Informing coarse-graining through concurrency

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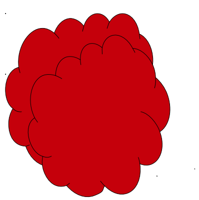

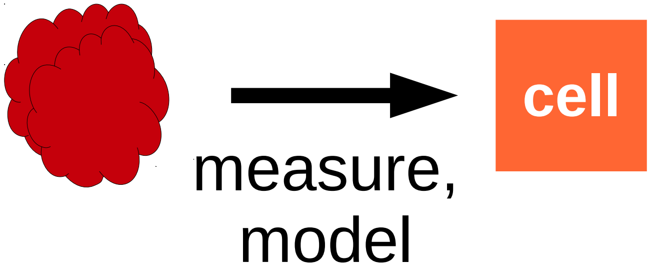
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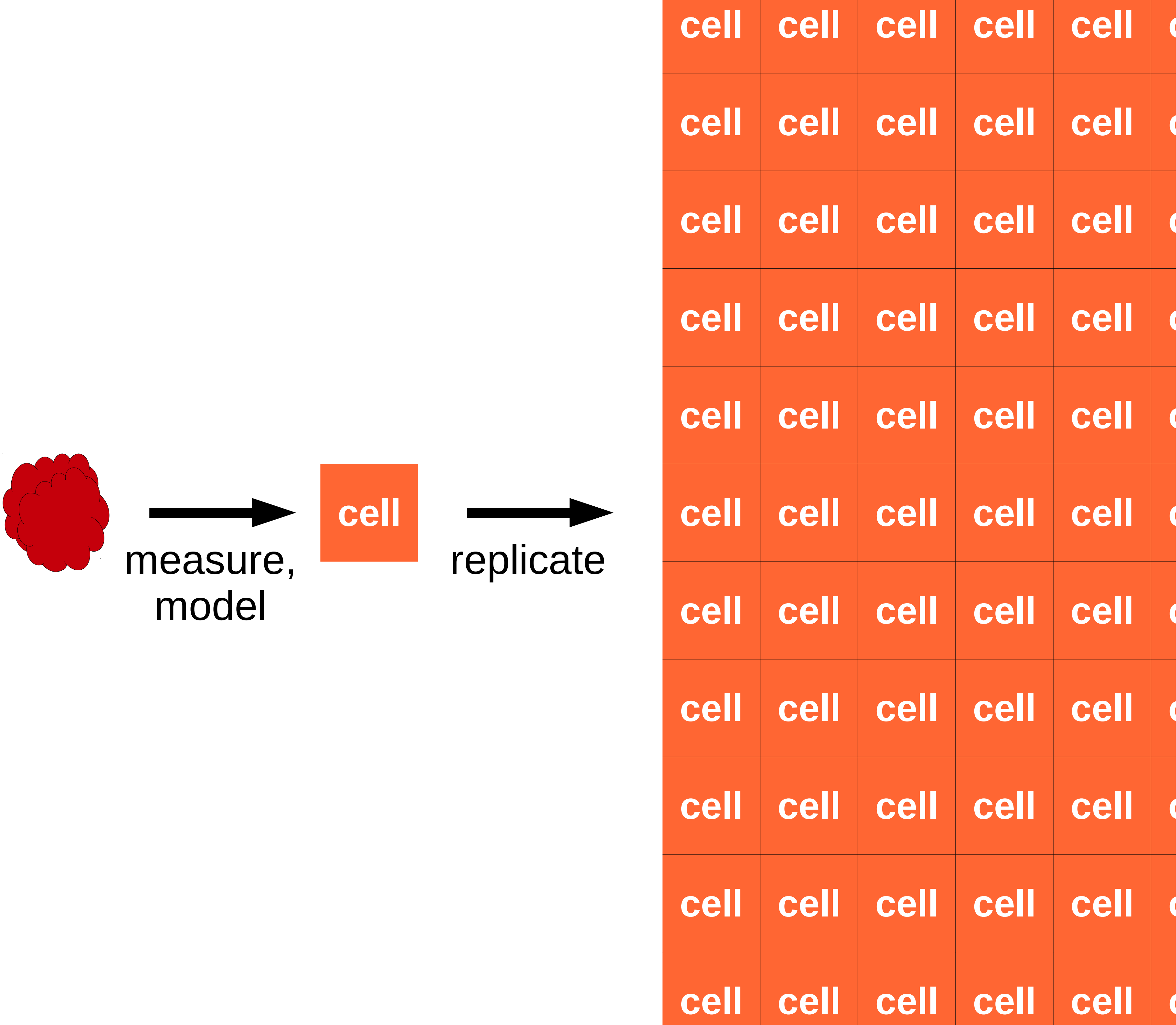
measure,
model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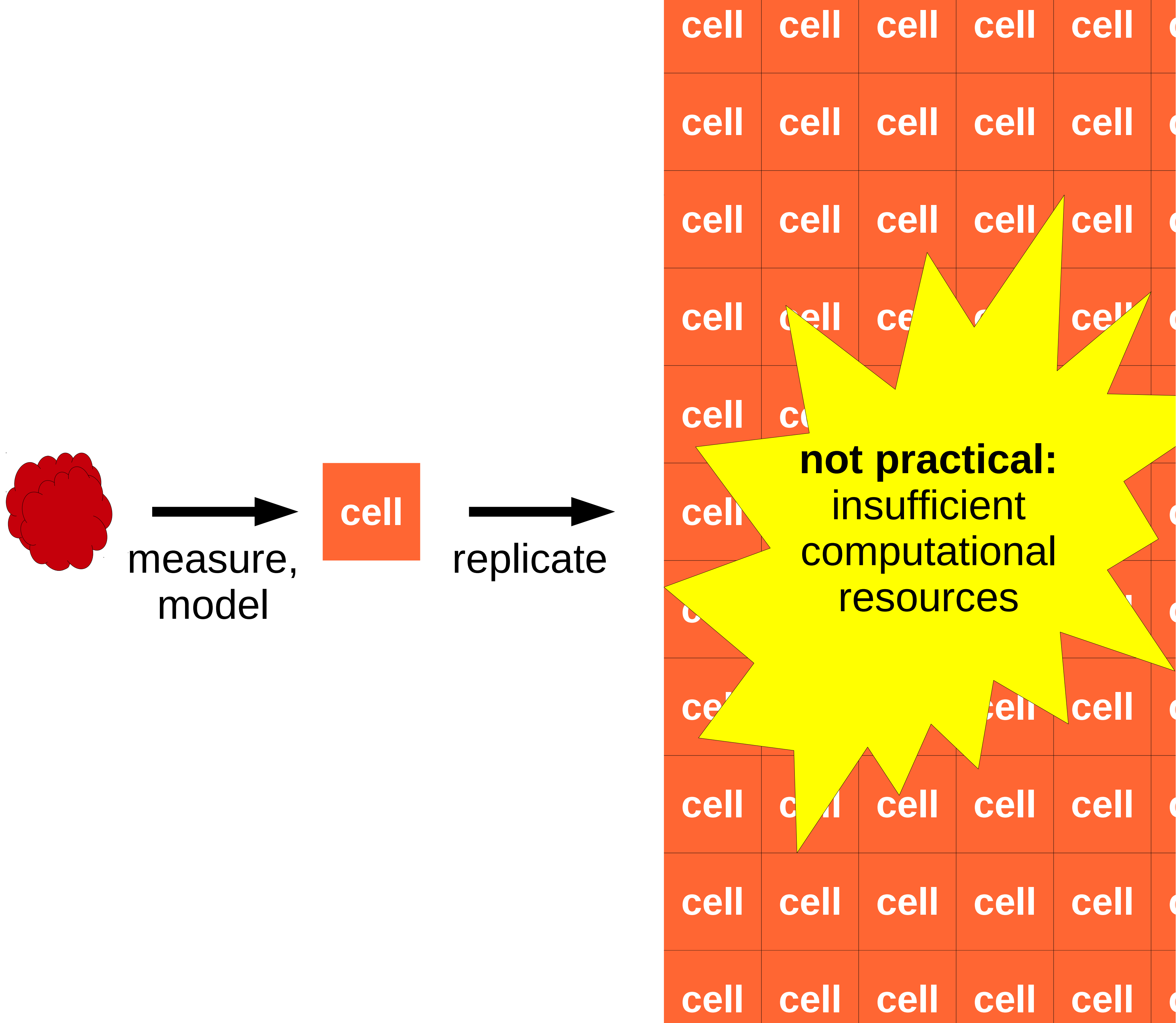
measure,
