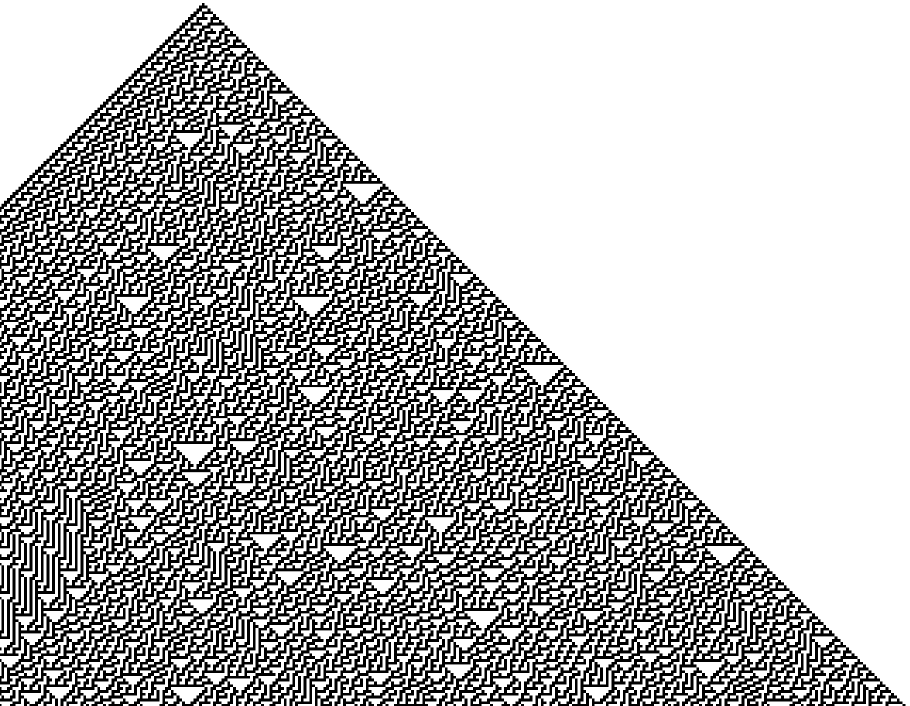
Fall 2012

CSE 633 Parallel Algorithms

Cellular Automata



Nils Wisiol

11/13/12

Simple Automaton: Conway's Game of Life

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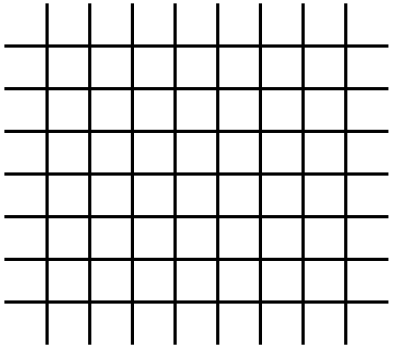

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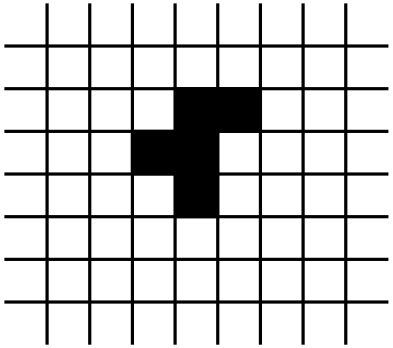

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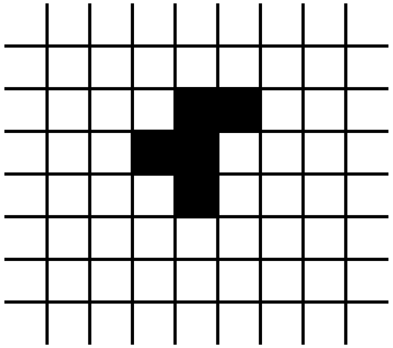

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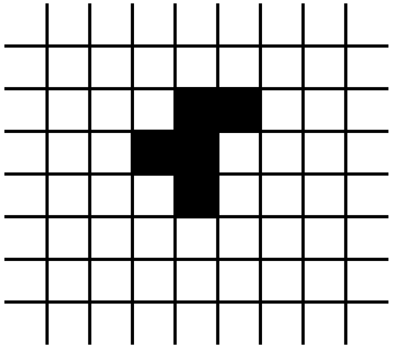

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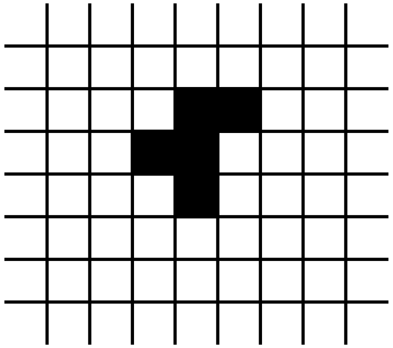

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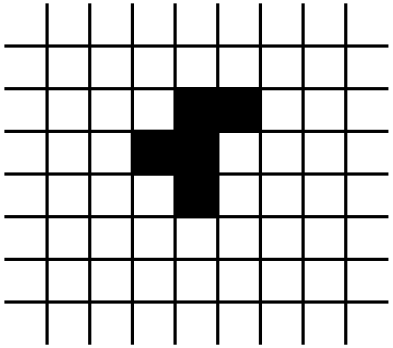

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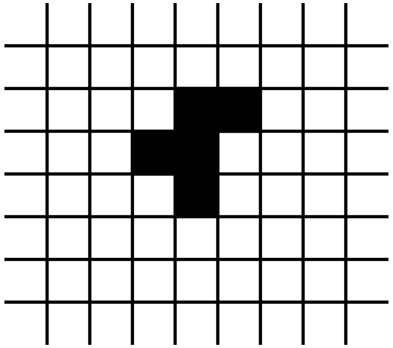

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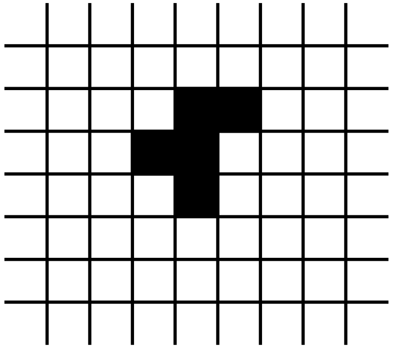

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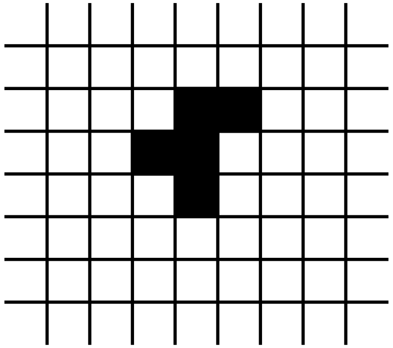

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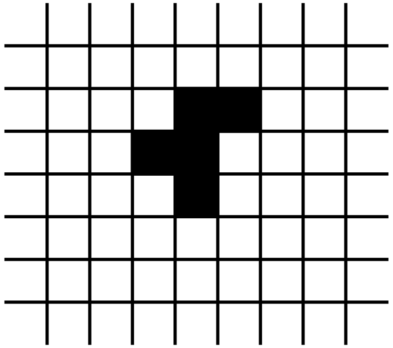

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step()
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      c $\leftarrow$ countN(j,i)
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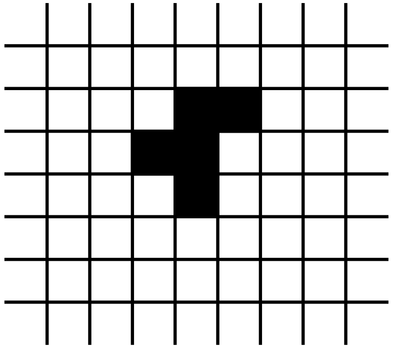

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countN() calculates the count of alive neighbours of the cell in row j and column i, rule() implements Conway's Game Of Life Rule.

