The Challenges of Irregular Parallelism

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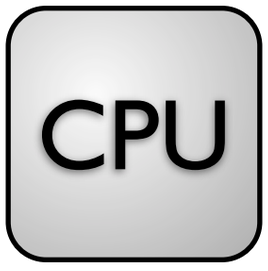
Why should I write parallel programs?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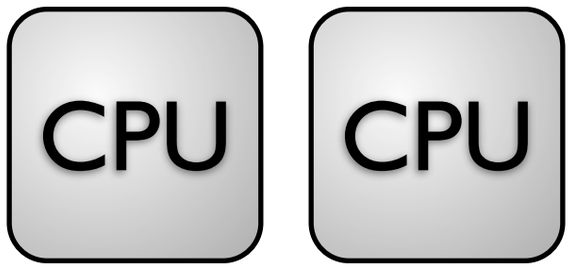
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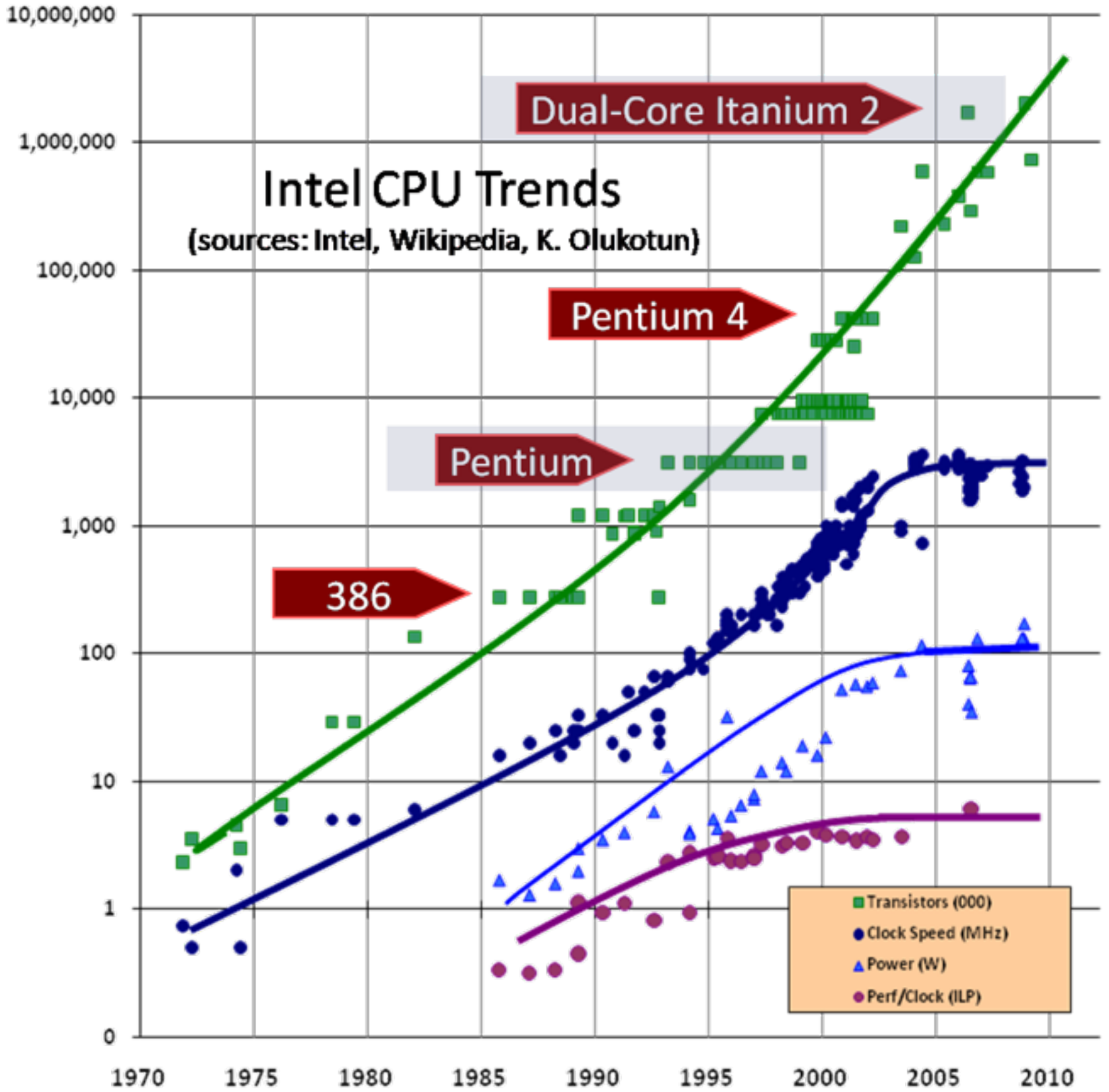
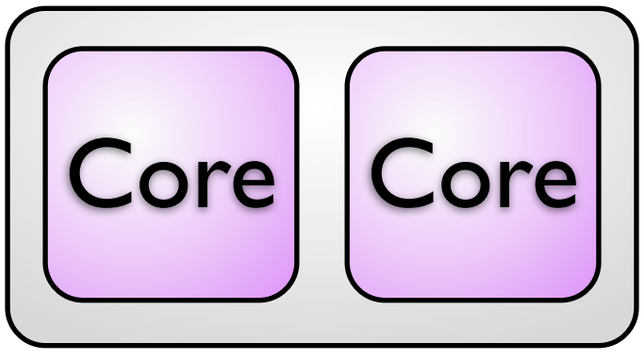


H. Stutter. The free lunch is over – a fundamental turn toward concurrency in software. Dr. Dobb's, 30(3), 2005.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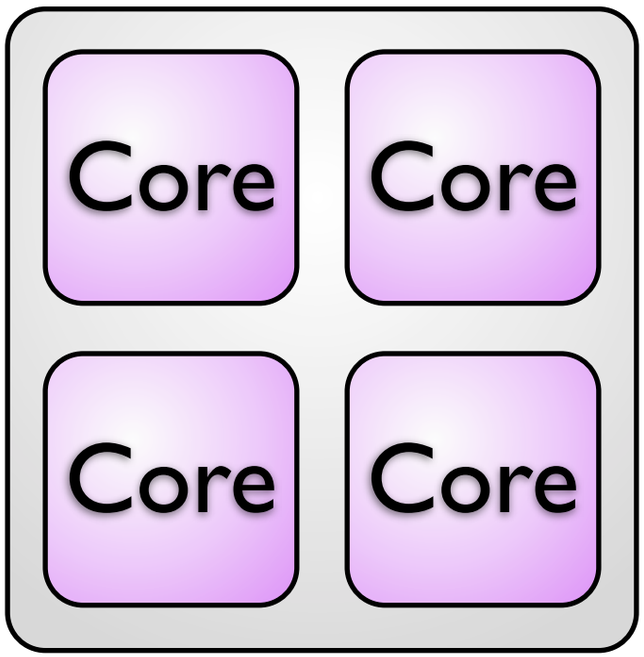
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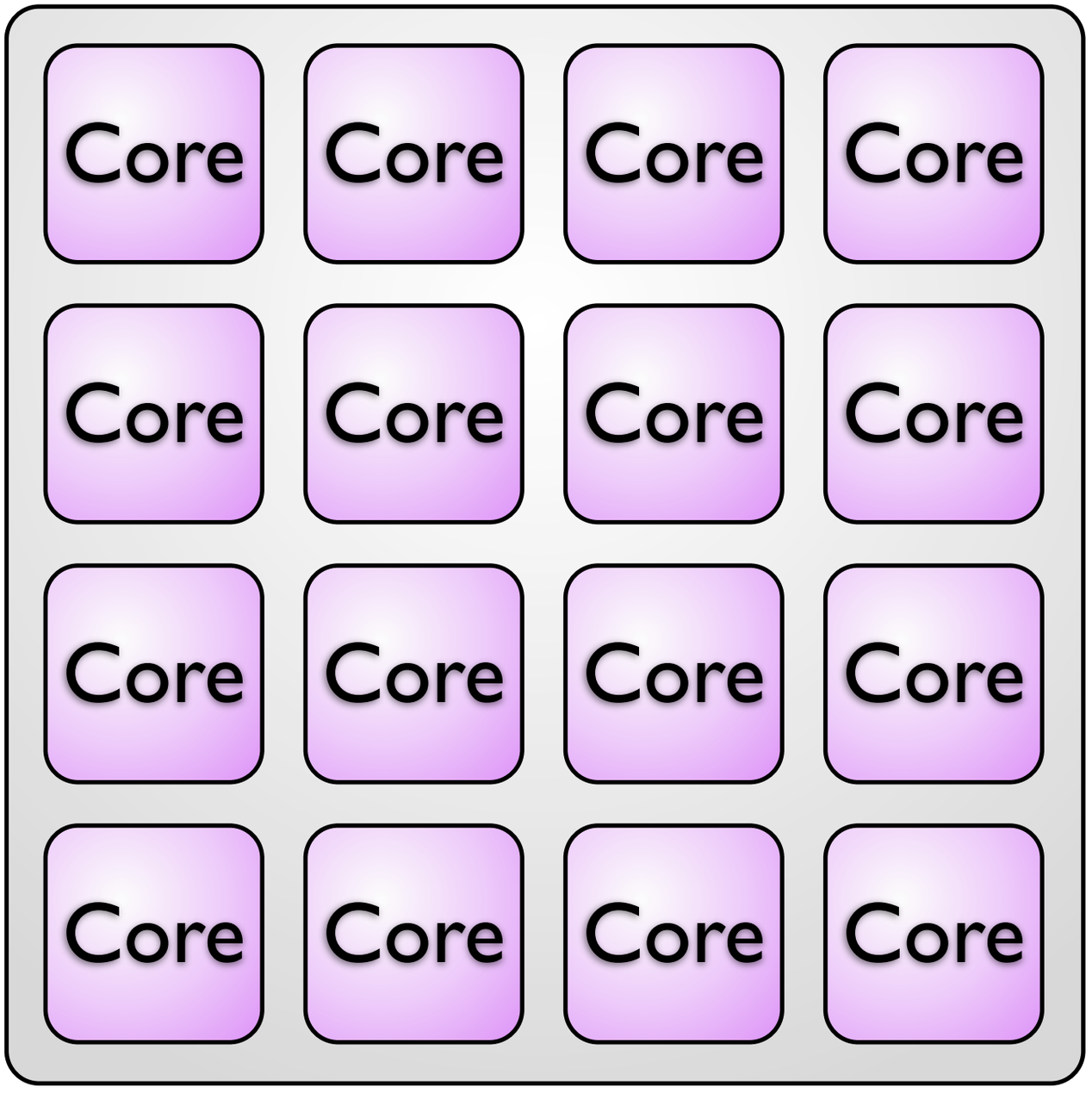
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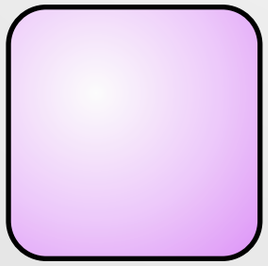
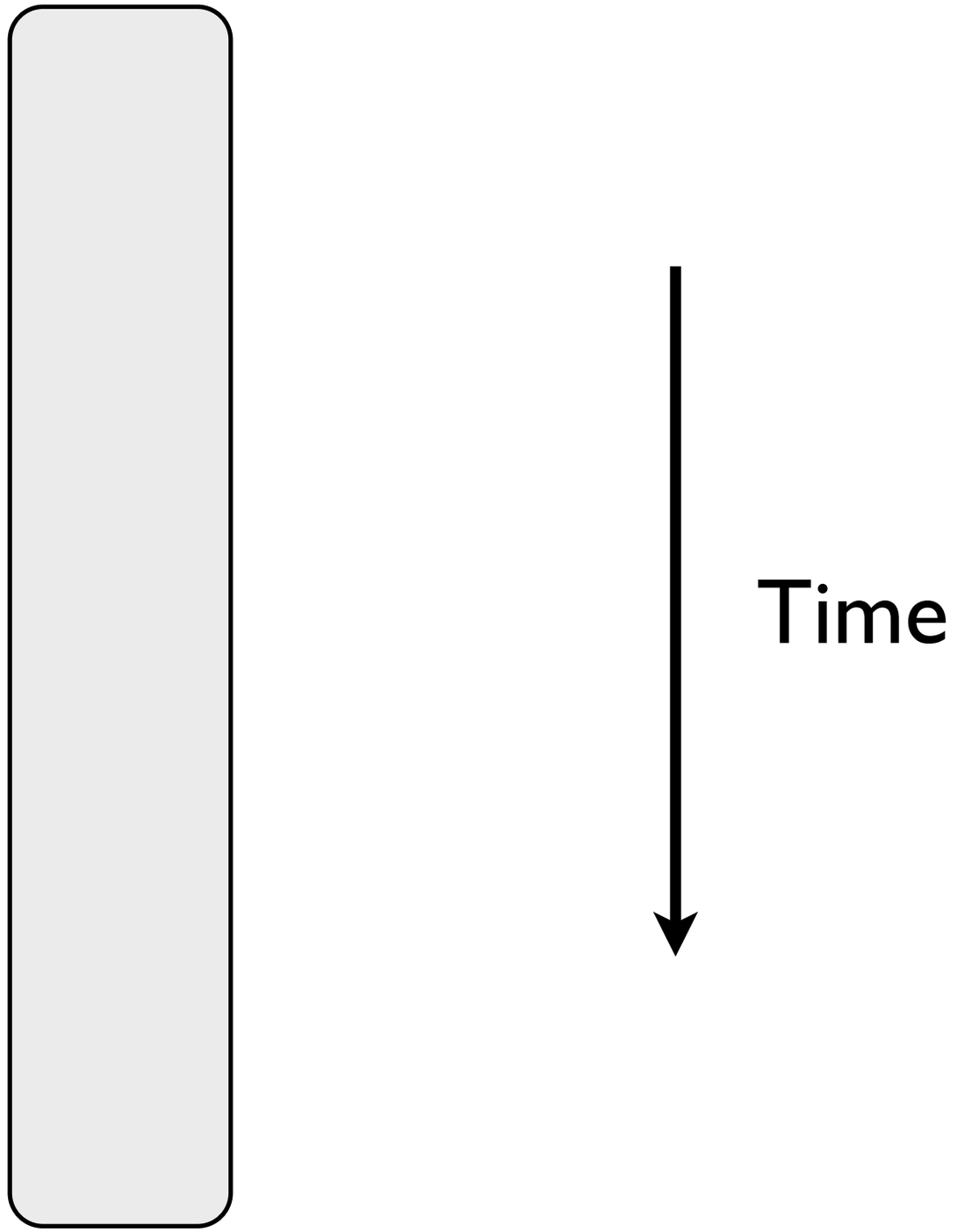