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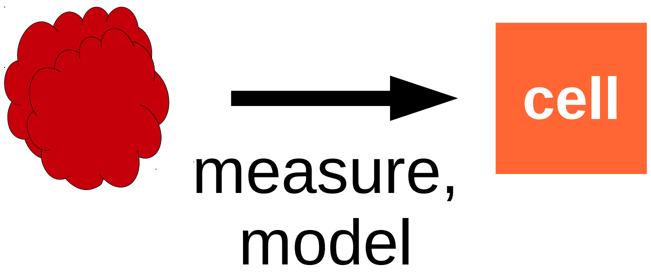
not practical:
insufficient
computational
resources


measure,
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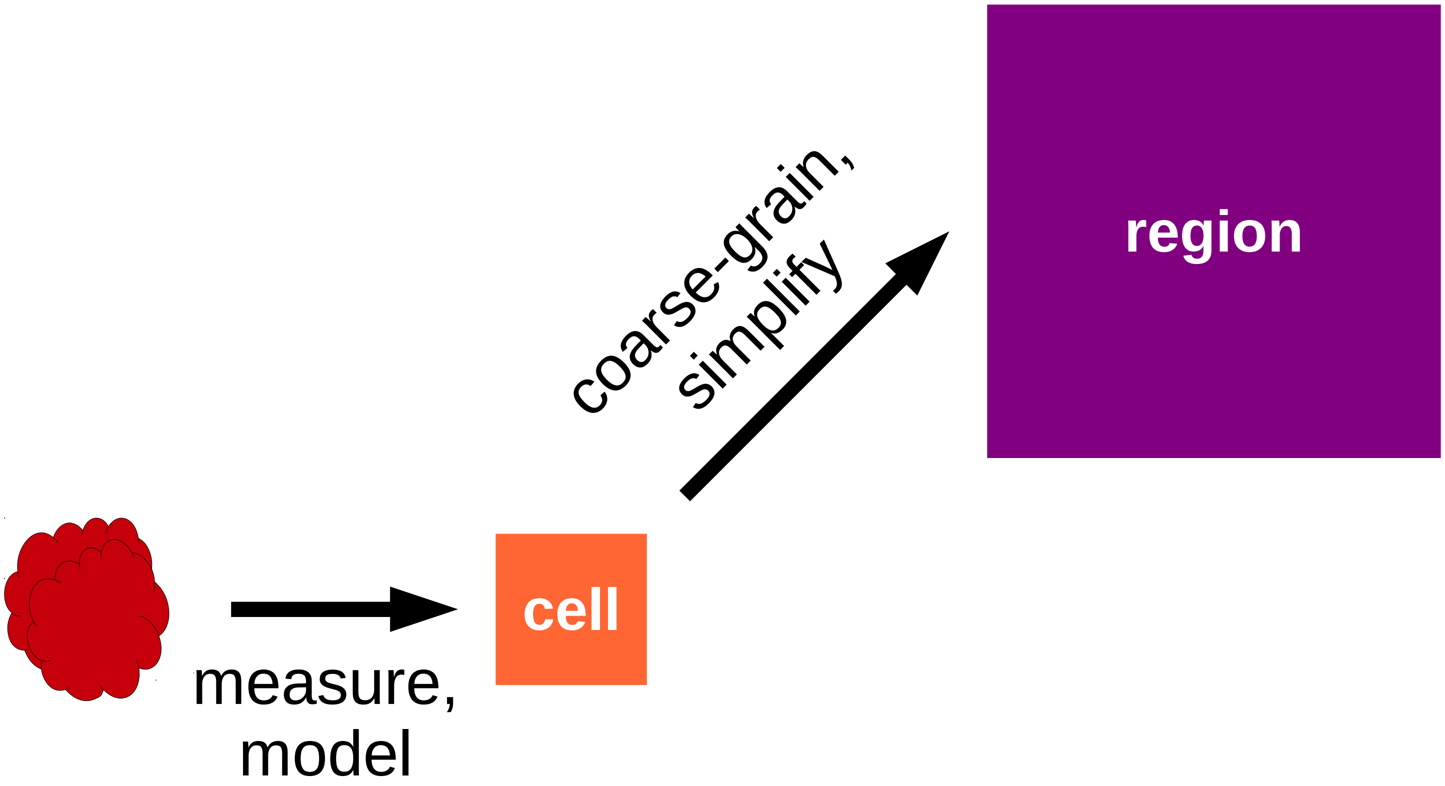
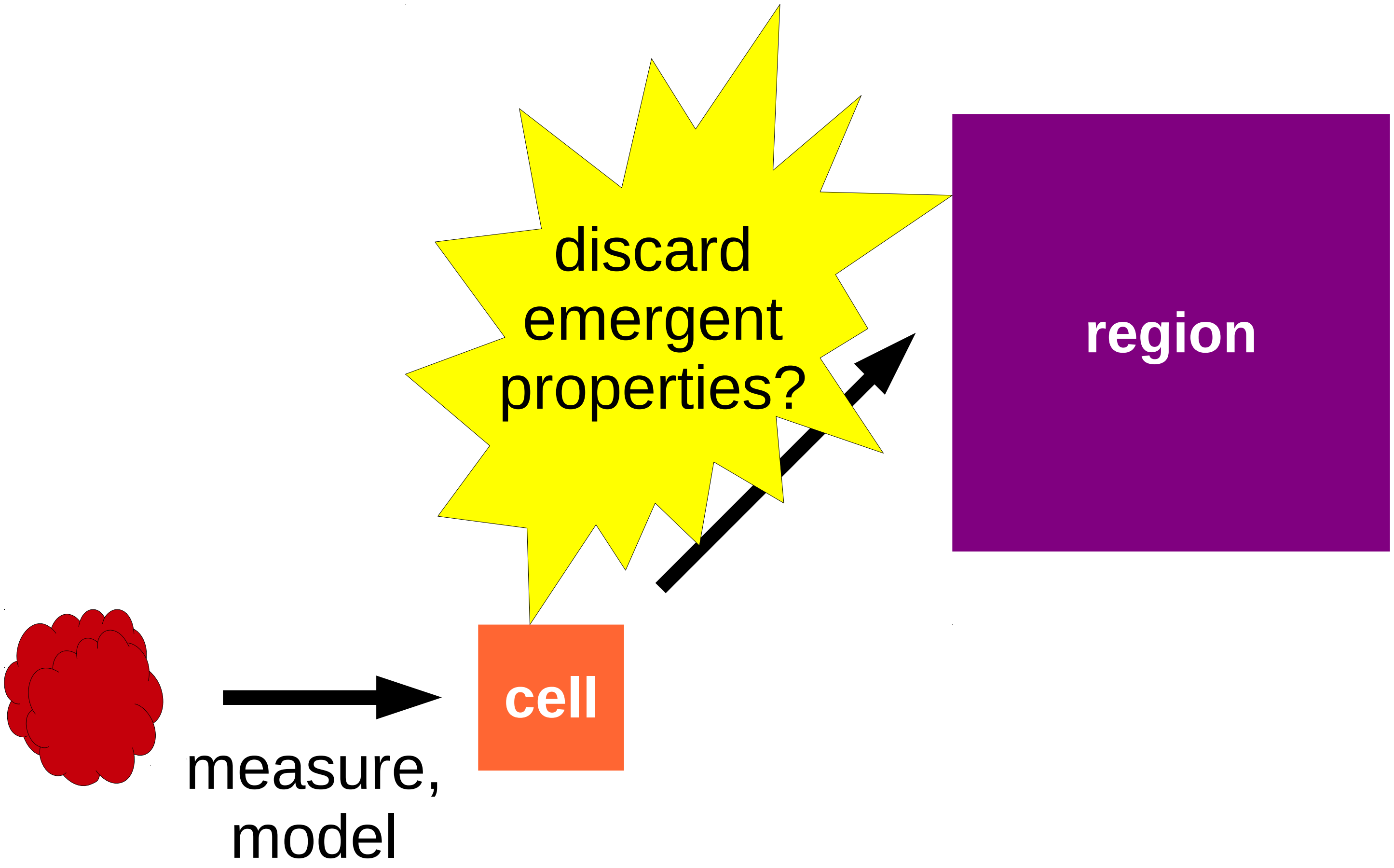
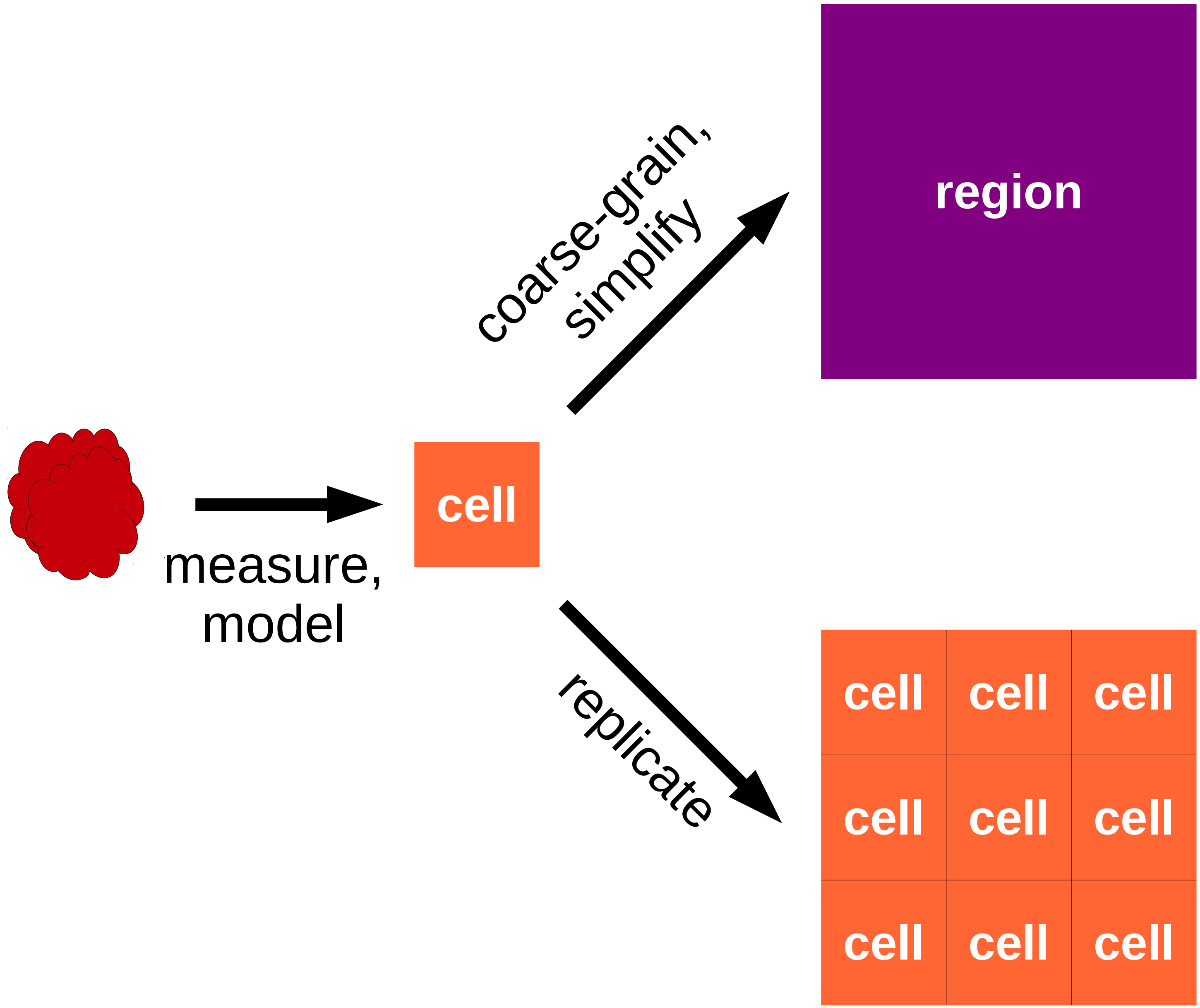

measure,
model
cell
coarse-grain,
simplify
region


discard emergent properties?