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The analysis of this simple simulation algorithm shows that for a board with n cells, the runtime for a fixed number of generations is $O(n)$.

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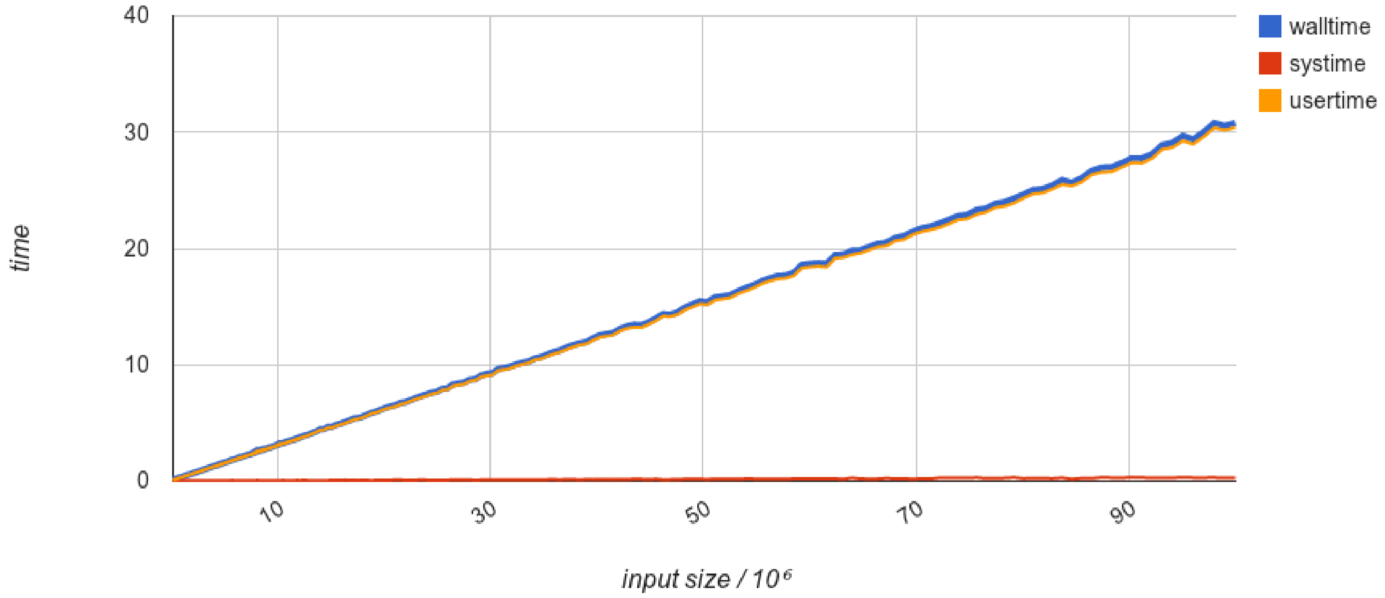

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void step() {
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  for (int j = 0; j < HEIGHT; j++) {
    for (int i = 0; i < WIDTH; i++) {
      int c = countN(i, j);
      buffer[j][i] = world[j][i] ? (c == 2 || c == 3) : c == 3;
    }
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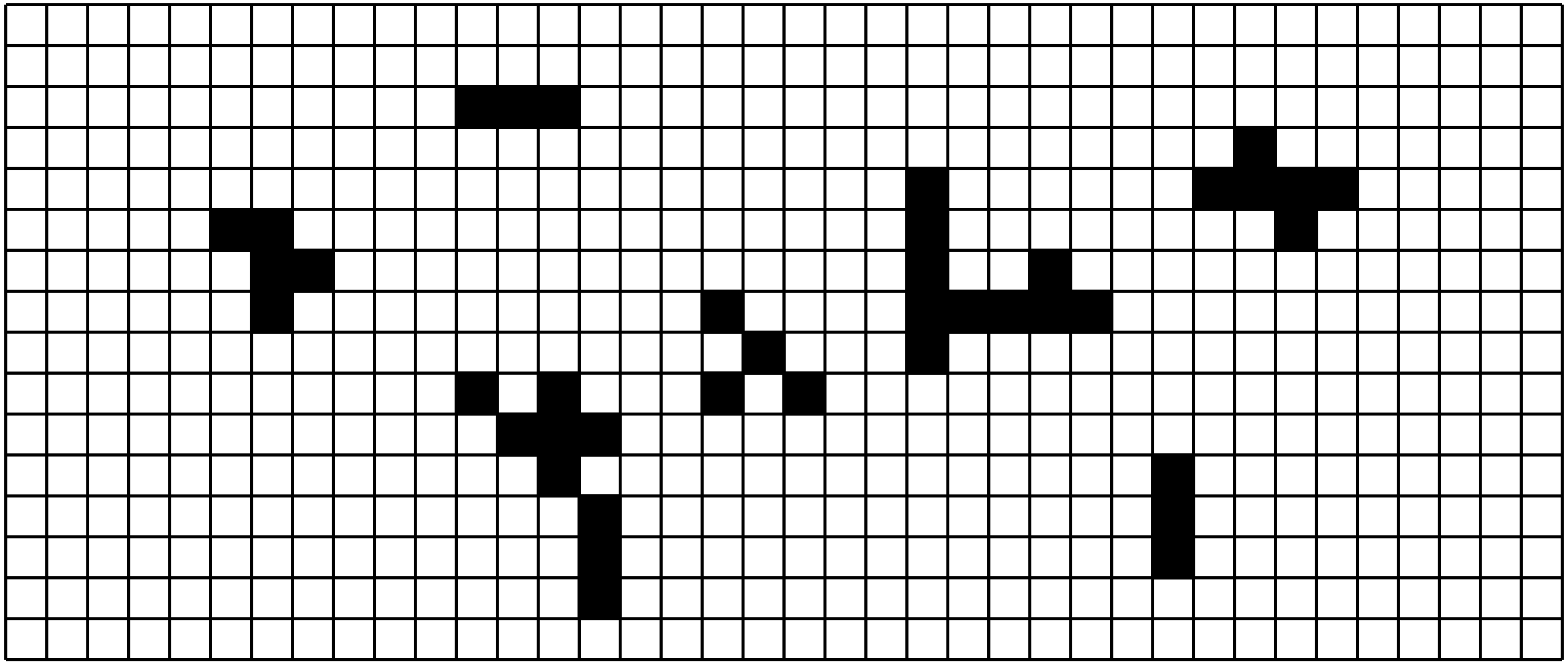
✓ speedup of 30.4 on the 32 core machine