We already know how to make parallel programs

Structure your program so that there are tasks that can run at the same time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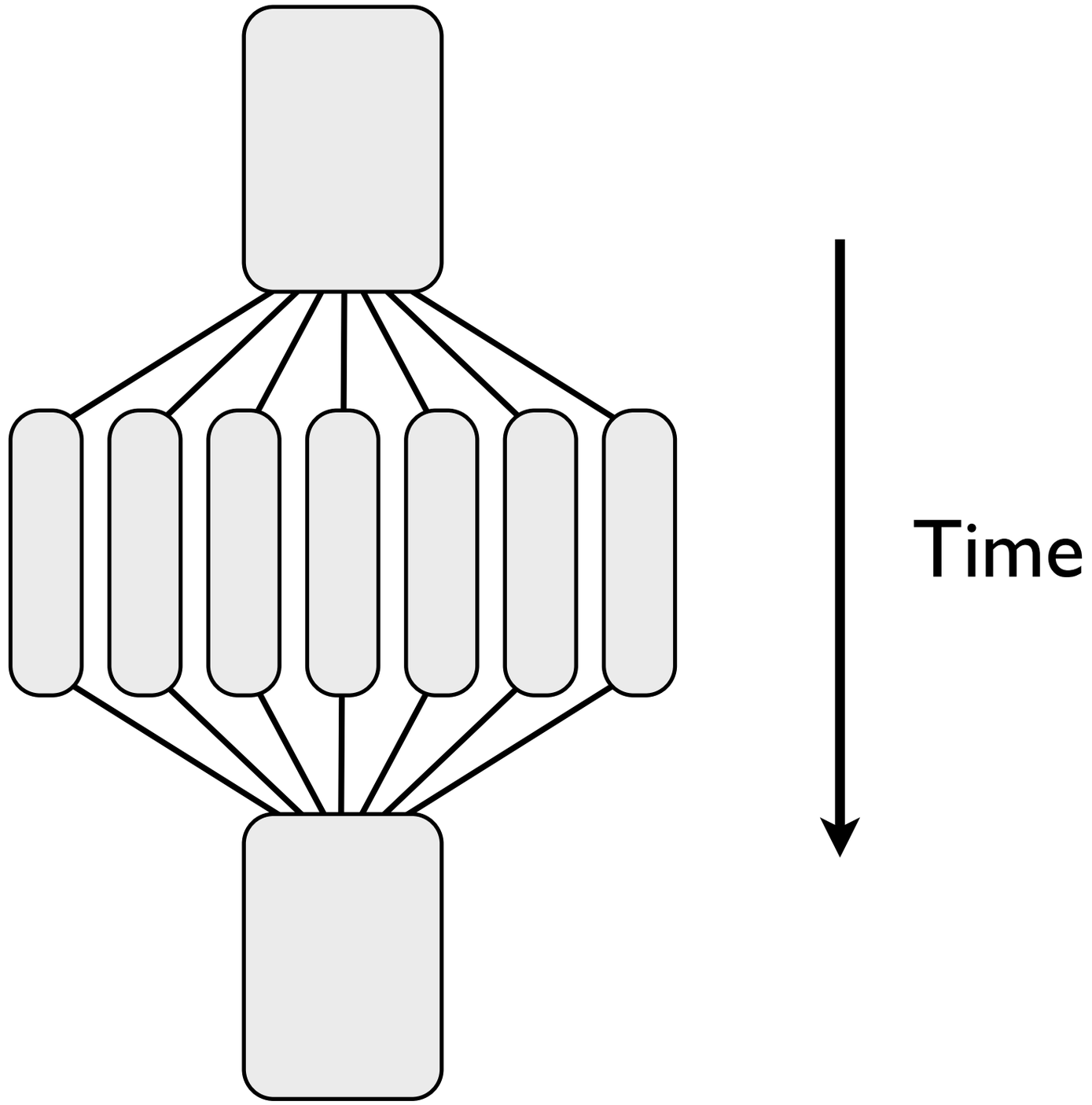
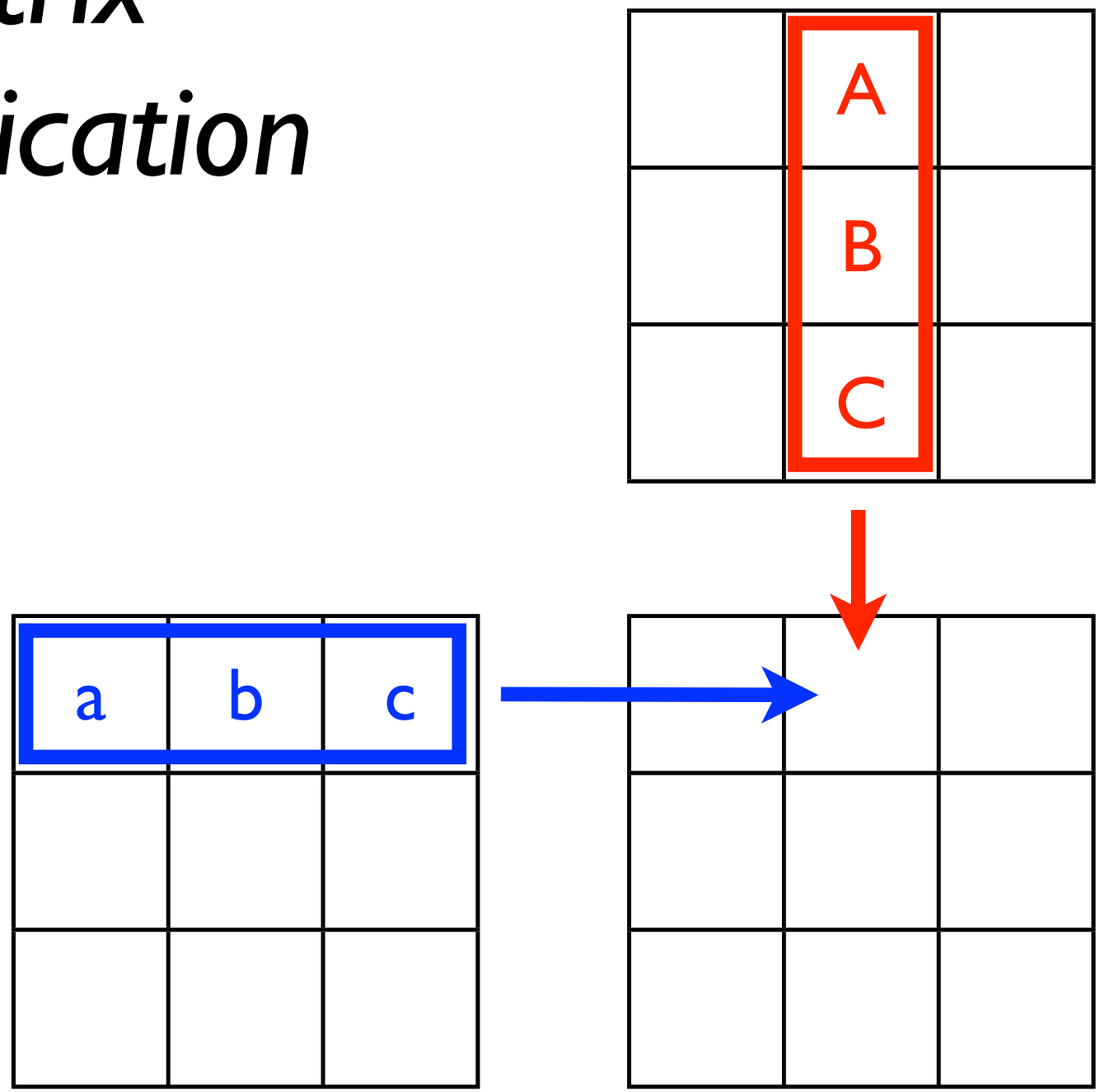
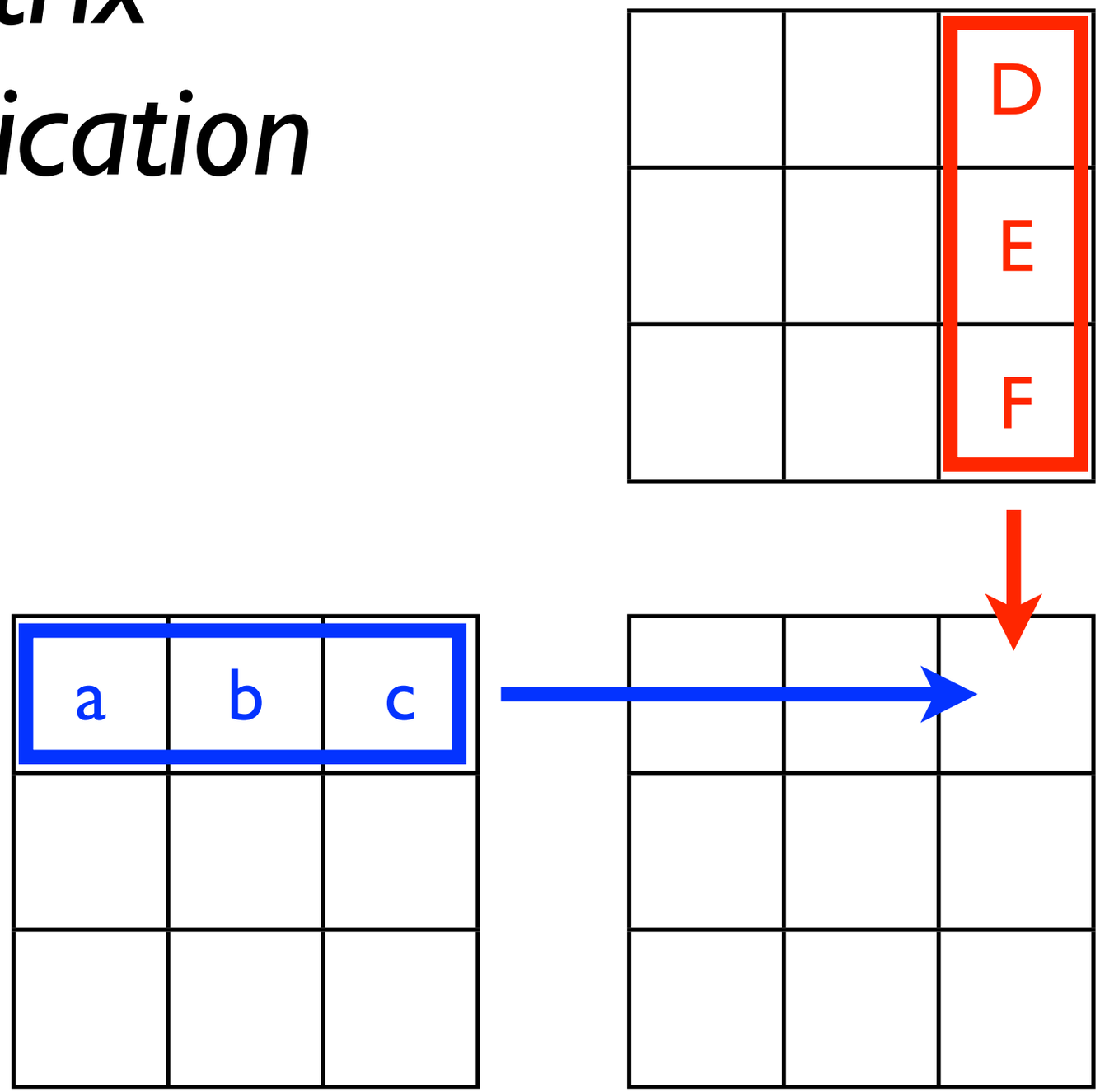