region
cell
measure, model



coarse-grain,
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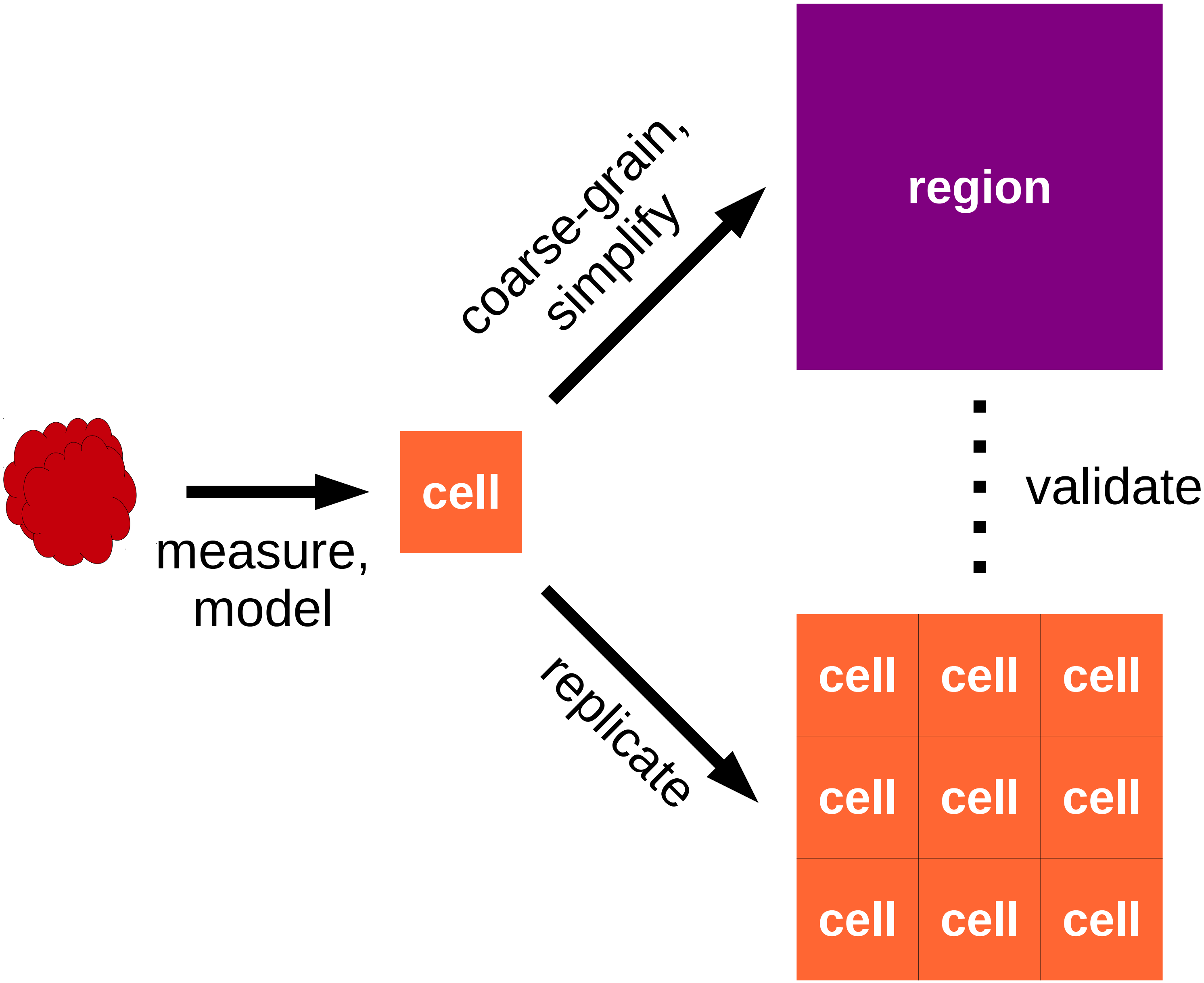
measure,
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