OpenMPI Implementation



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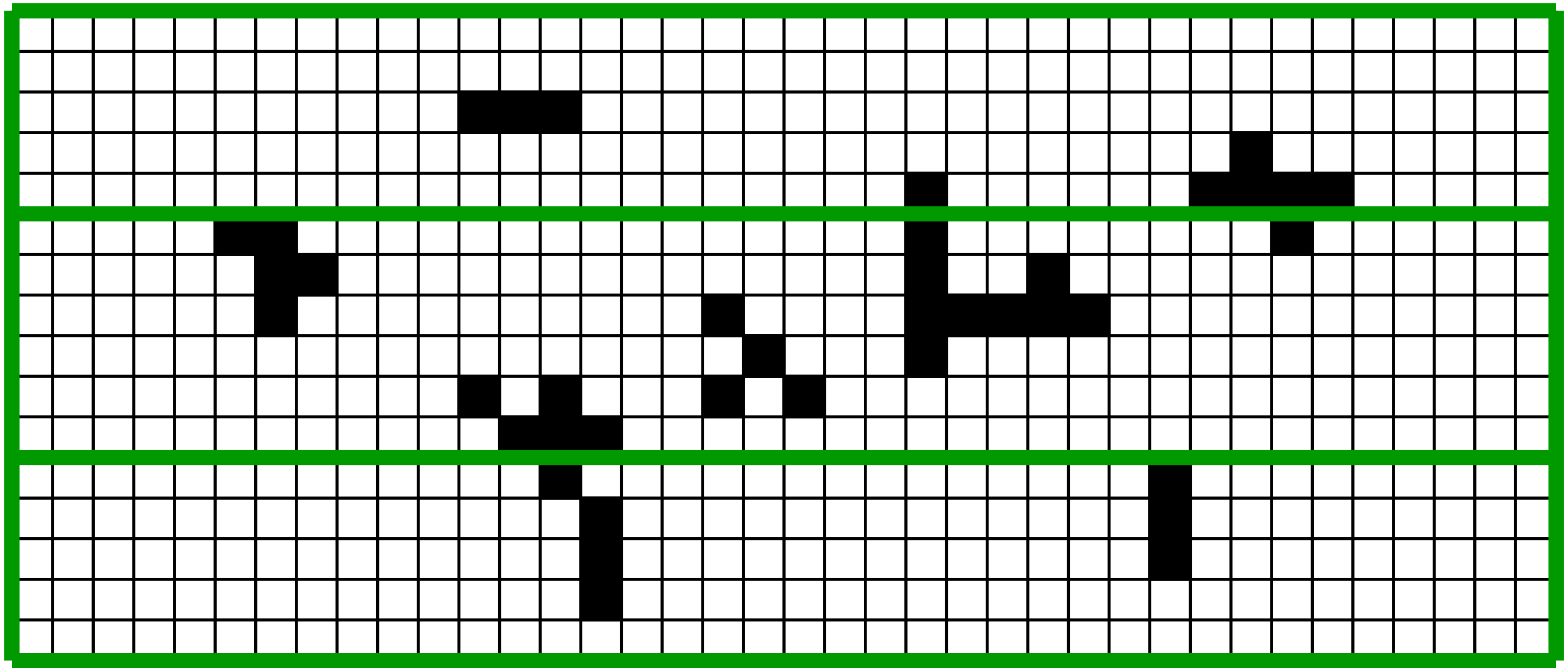

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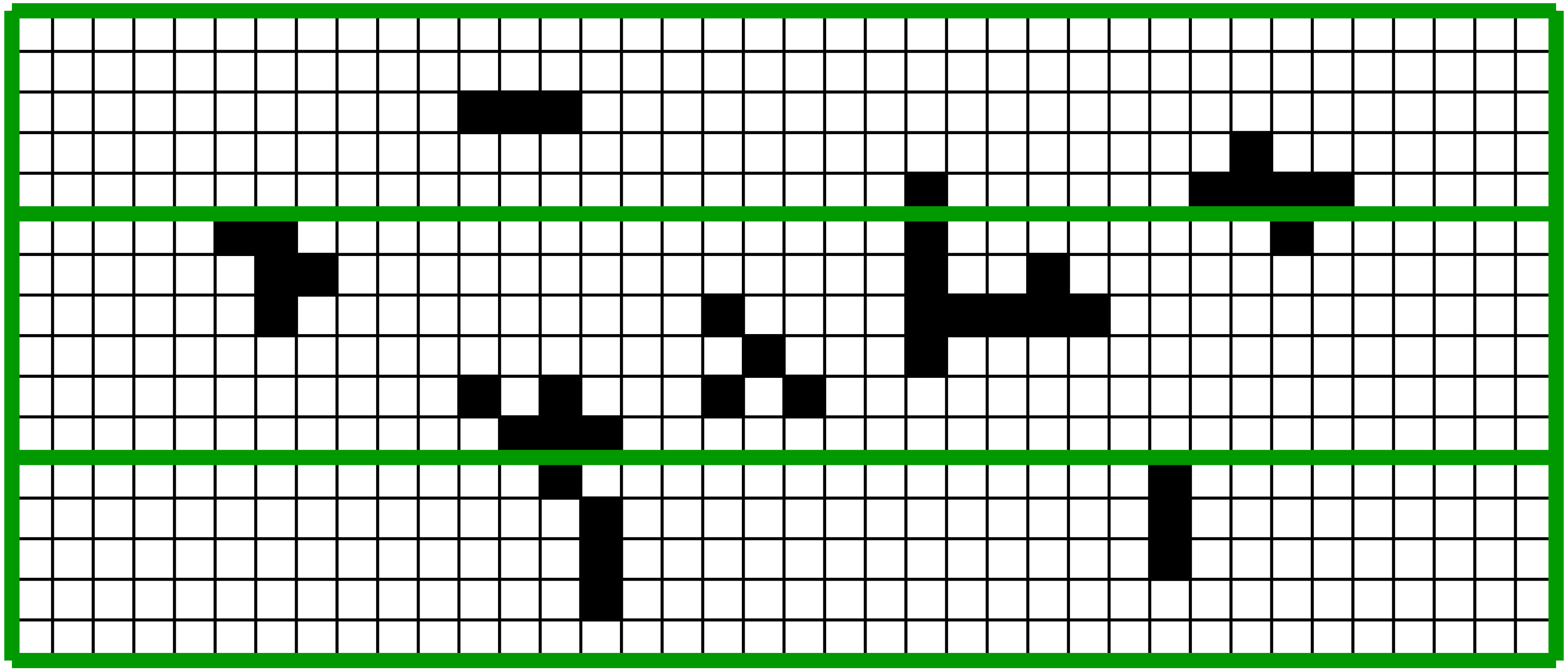