Time

Matrix multiplication



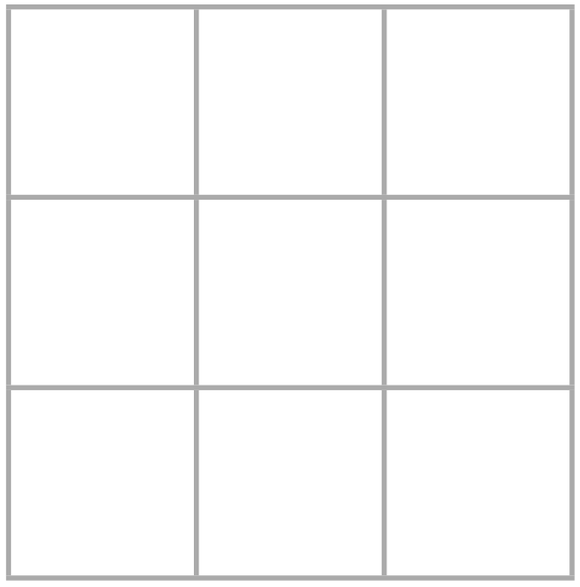
$$aA + bB + cC$$

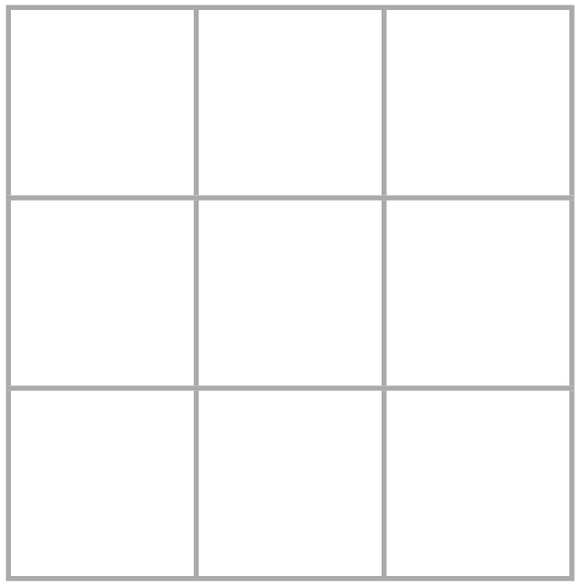
Matrix multiplication

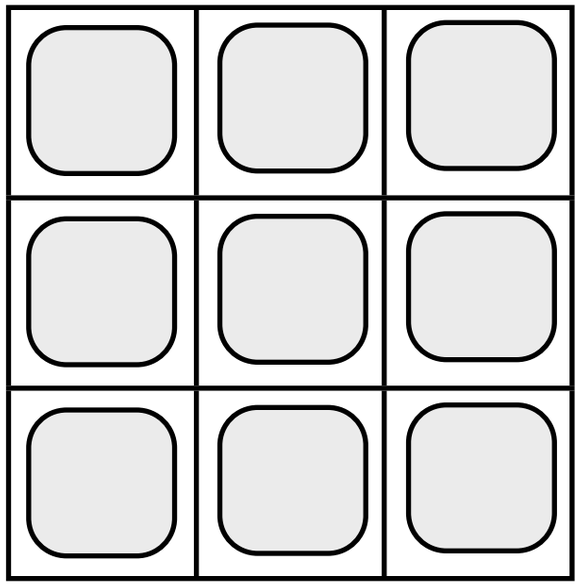


$$aD + bE + cF$$

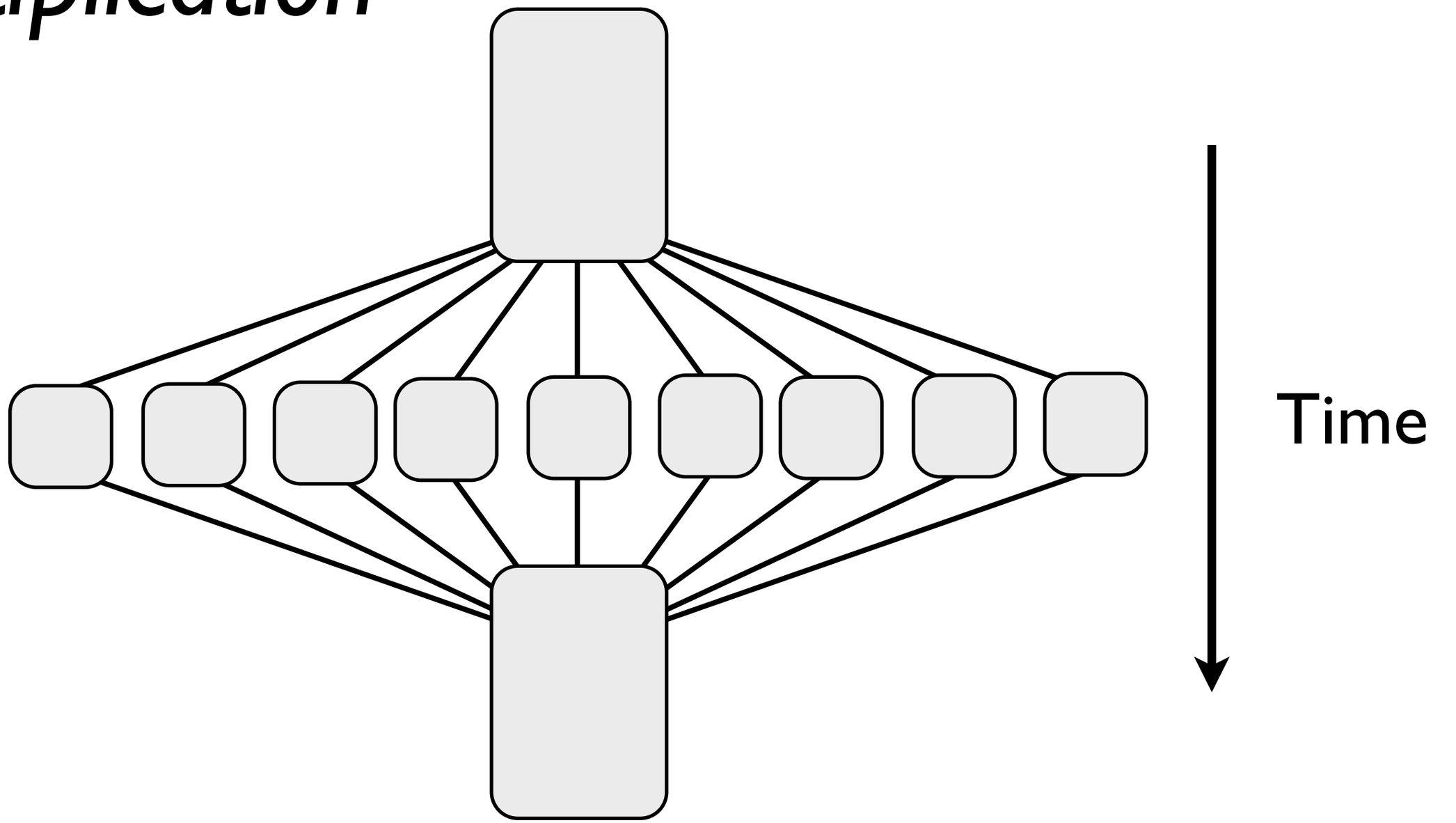
Matrix multiplication



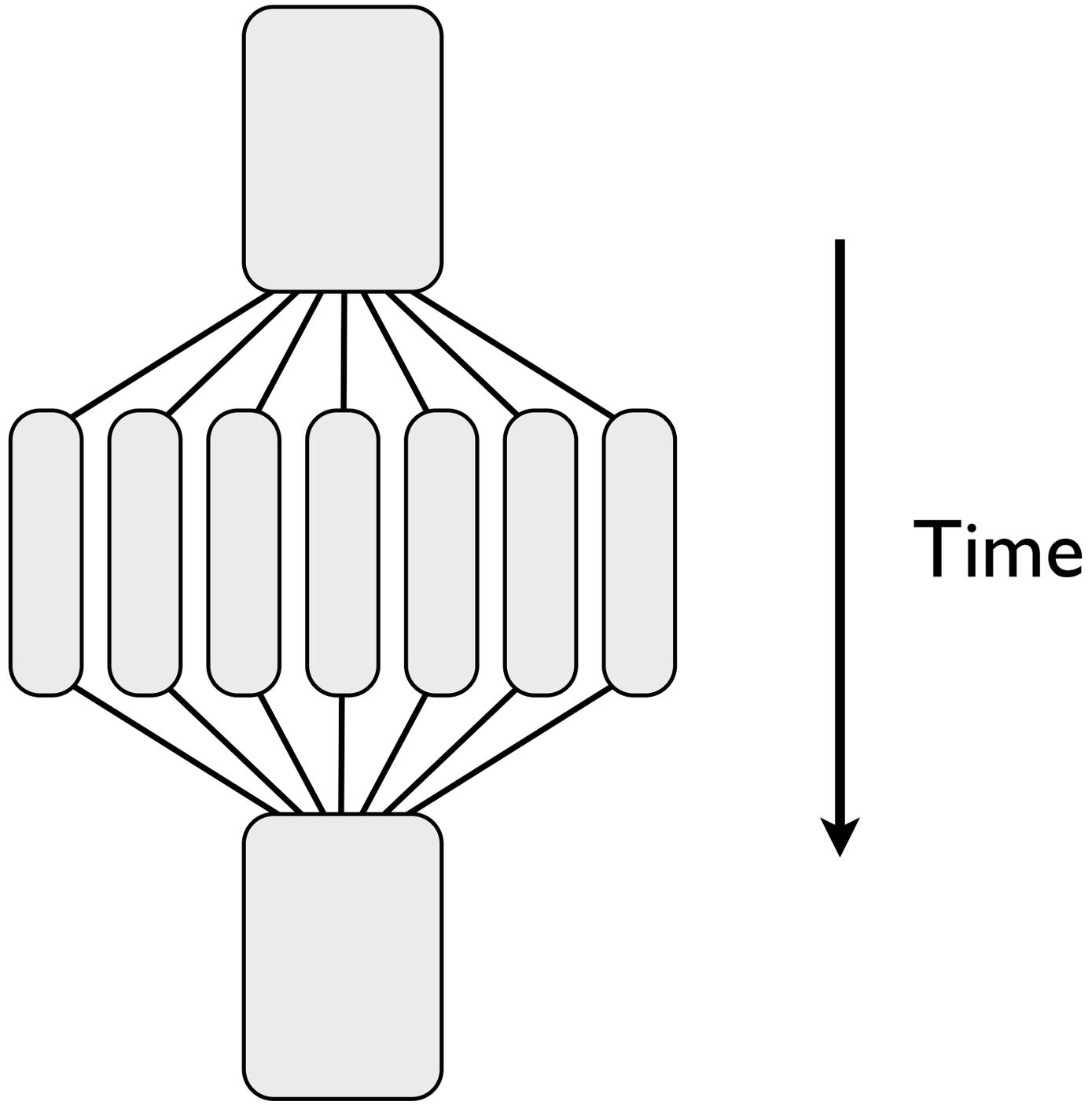




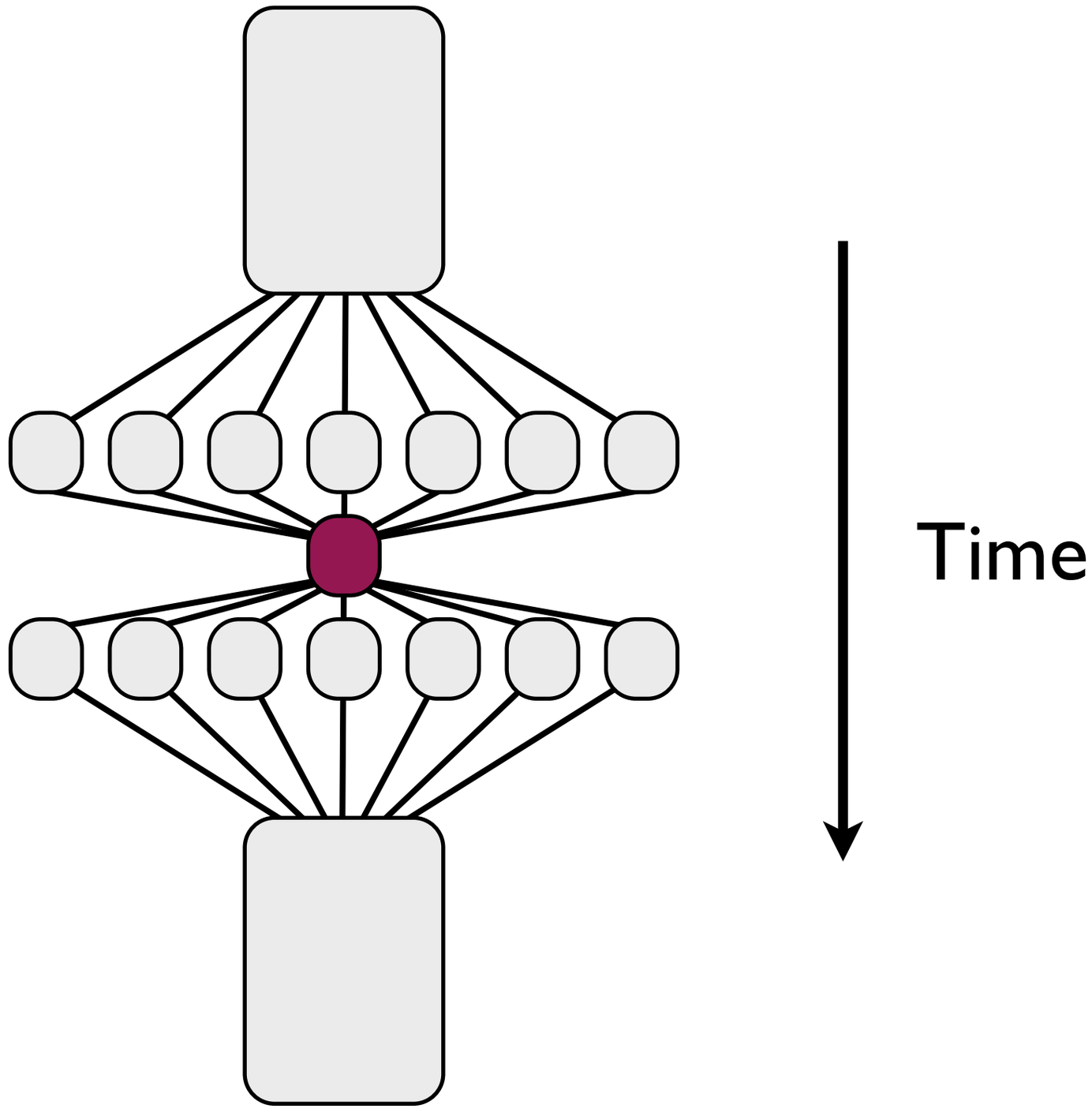
Matrix multiplication



However, this only works if those tasks are entirely independent of each other


Time

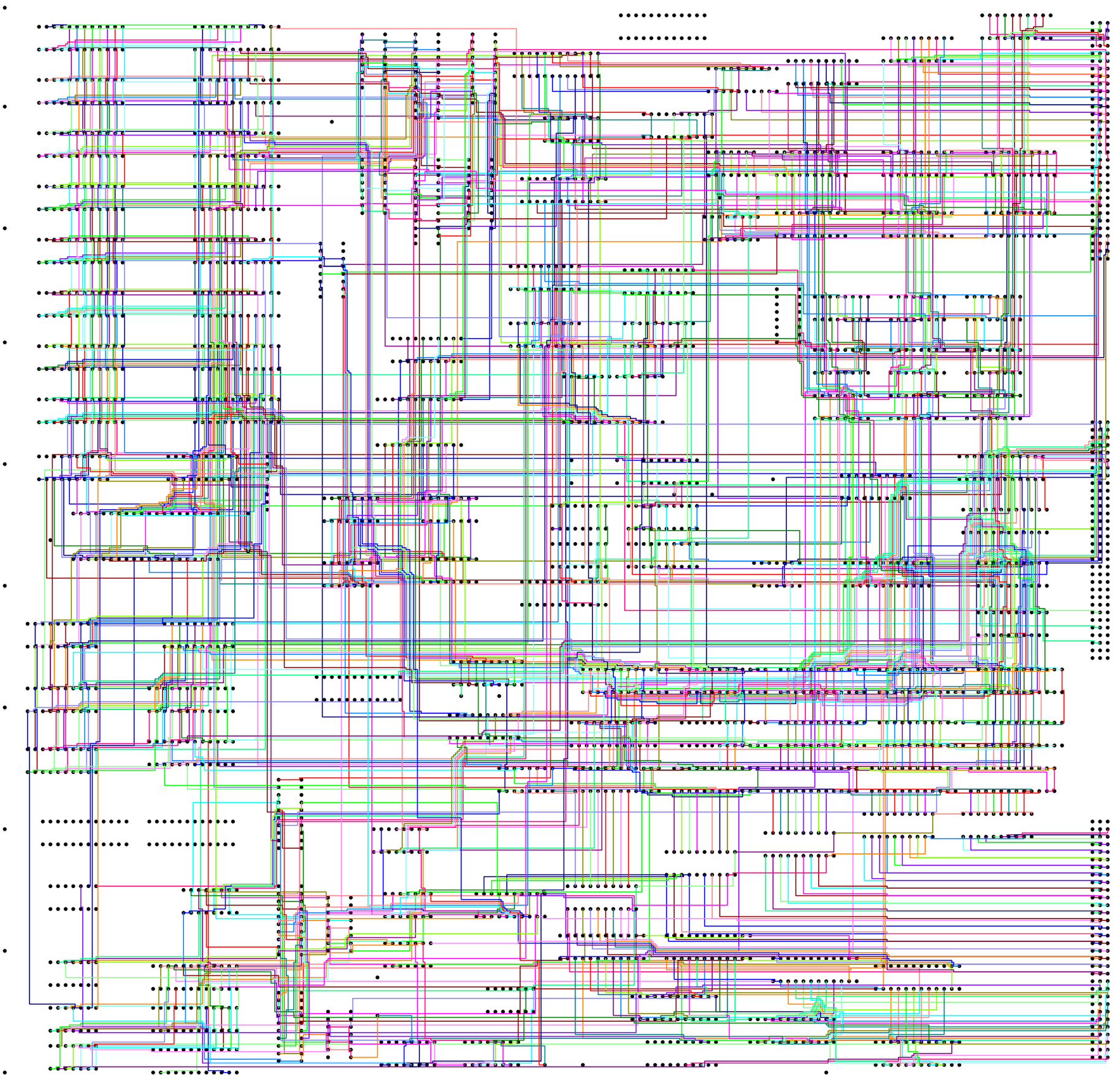
Some kind of shared object - choke point