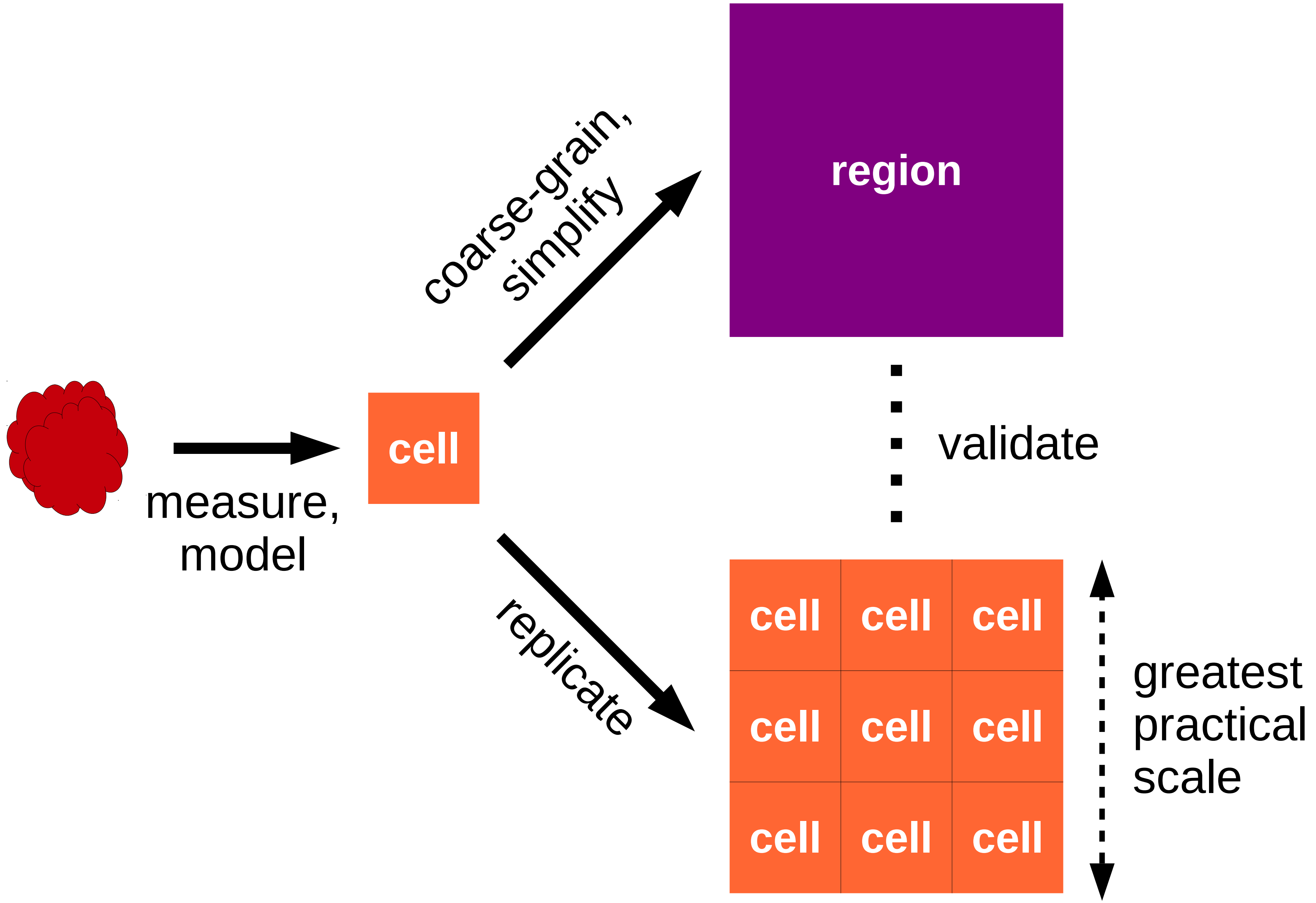

measure,
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coarse-grain,
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validate
replicate