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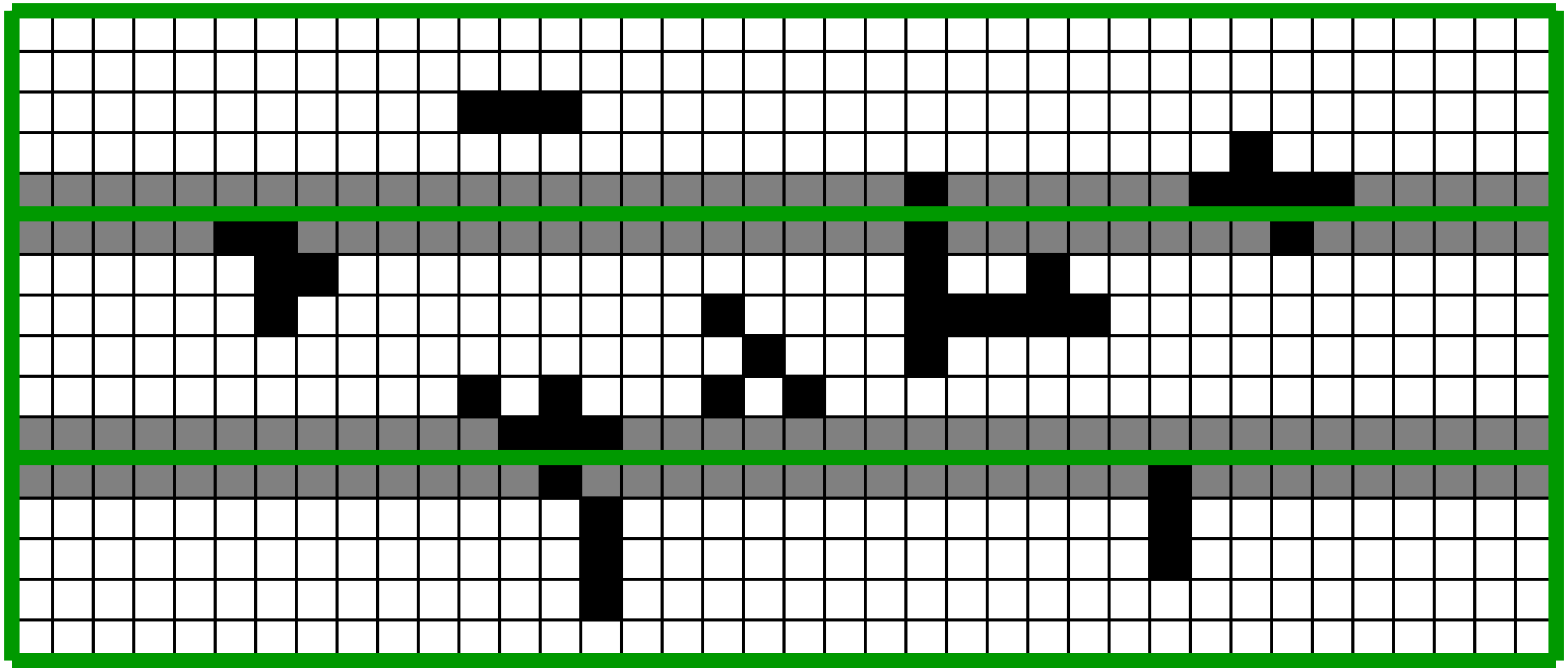

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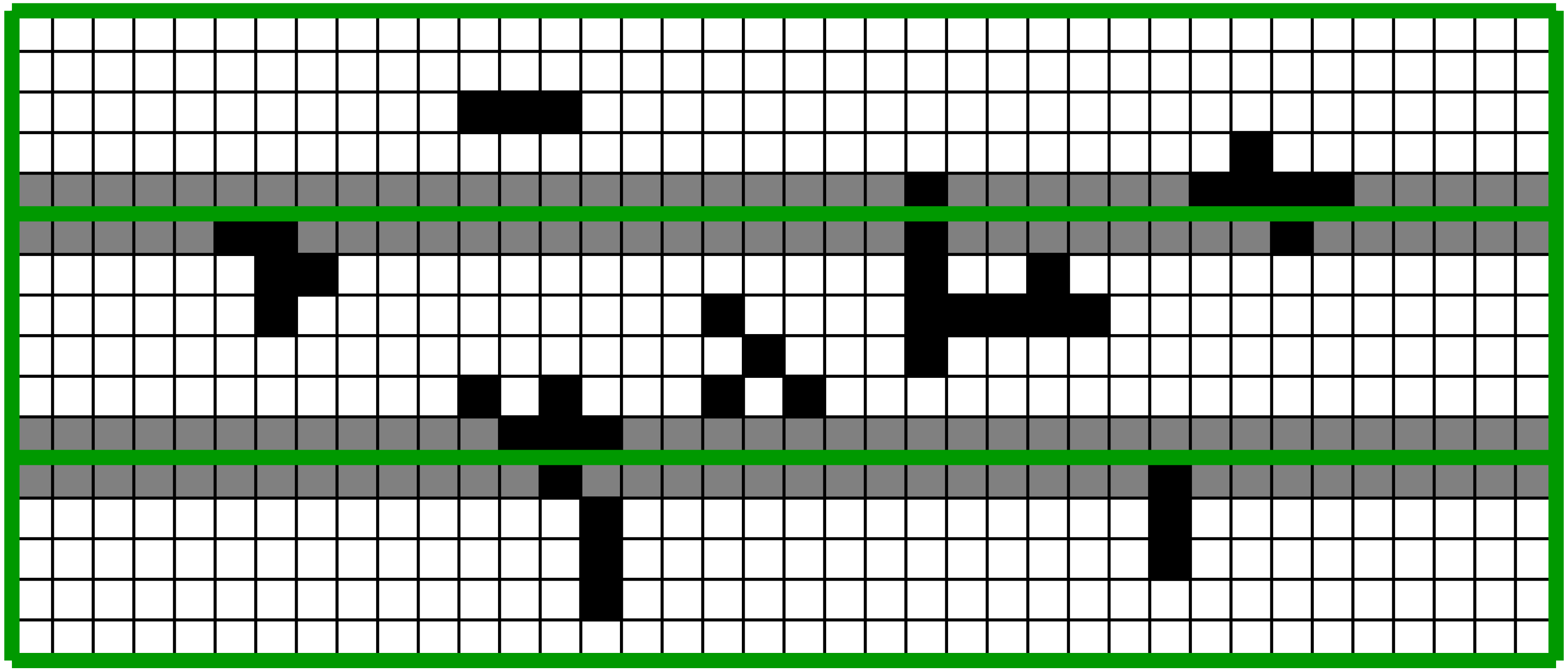

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- Output result state on command line (for small boards)
- comparison to (single-core) reference implementation (`golly`)
- calculation of well-known patterns

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Compared to the OpenMP implementation, the Open MPI implementation shows a much worse speedup, even on a single machine. This is due to the message passing, which can be done through a network of nodes, but significantly slows down things.