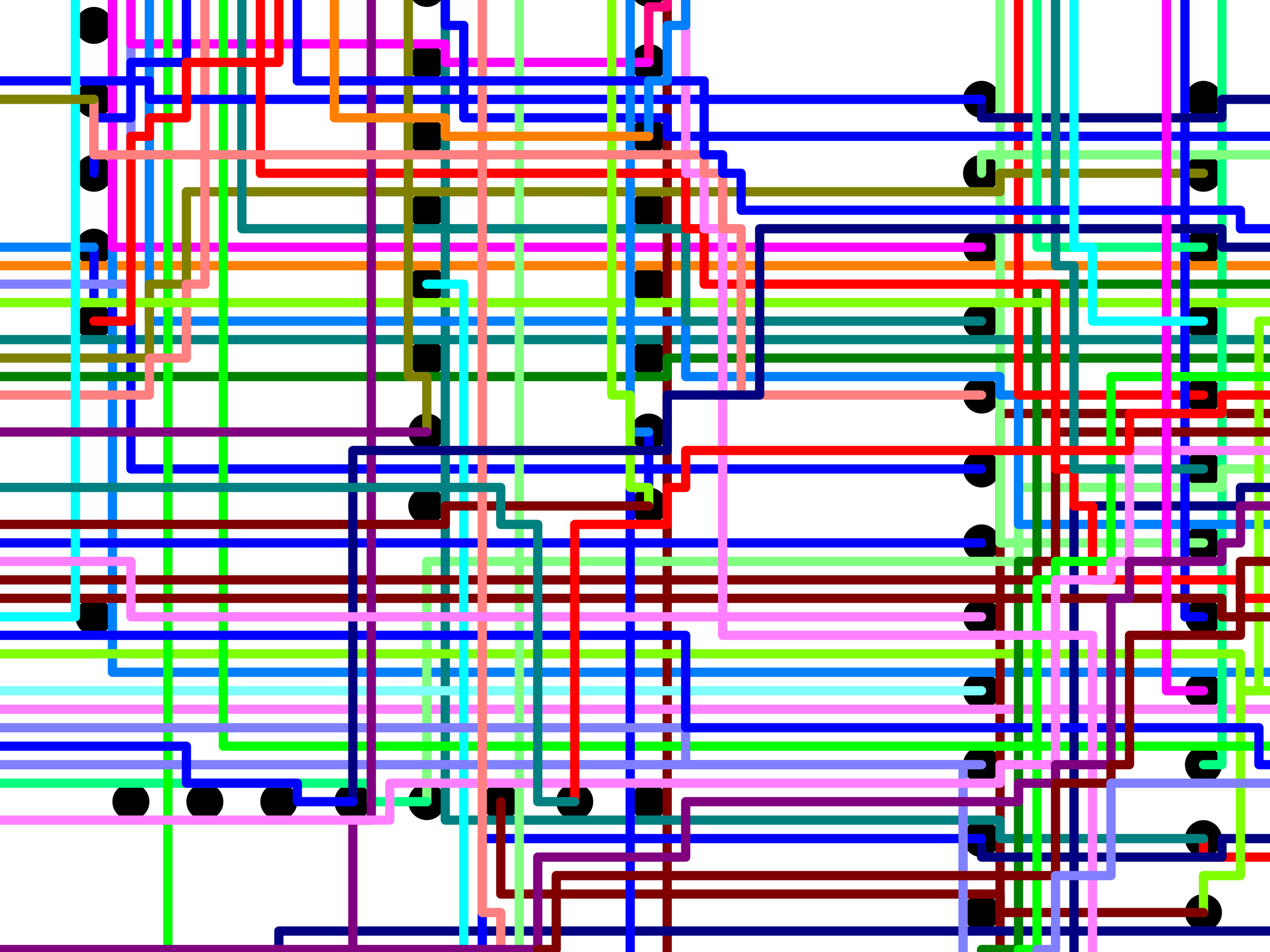


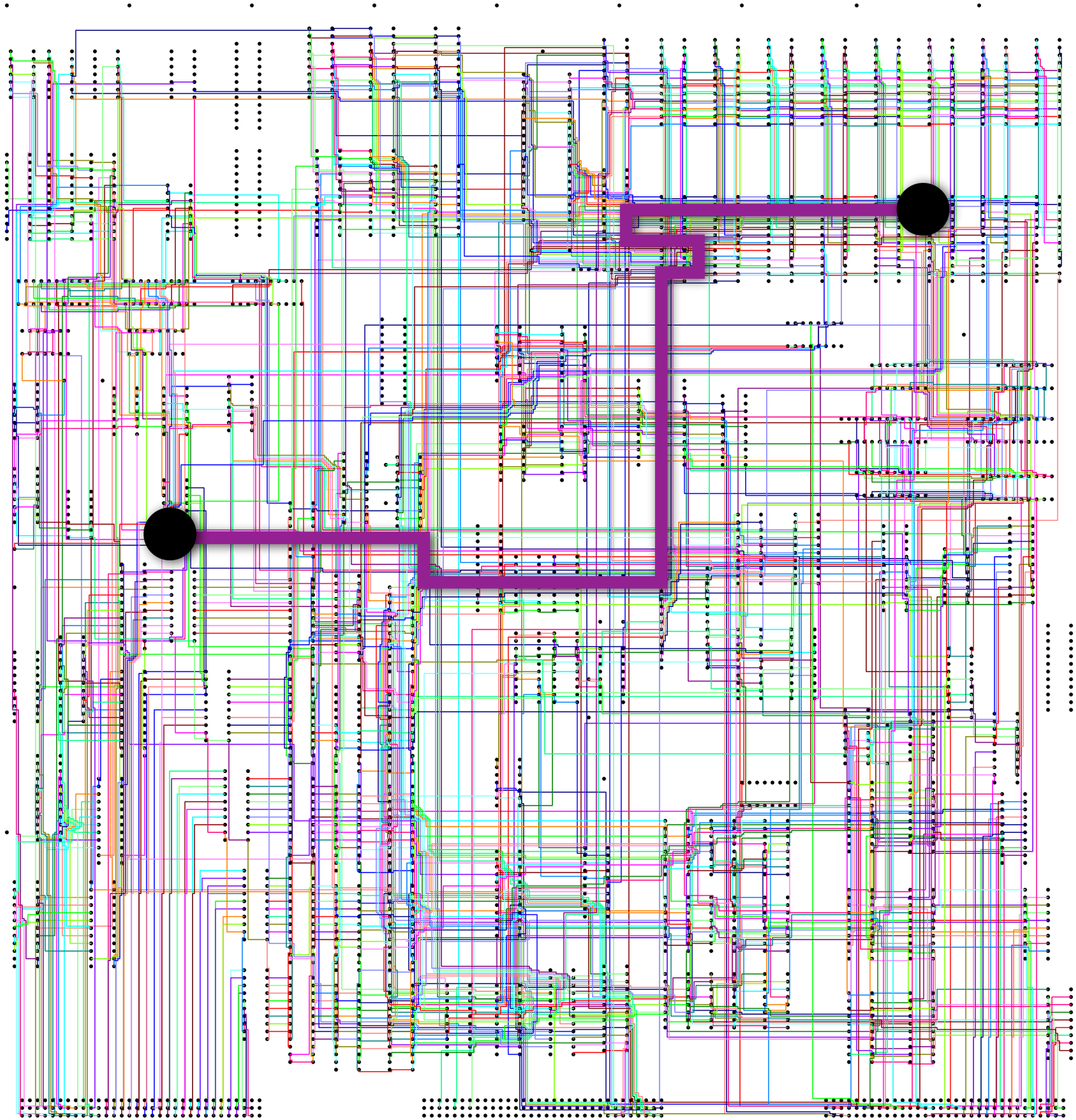
Ideally don't write software with shared objects that cause choke points

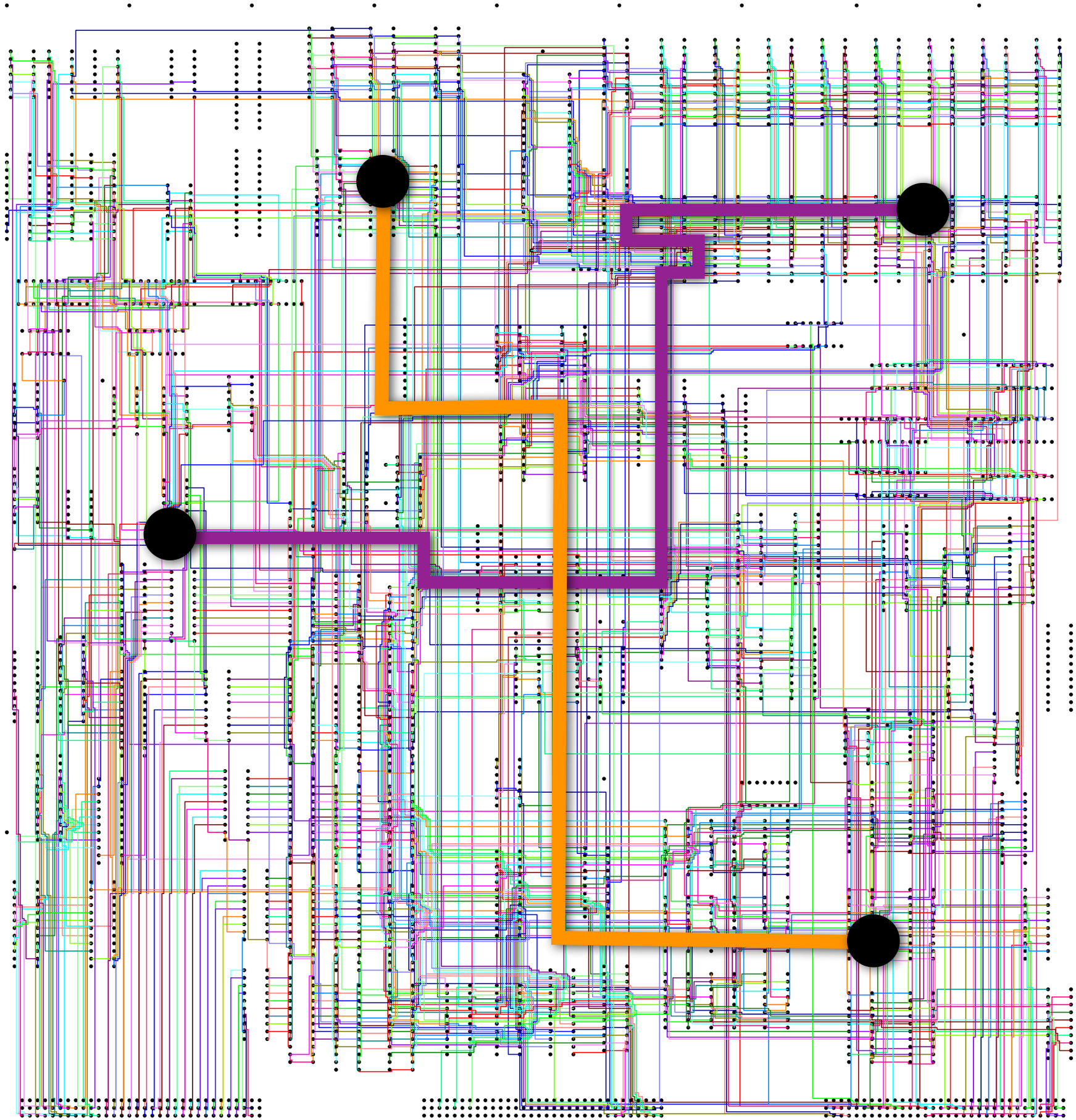
Photo courtesy of Argonne National Laboratory.