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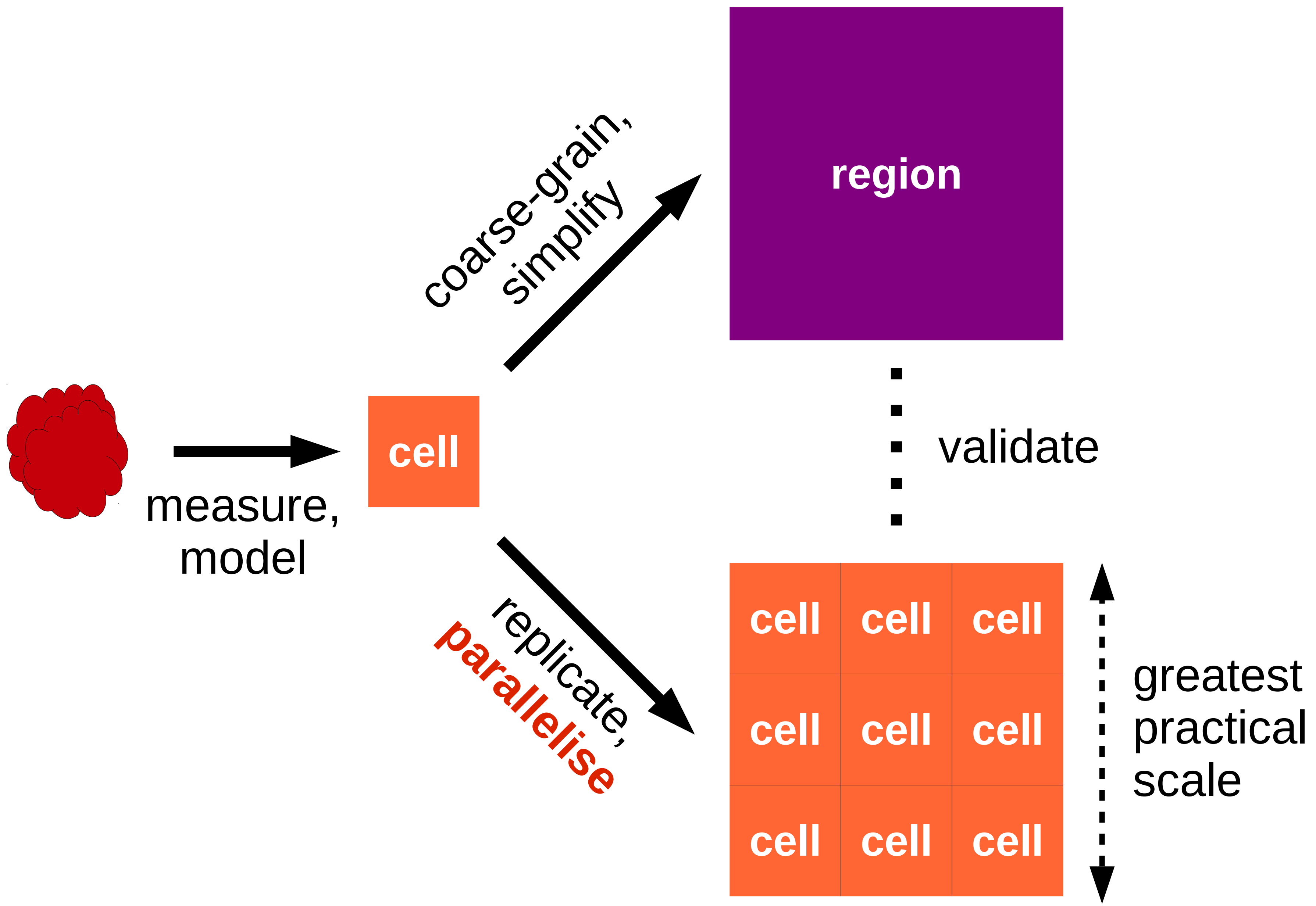
greatest
practical
scale



measure,
model
cell
coarse-grain,
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validate