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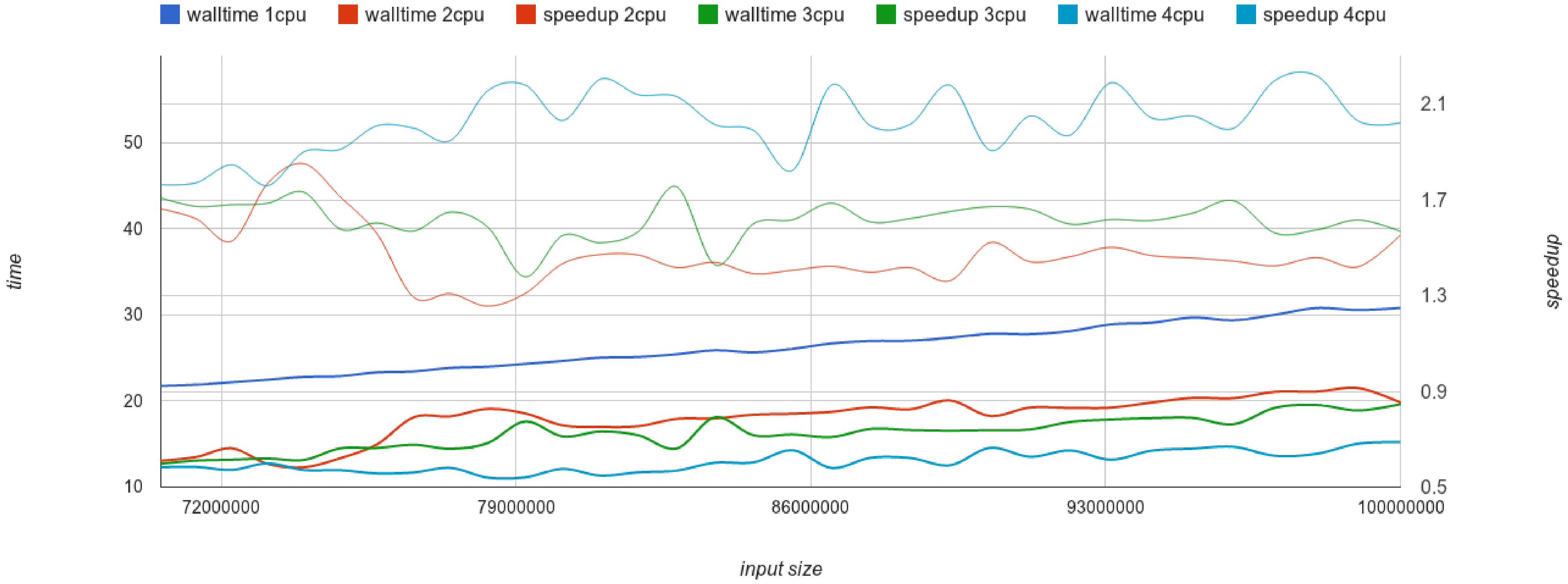

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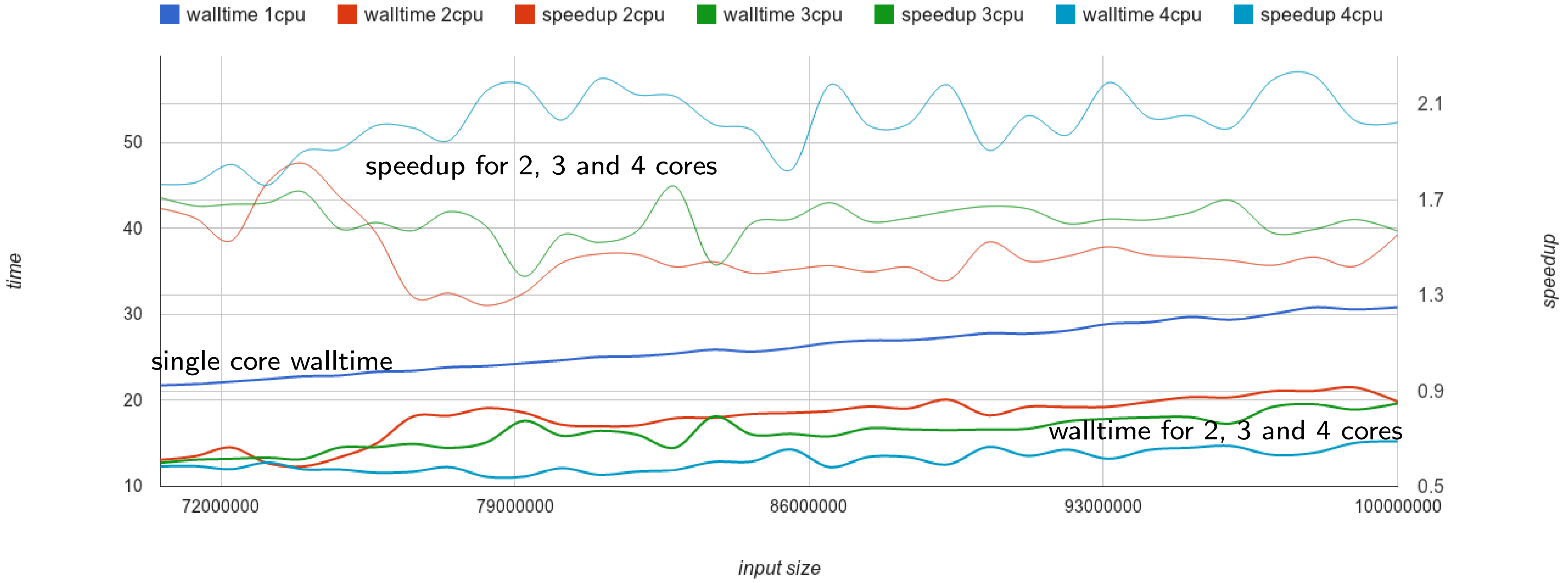