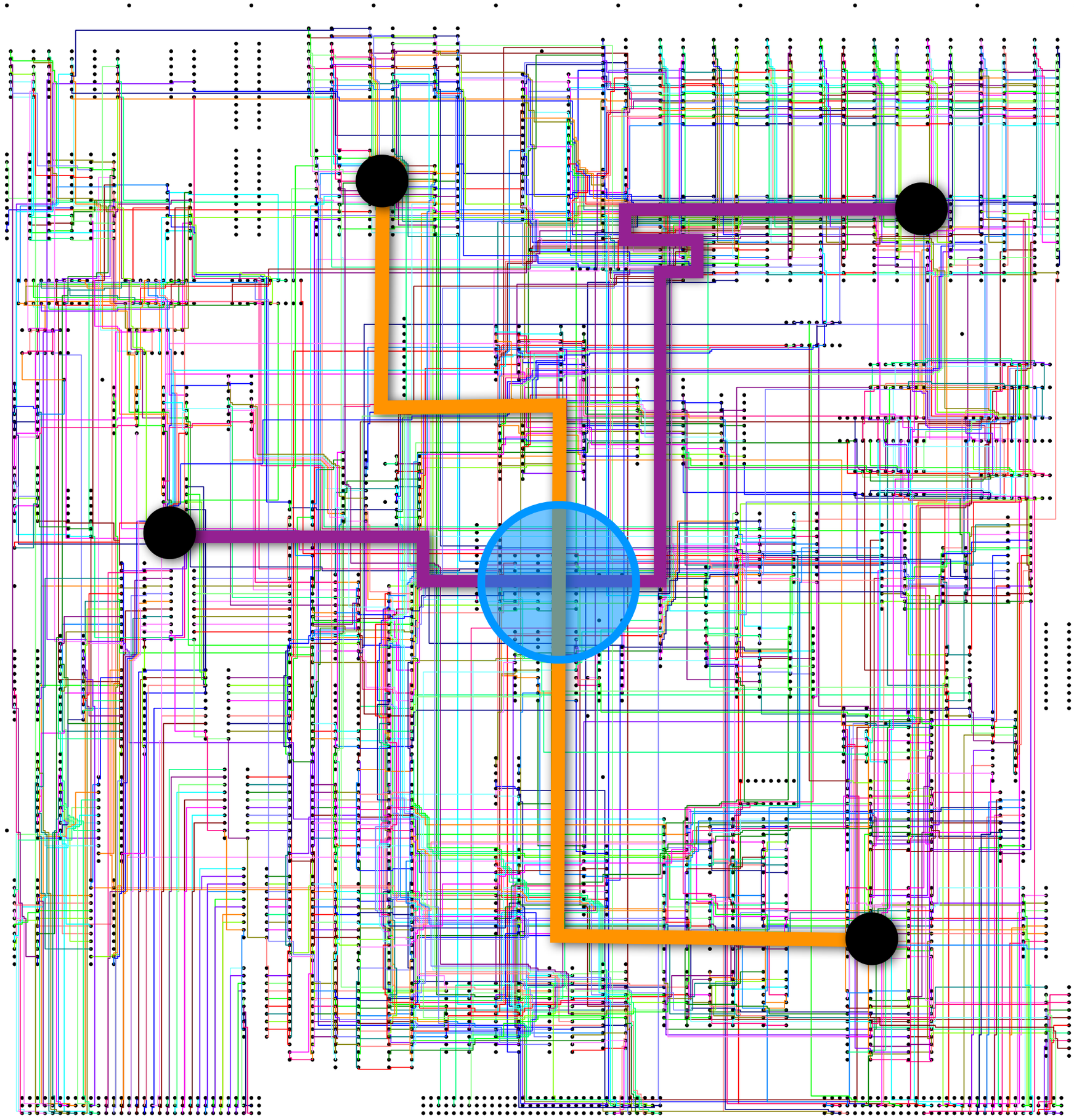
Let's look at a tricky problem

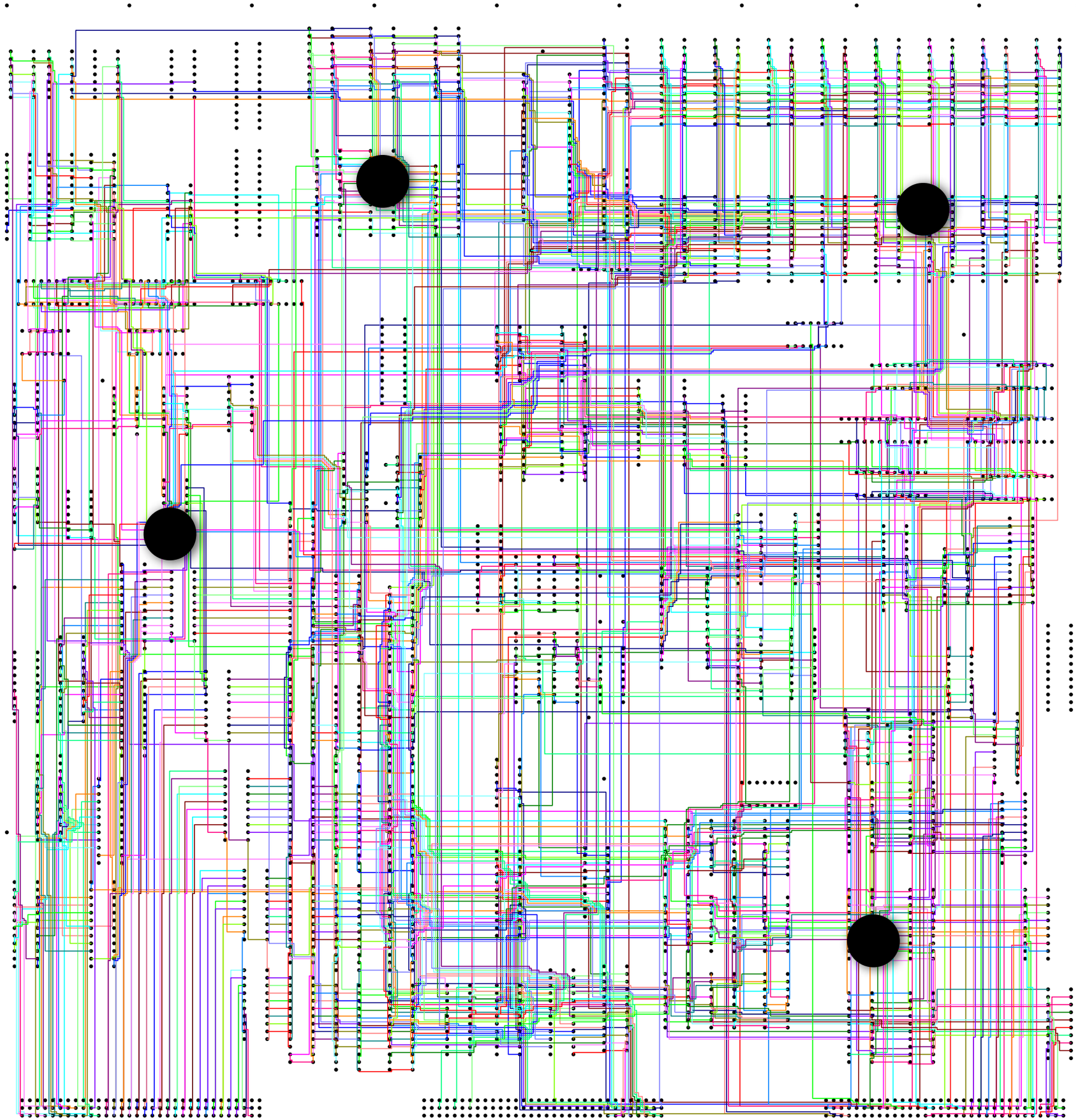


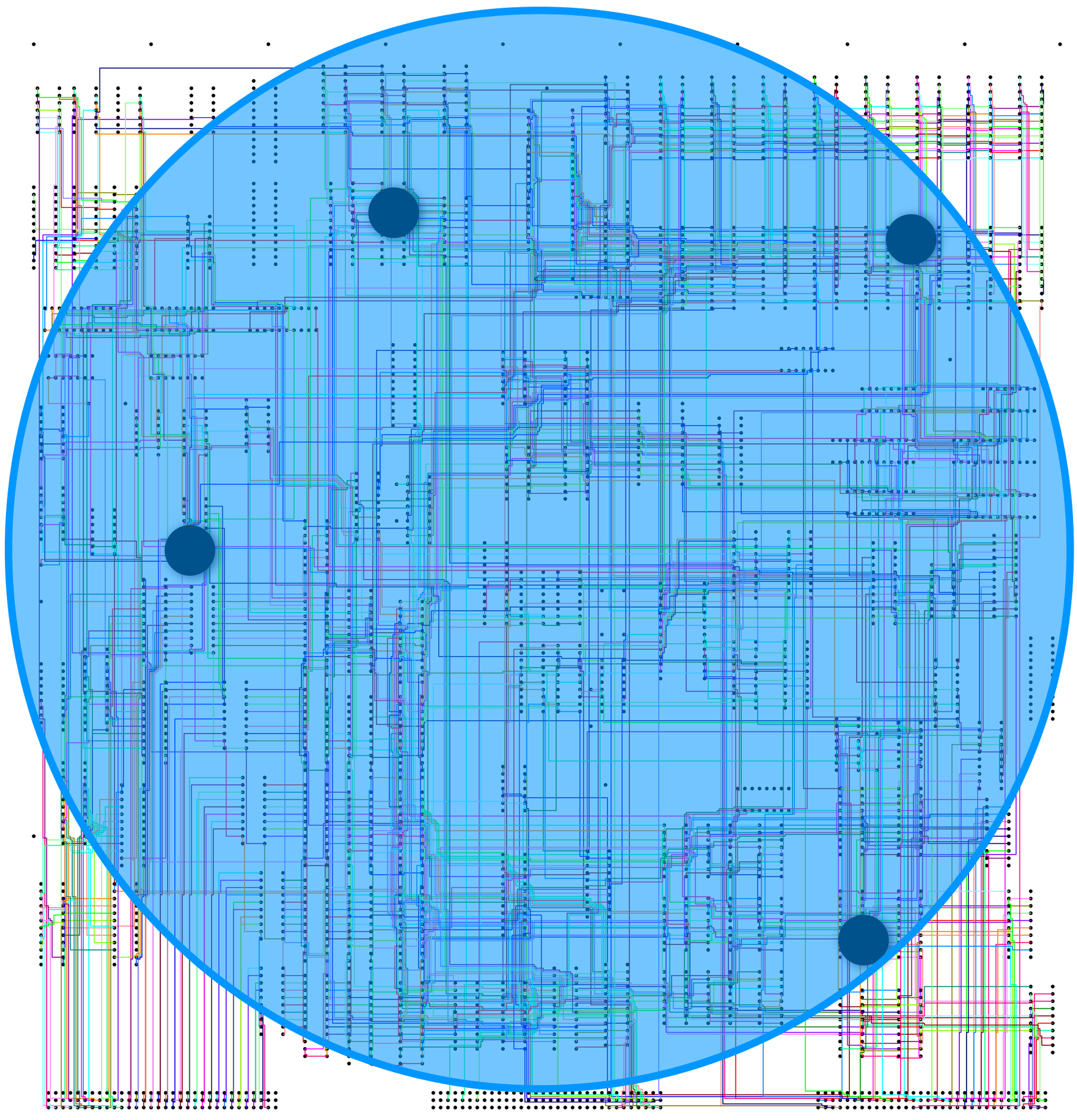




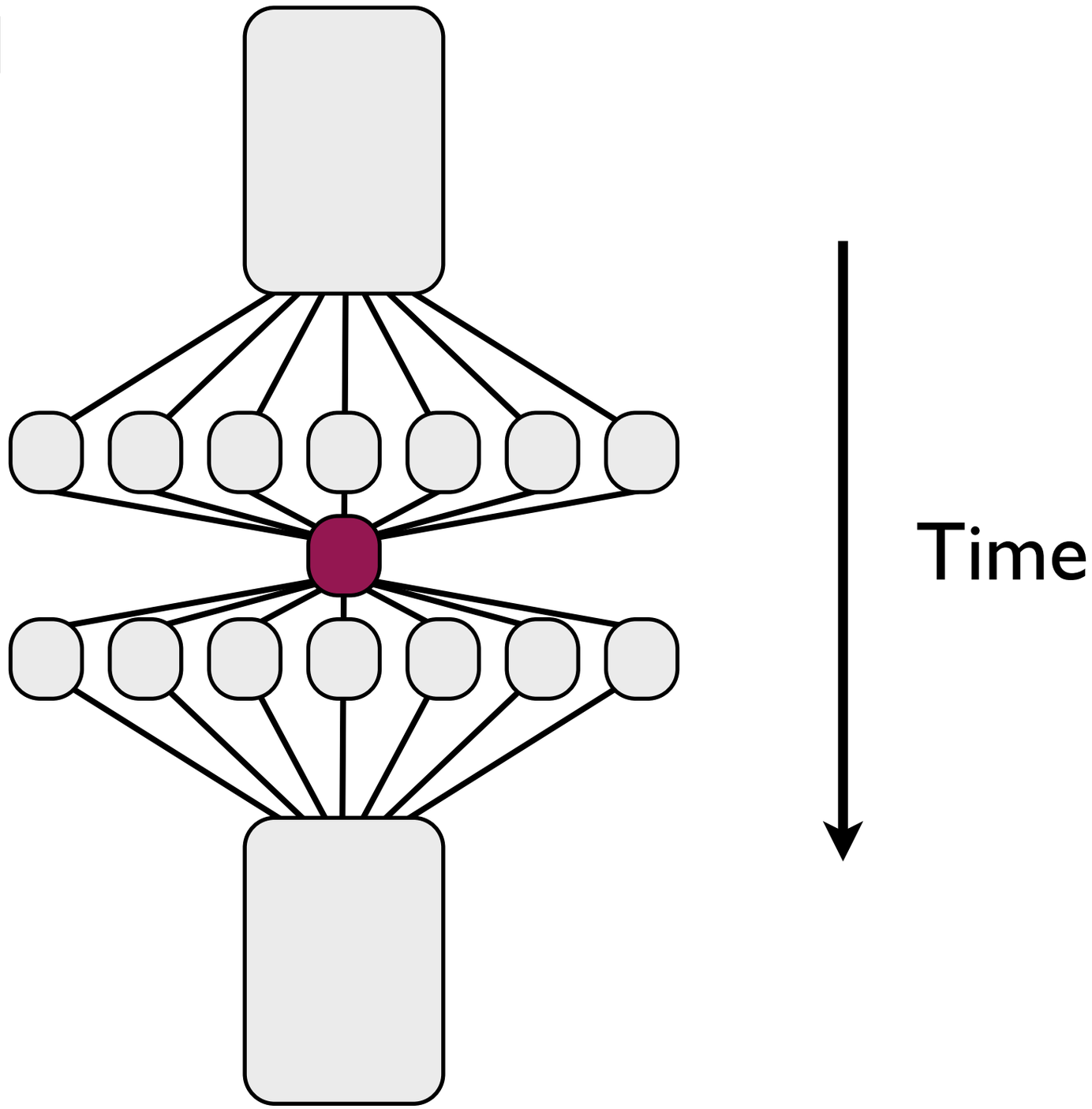








The entire board is one big shared object



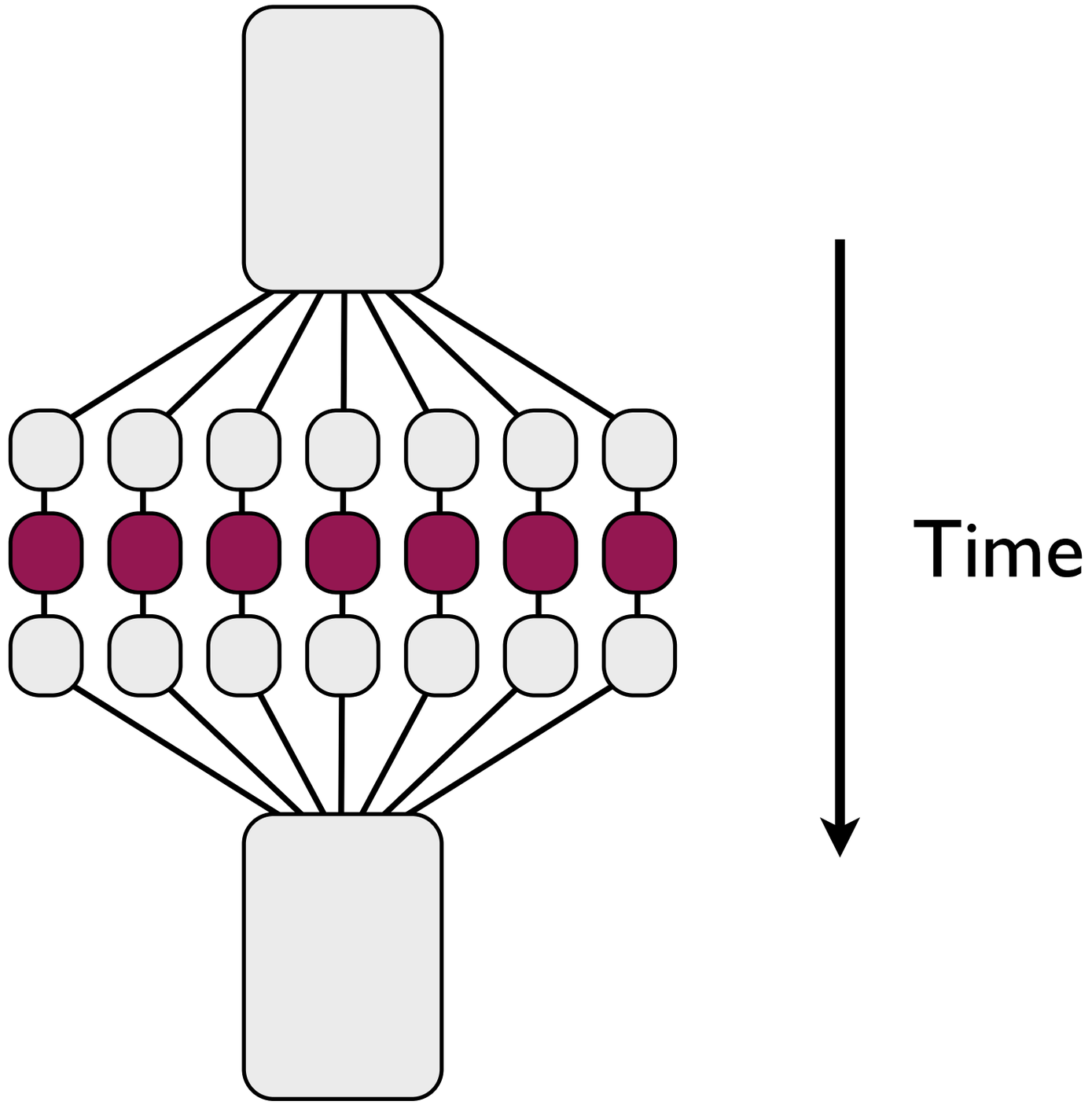
Time

We're calling this an irregular problem - we can't divide up the shared resource before the tasks start

"It's easier to ask forgiveness than it is to get permission."

We'll assume that tasks will not get in each other's way