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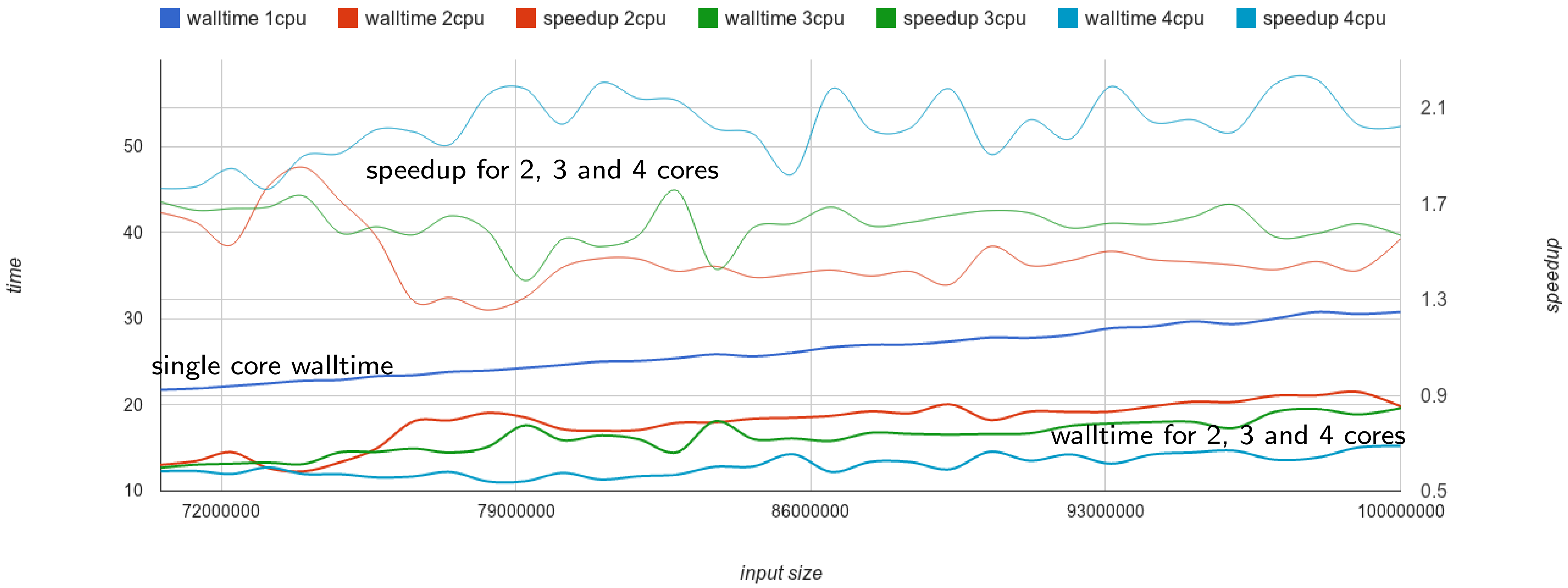

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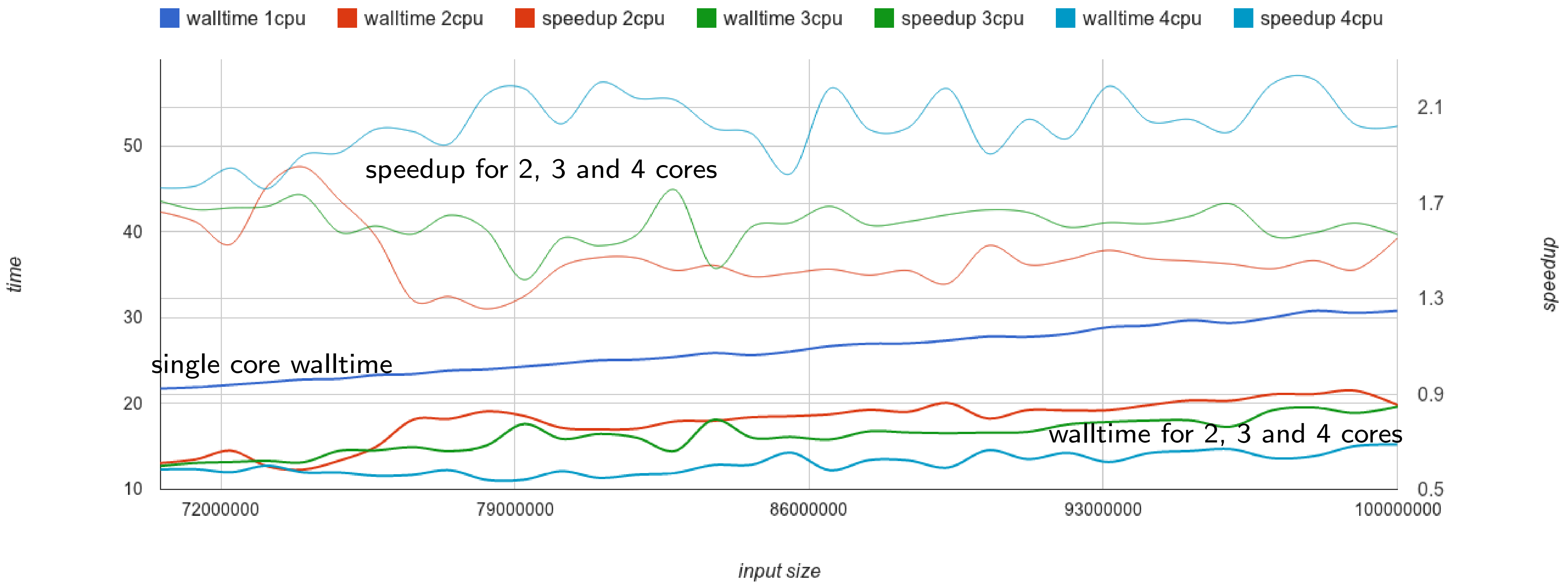