If they do, we'll sort it out when it happens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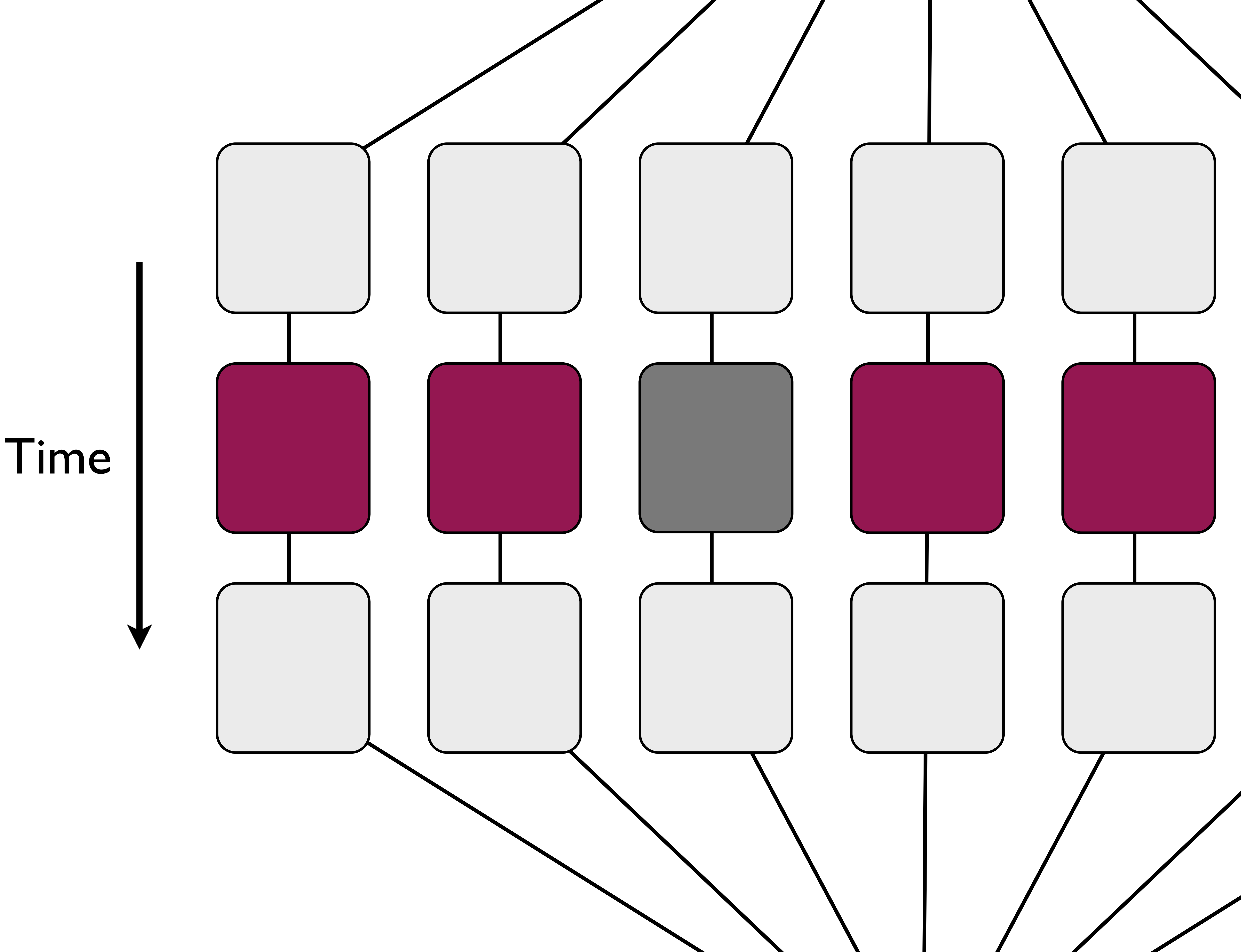

Time

A little more time

Two questions:

How can you tell when one task gets in the way of another?

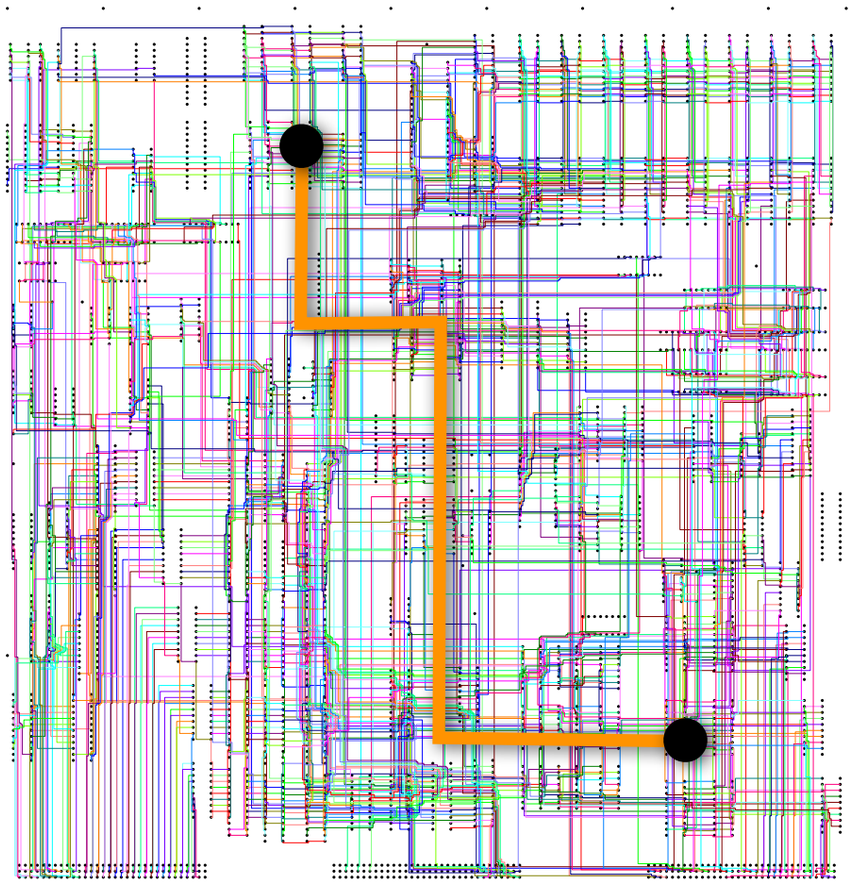
How can you cancel a task that has already been running?

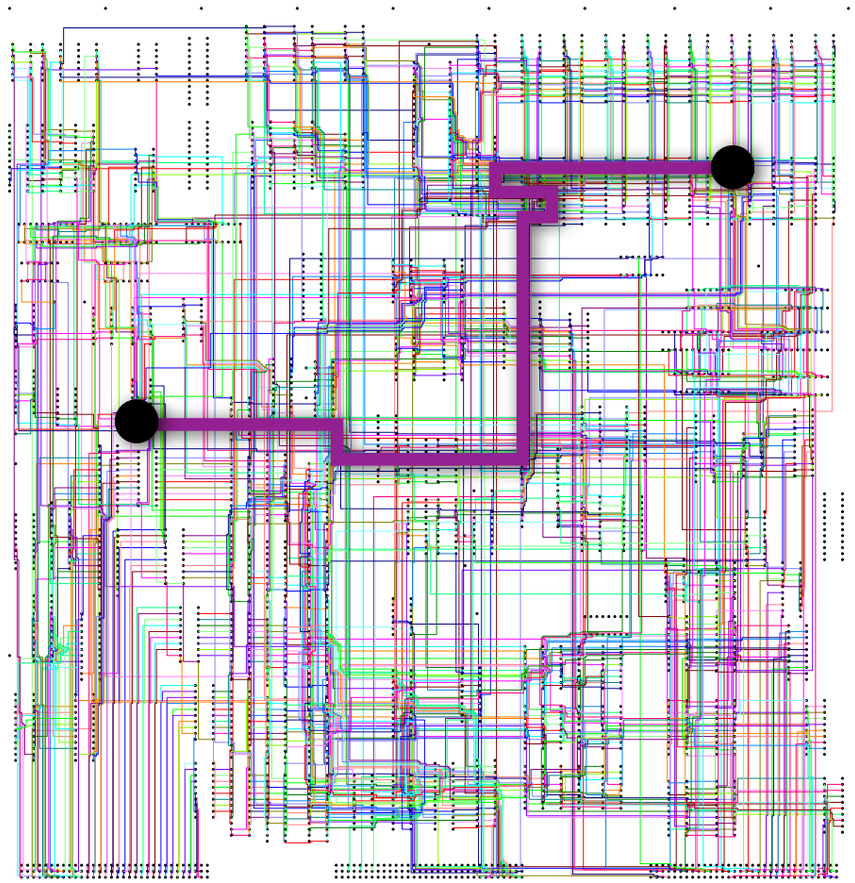
Transactional memory

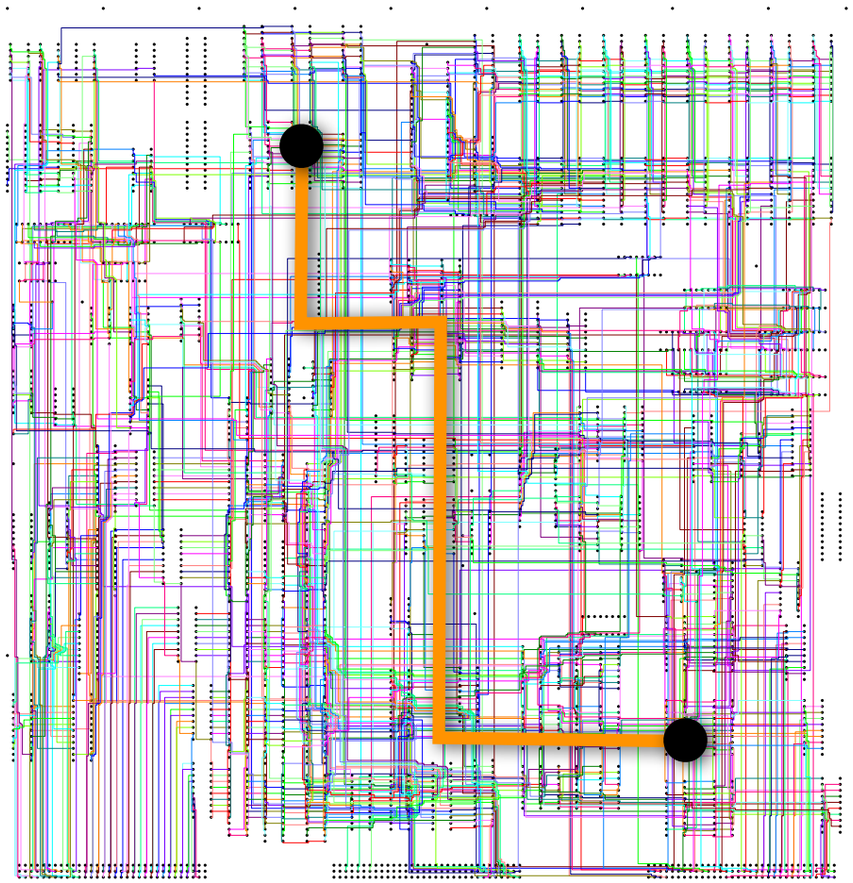
Instead of writing to memory, write to a log

You can tell if two tasks are getting in each other's way by comparing their logs

You can cancel a task by throwing the log away







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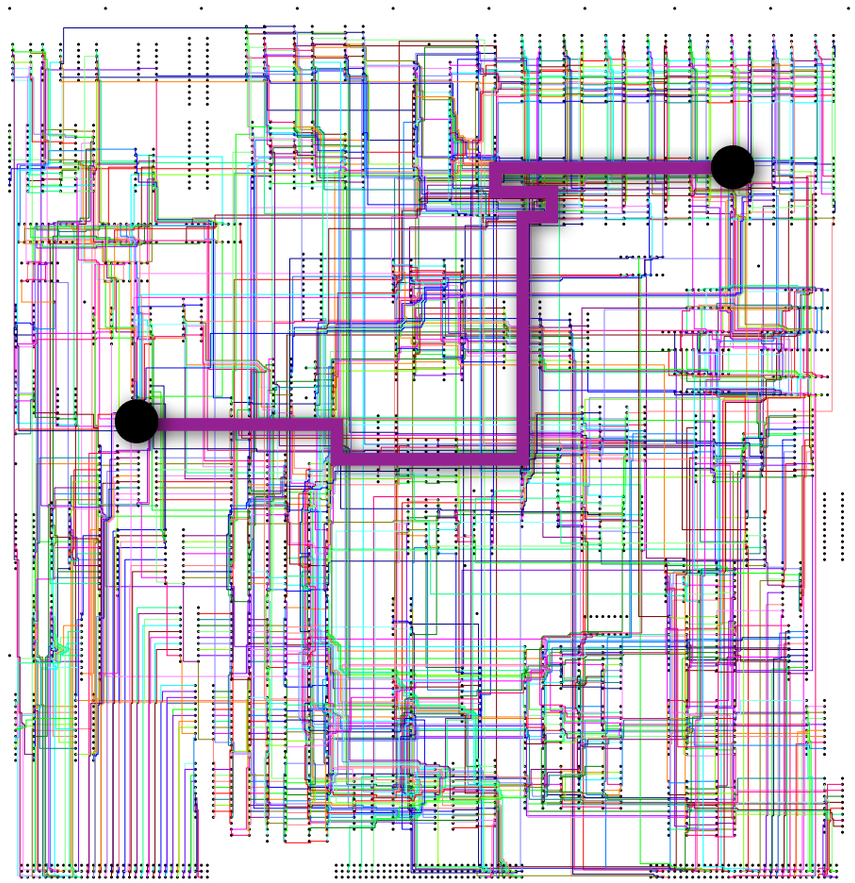

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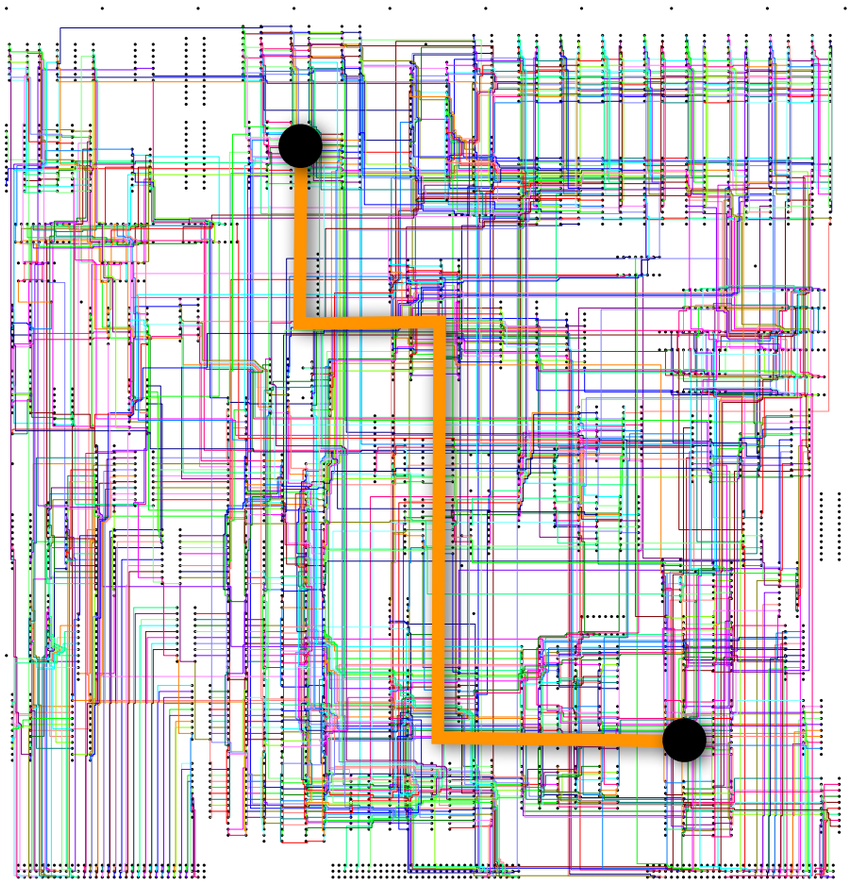

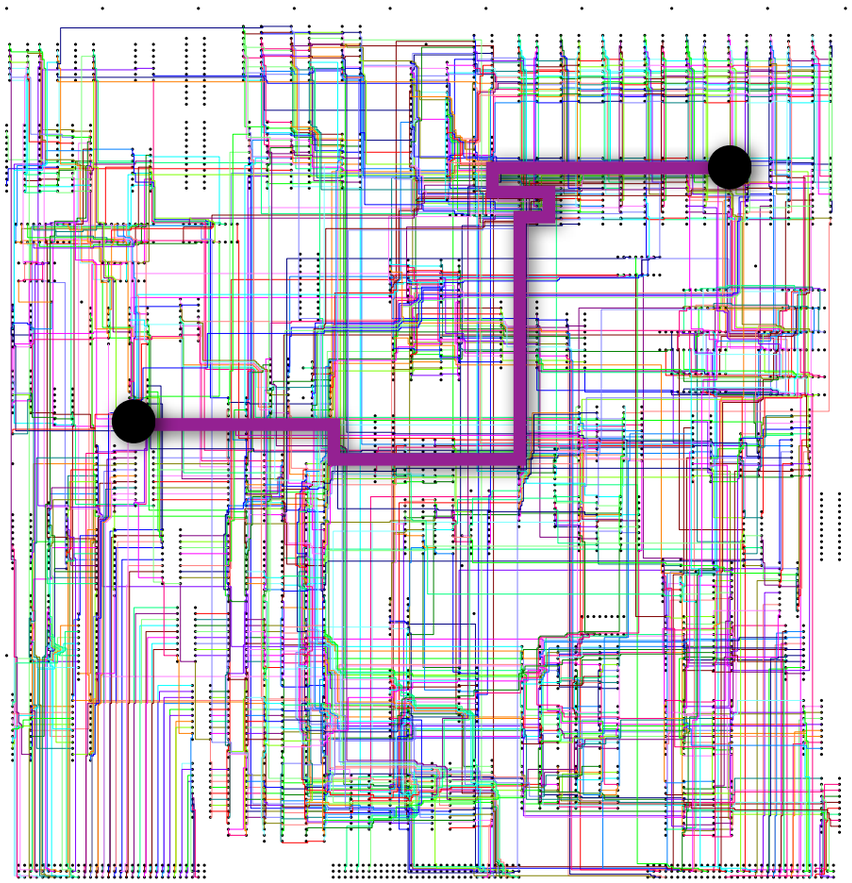

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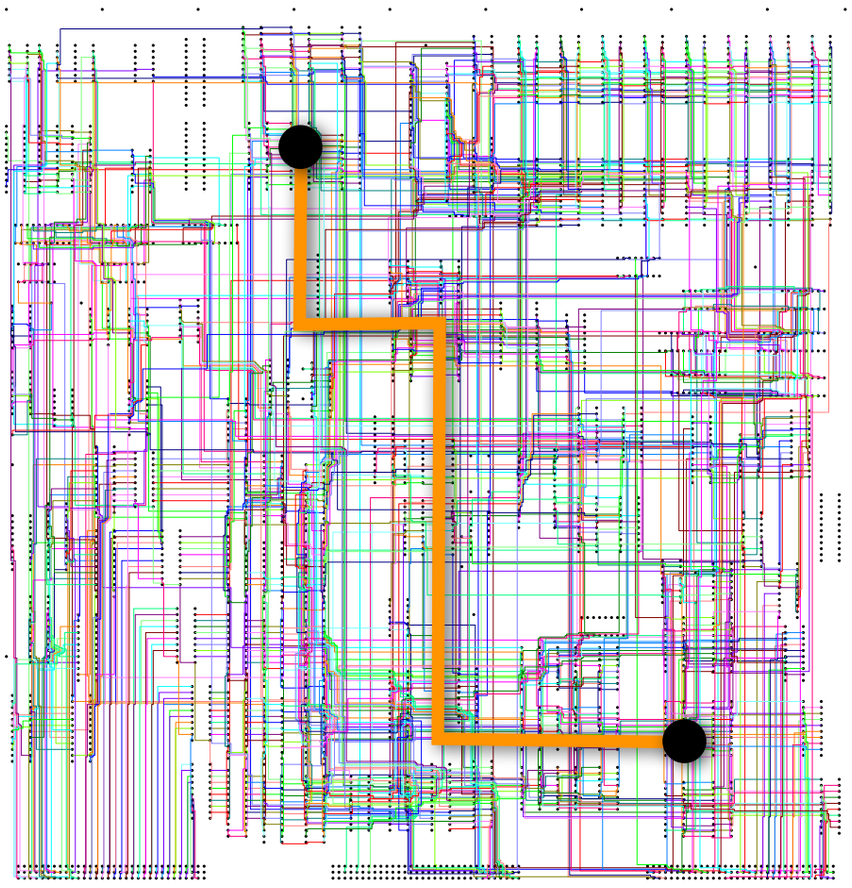

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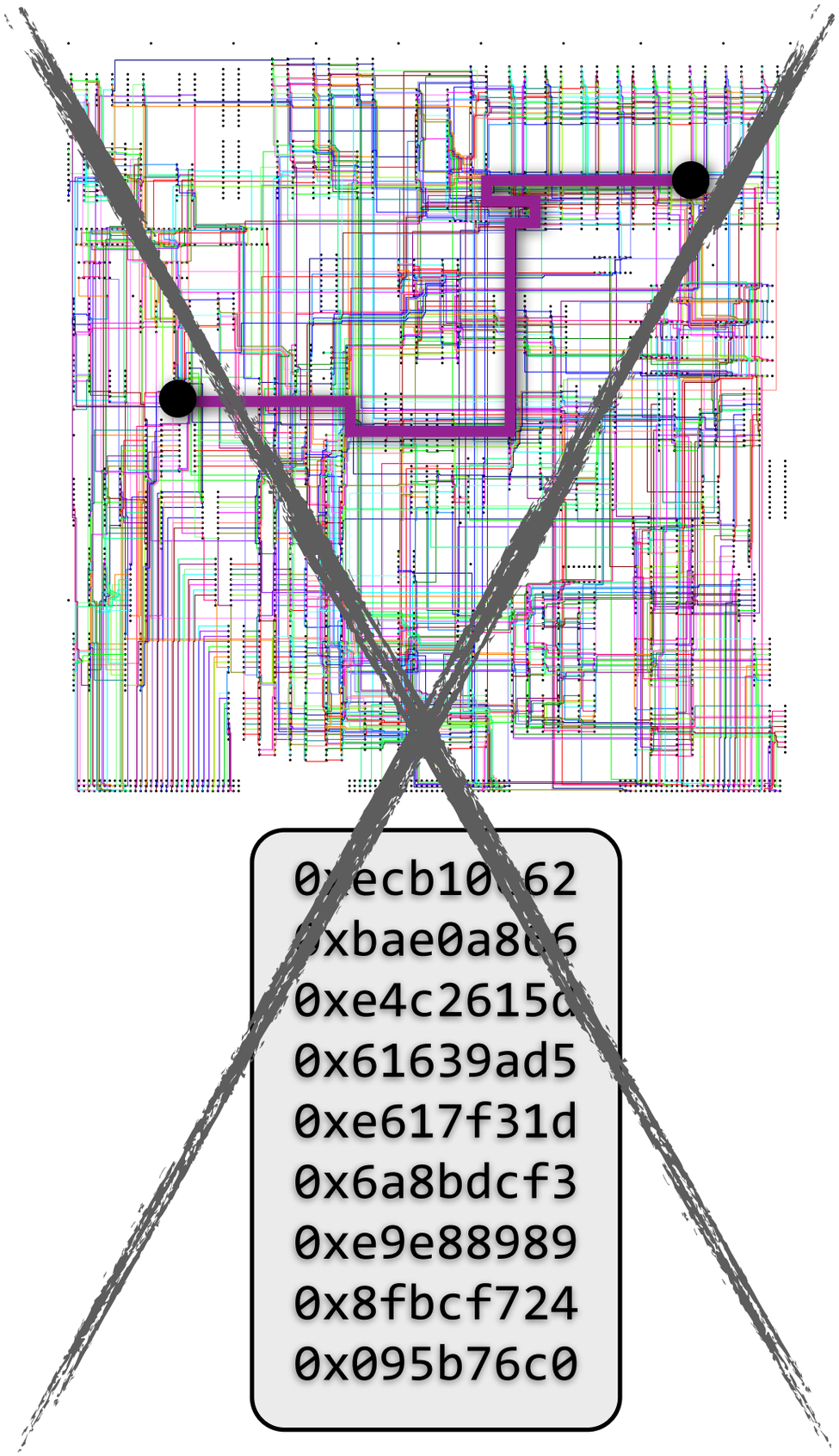