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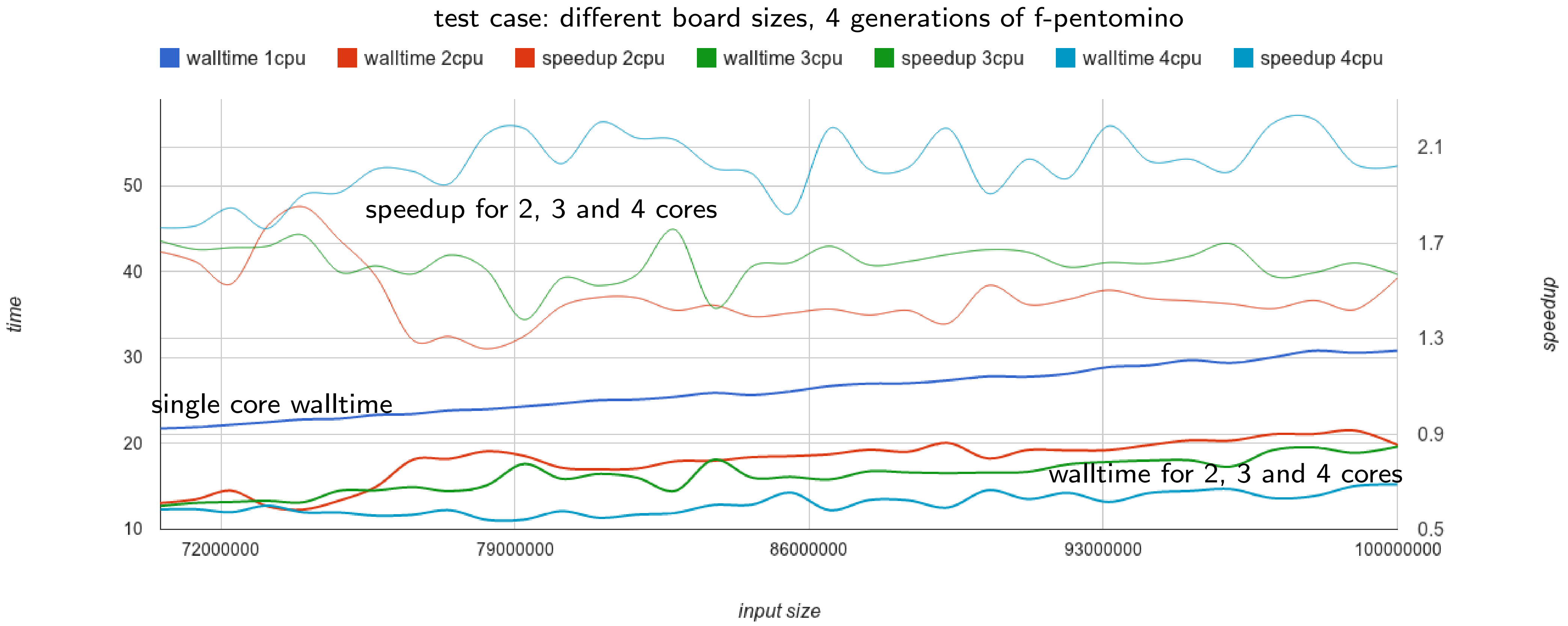
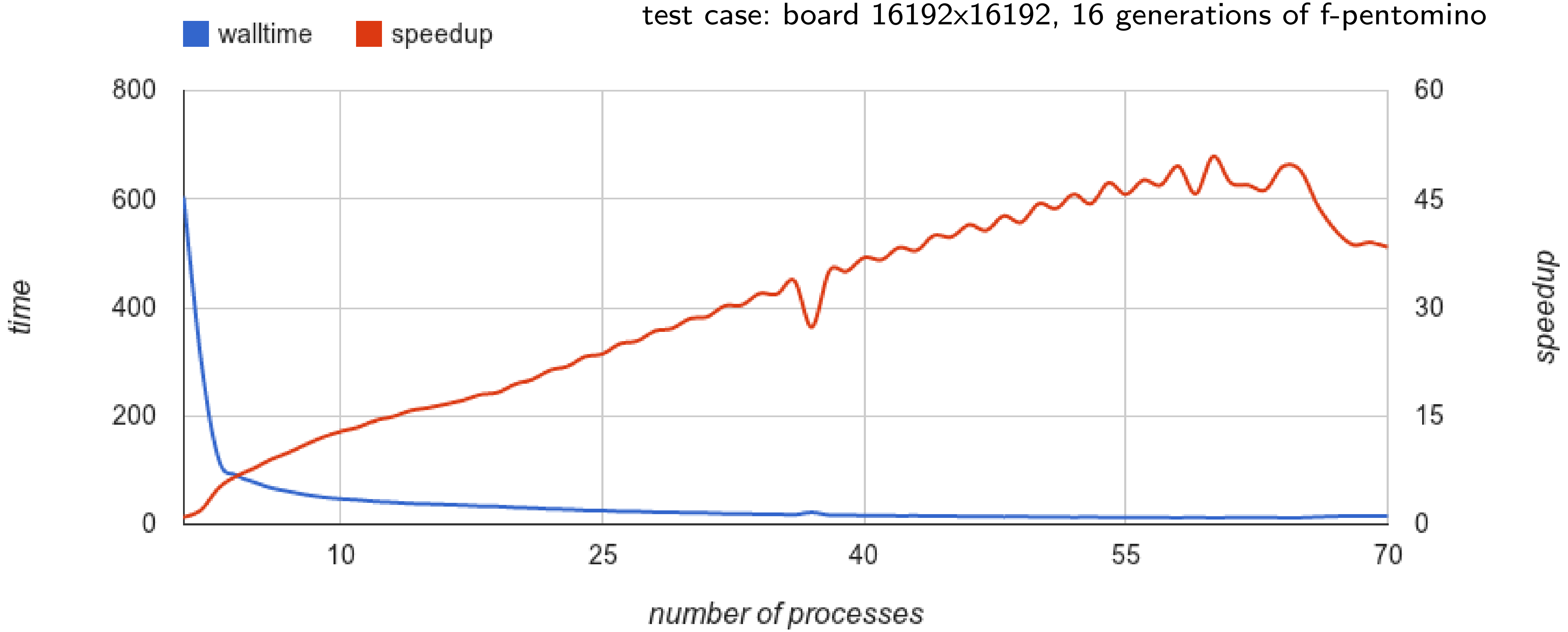
- multi-process MPI runtime varies more than single-process runtime



Open MPI Process Number Benchmark

At CCR, the maximum speedup we can achive with a OpenMP implementation is 32. With the Open MPI implementation, we can achive greater speedups. For example, by using 32 2-core nodes, we can achieve up to 50 times the single-core speed.

test case: board 16192x16192, 16 generations of f-pentomino



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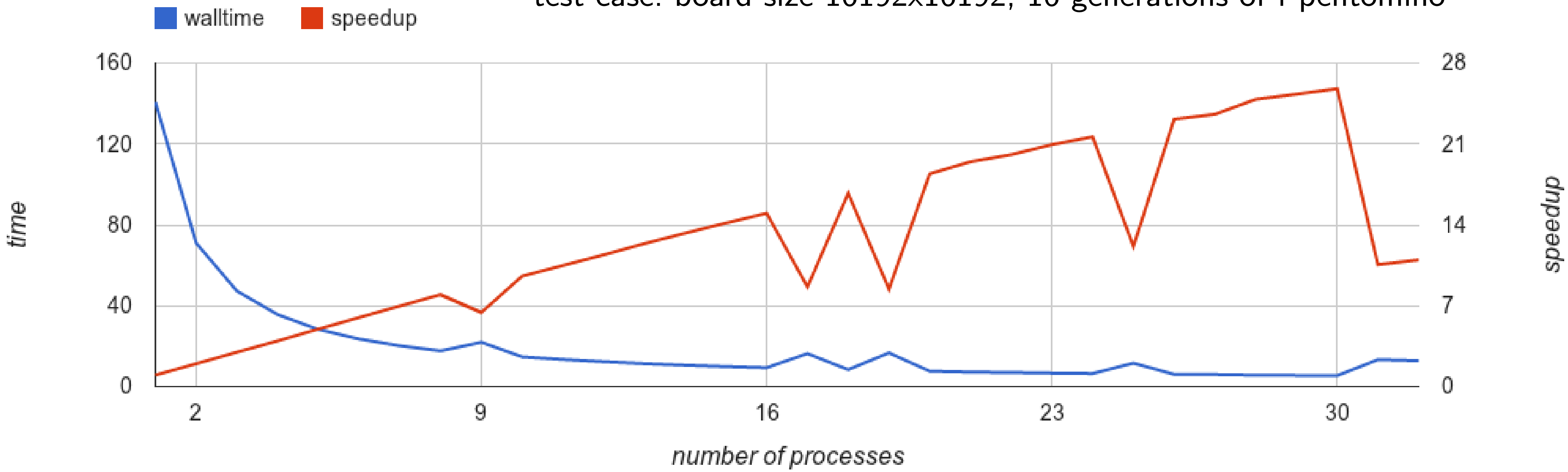

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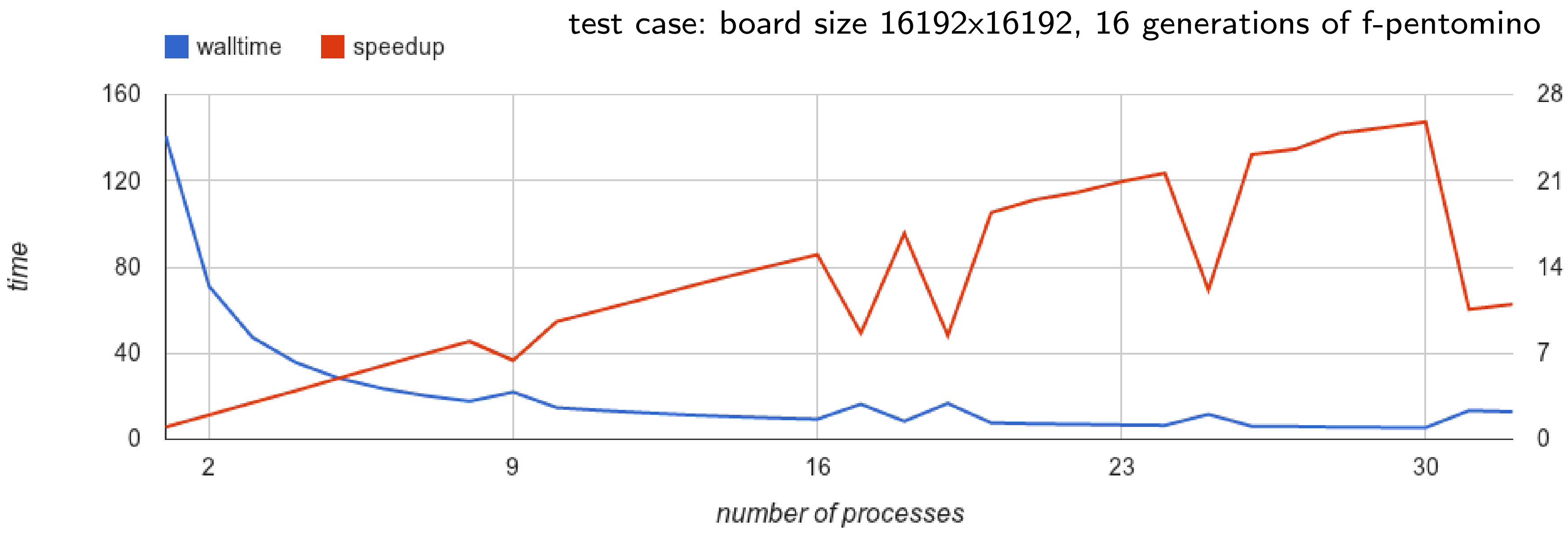

It's remarkable that for the first 8 tests, which all took place on a single machine with 8 cores, the speedup is almost optimal (that is, 7.96 when using 8 cores).

Further Improvements

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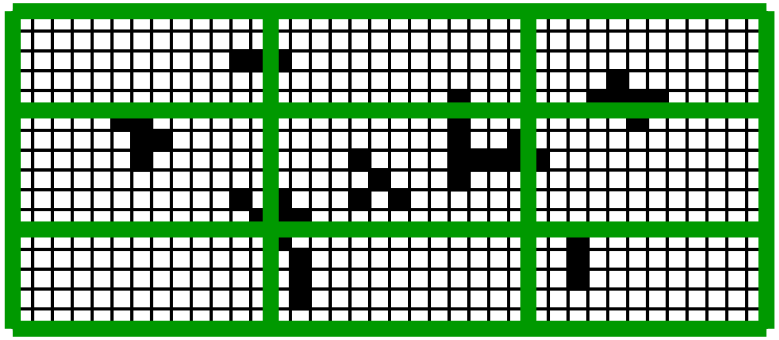
- improve runtime by splitting the game's board into a grid which mirrors the structure of the cluster, in order to minimize waiting times



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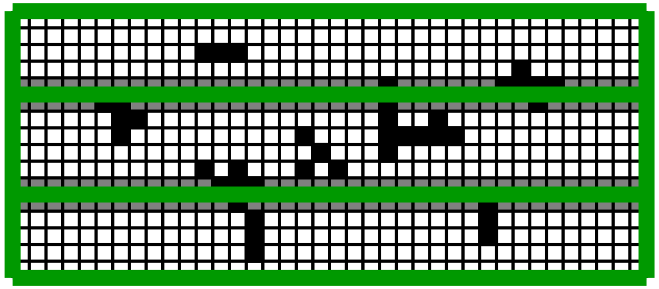

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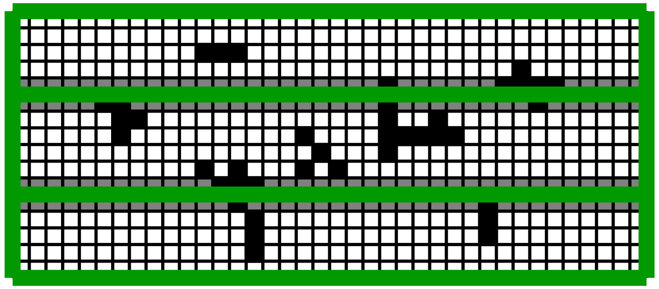

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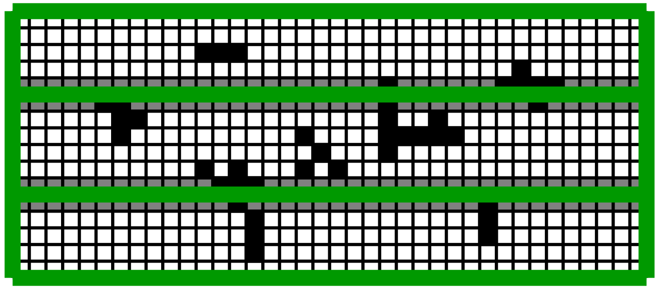

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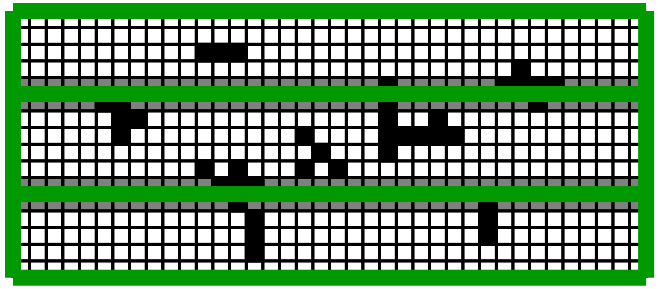

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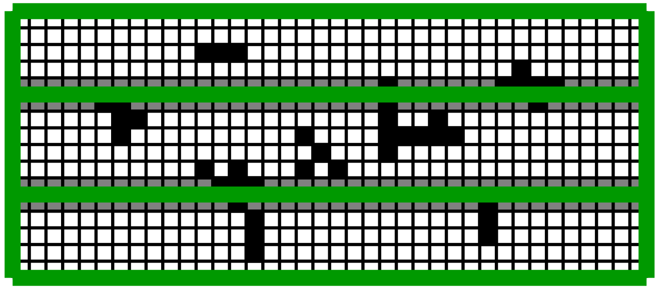

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- Engine should be extended in a way that can simulate other cellular automatons