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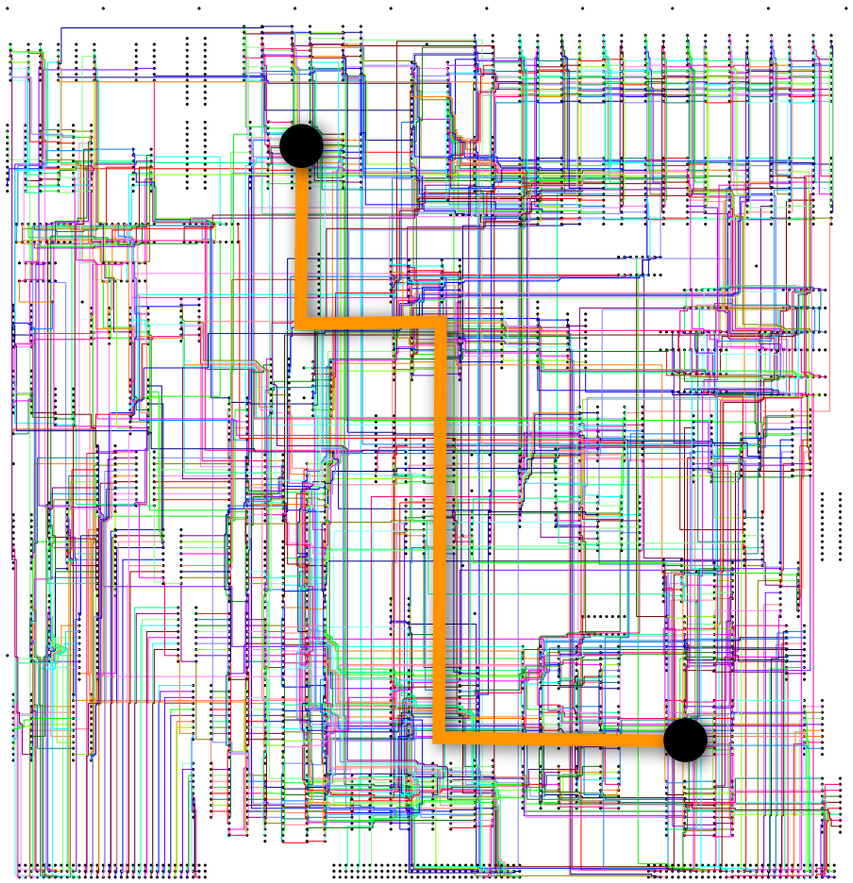
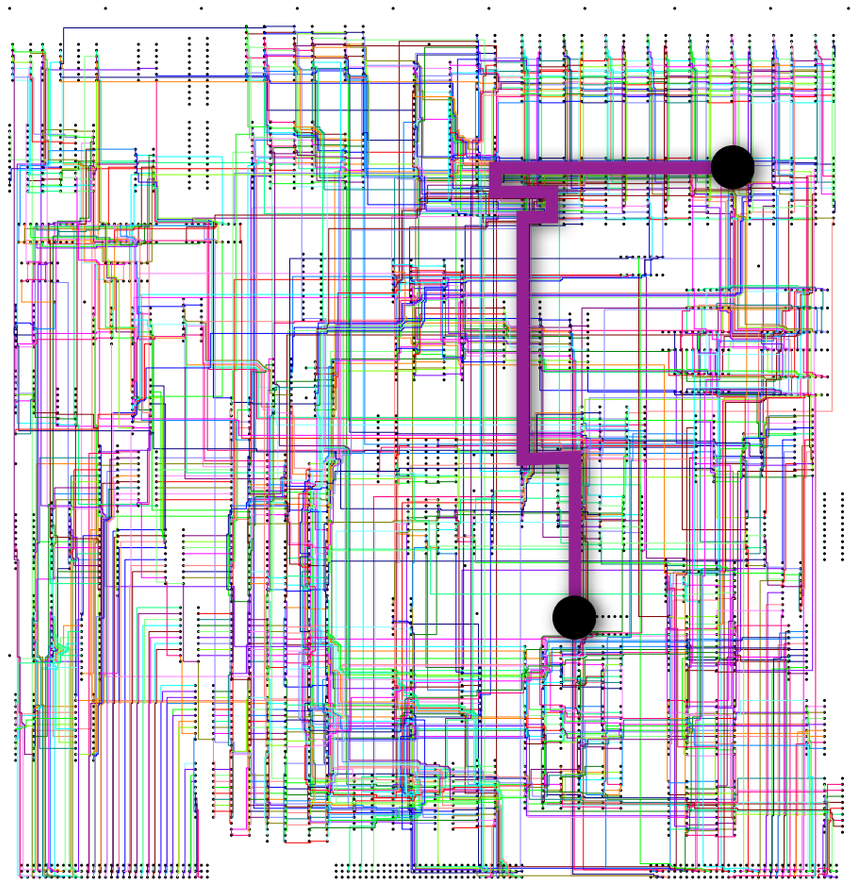
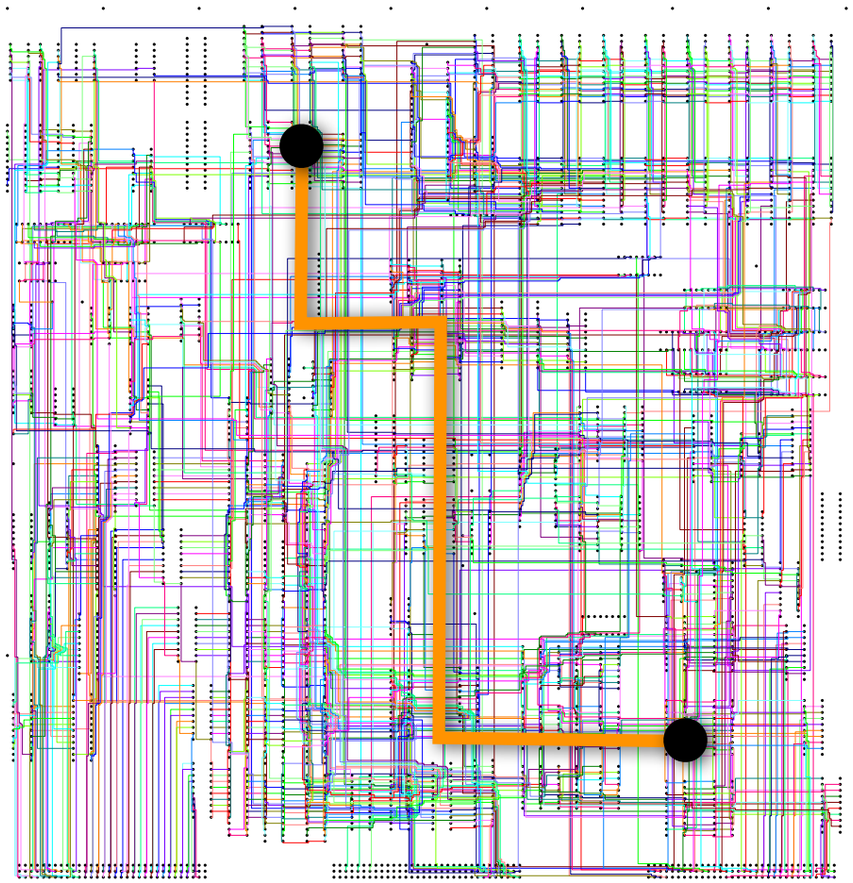
Actually write to memory







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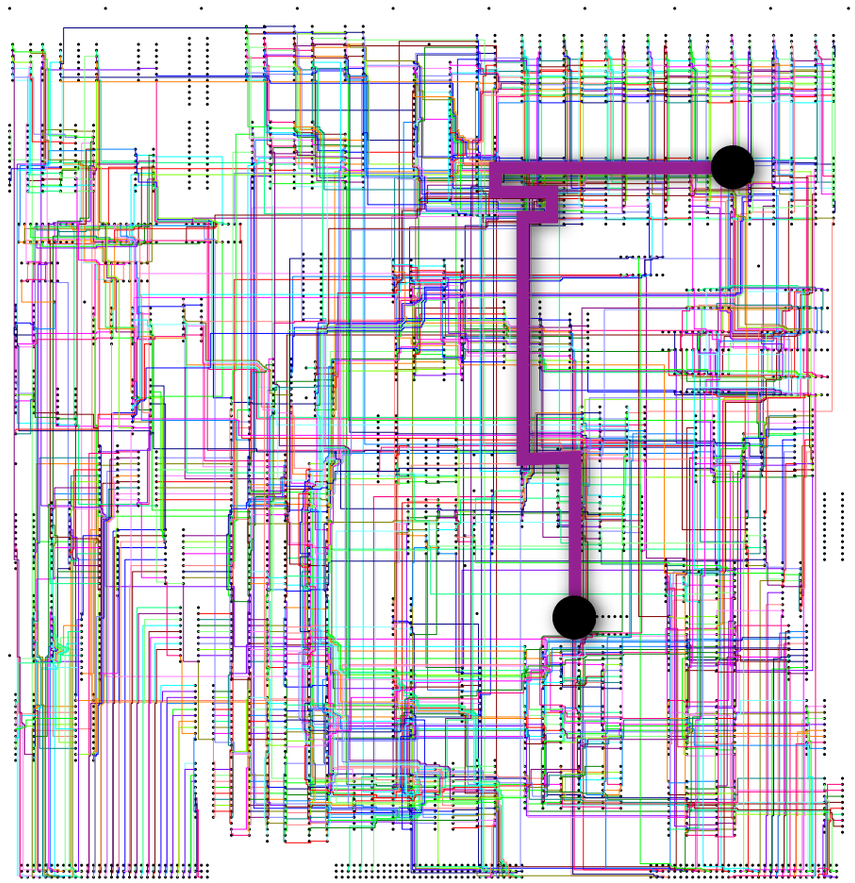

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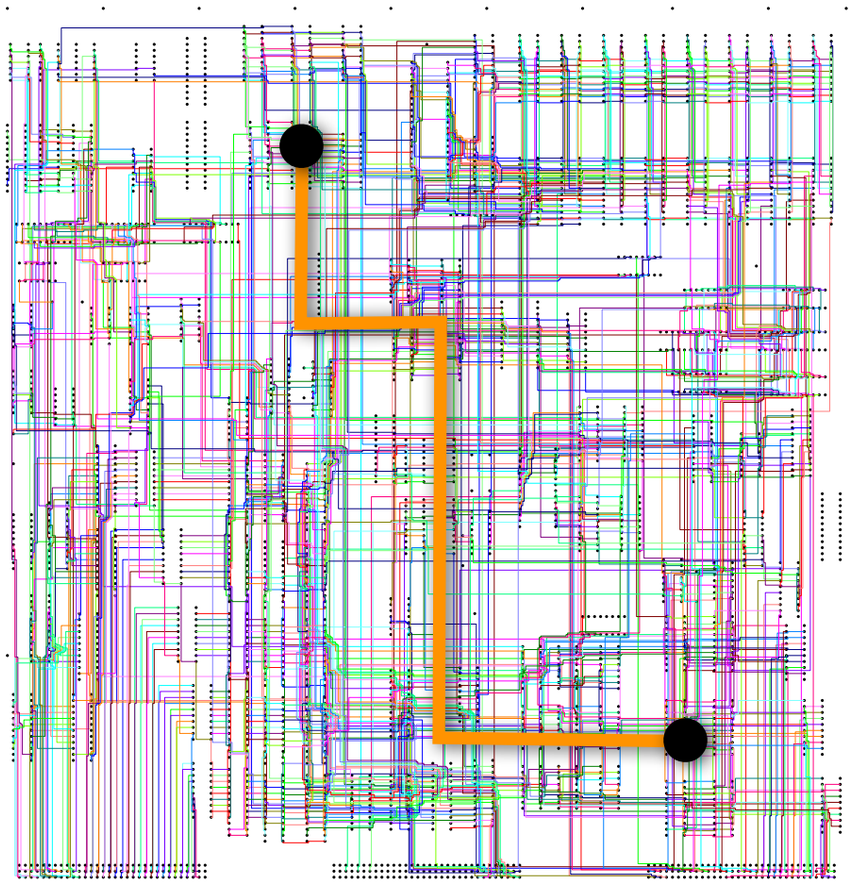

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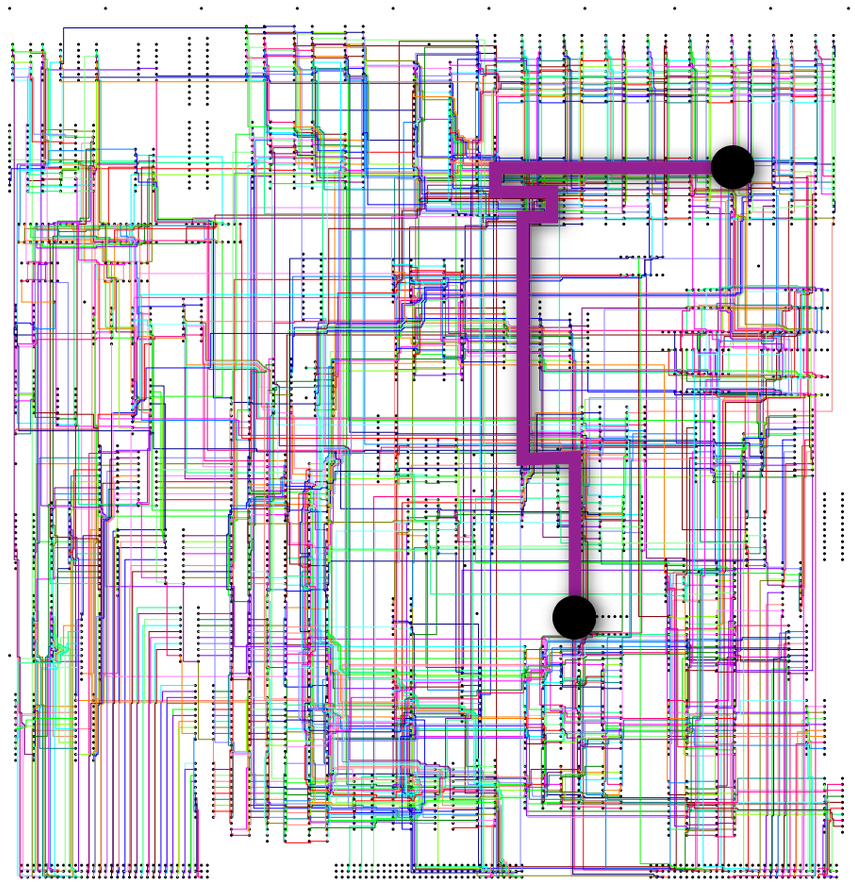
Actually write to memory



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Actually write to memory

Transactional memory is moving from research to production

C, C++, Java, Scala, Clojure, Haskell

There are other techniques for reversing computation

If you know you added x to a value, subtract x. If you know you added a node to a graph, remove it.

The Jefferson Time Warp System from the mid-80s - send anti-messages over networks.

Do we have a solution?

Transactional memory can be slow

The hardware is probably limited

Not the magic bullet some hoped

Optimistic execution in general can be wasteful

Irregular problems are the billion dollar problems

facebook

Google™

[1]

Physical meshes
Web and social graphs
Machine learning networks
Data mining

[1] J. Tournois, C. Wormser, P. Alliez, and M. Desbrun. *Interleaving Delaunay refinement and optimization for practical isotropic tetrahedron mesh generation*. Technical Report 6826, INRIA, 2009.

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