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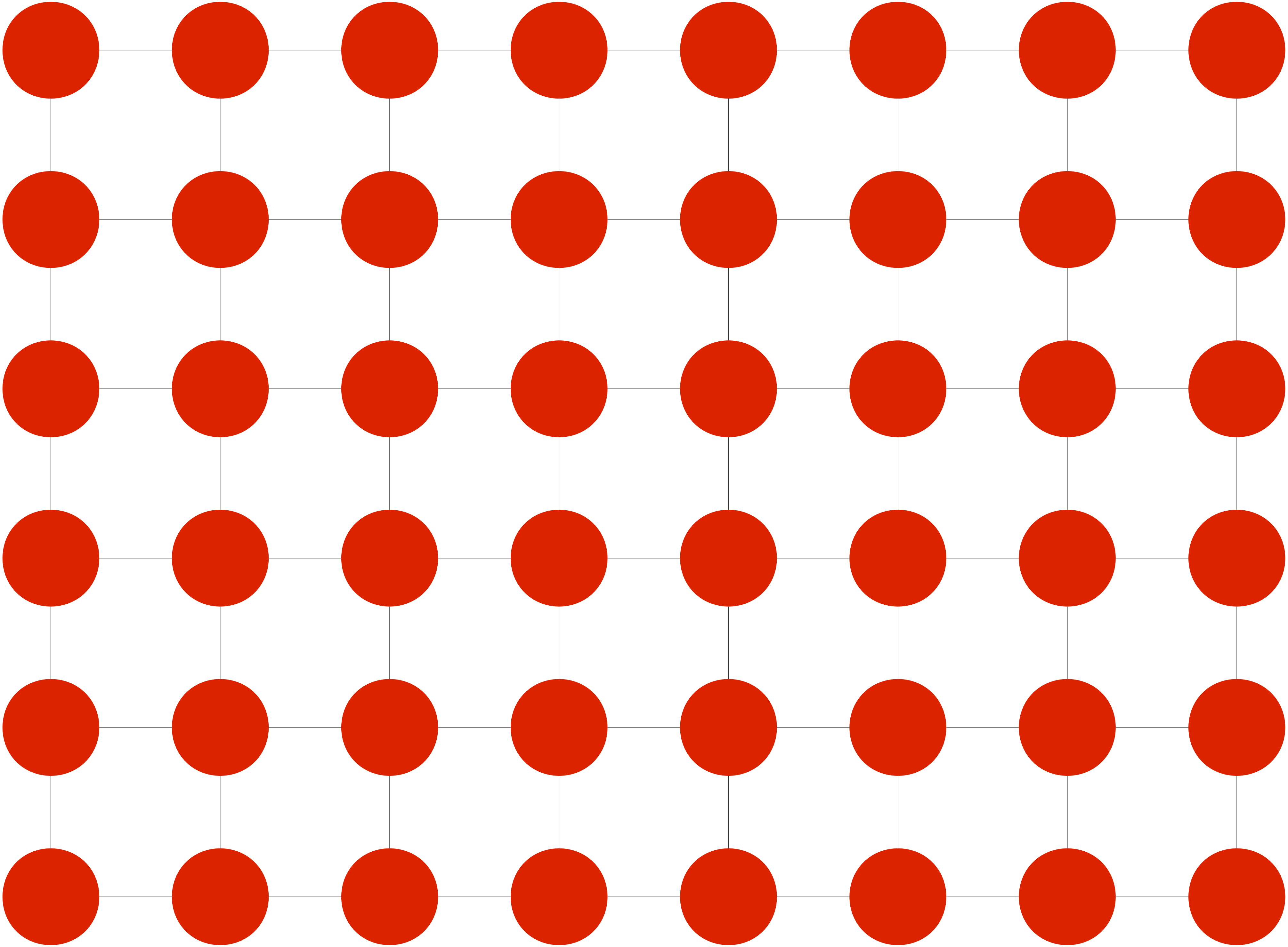
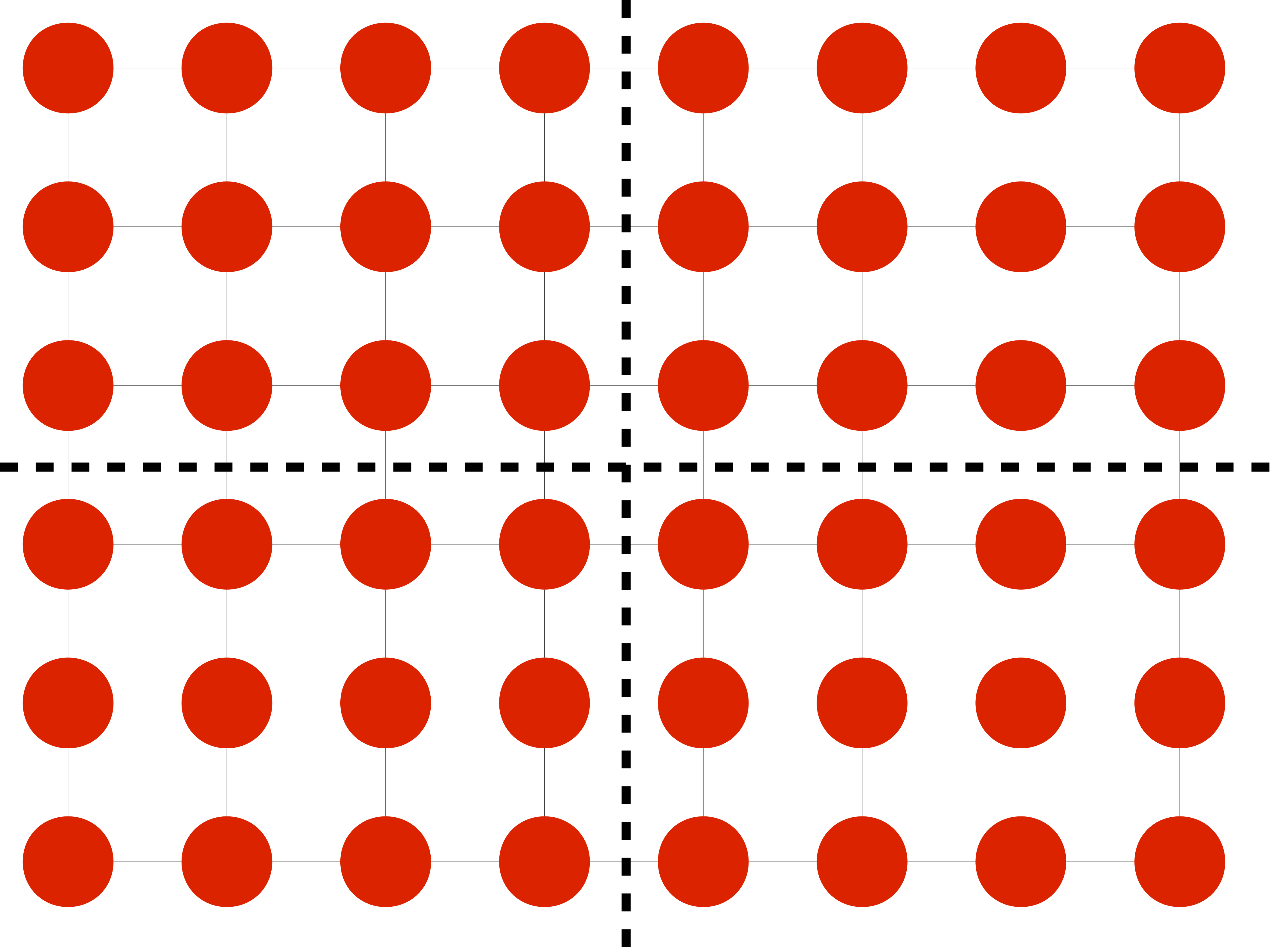
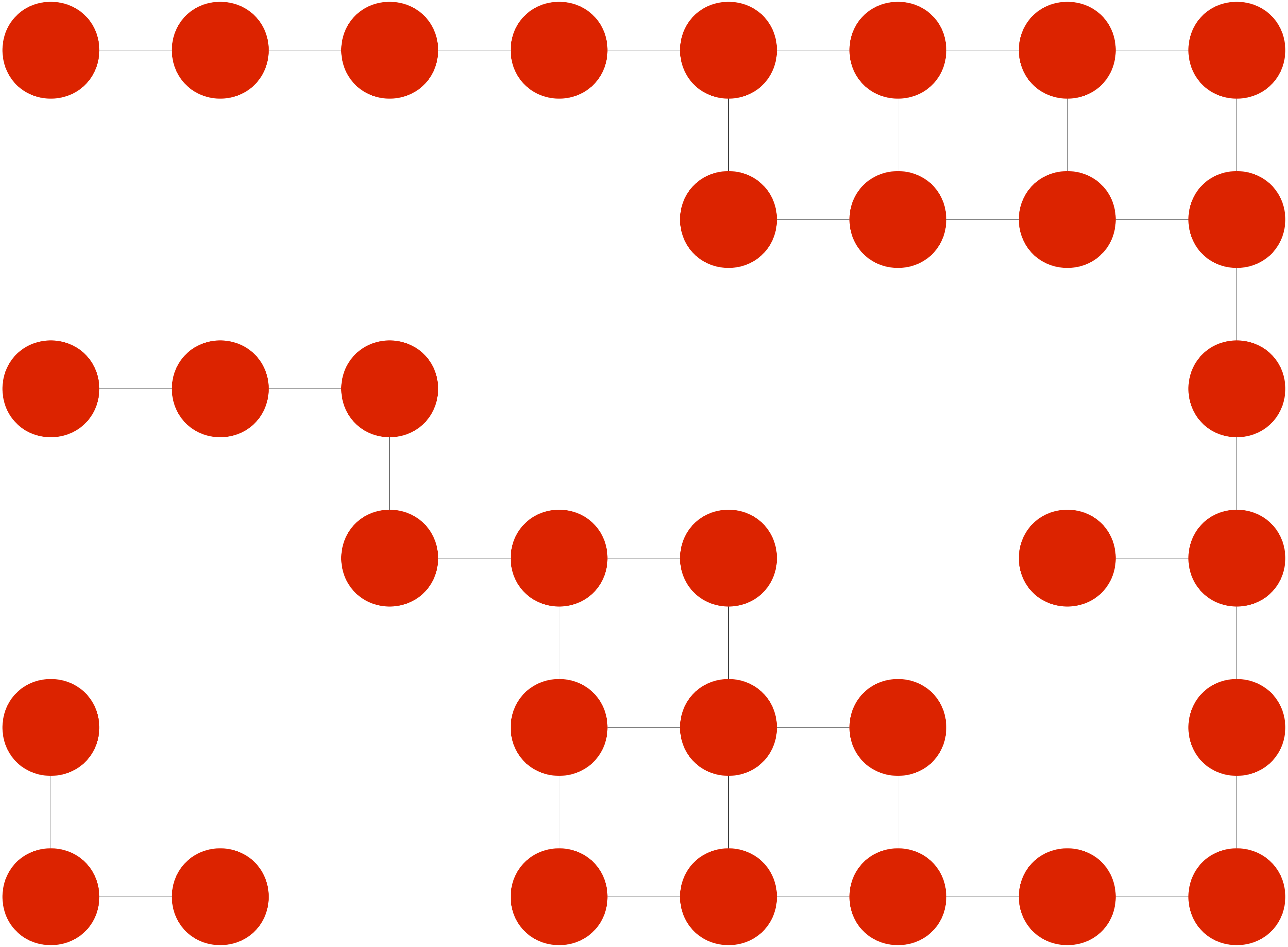
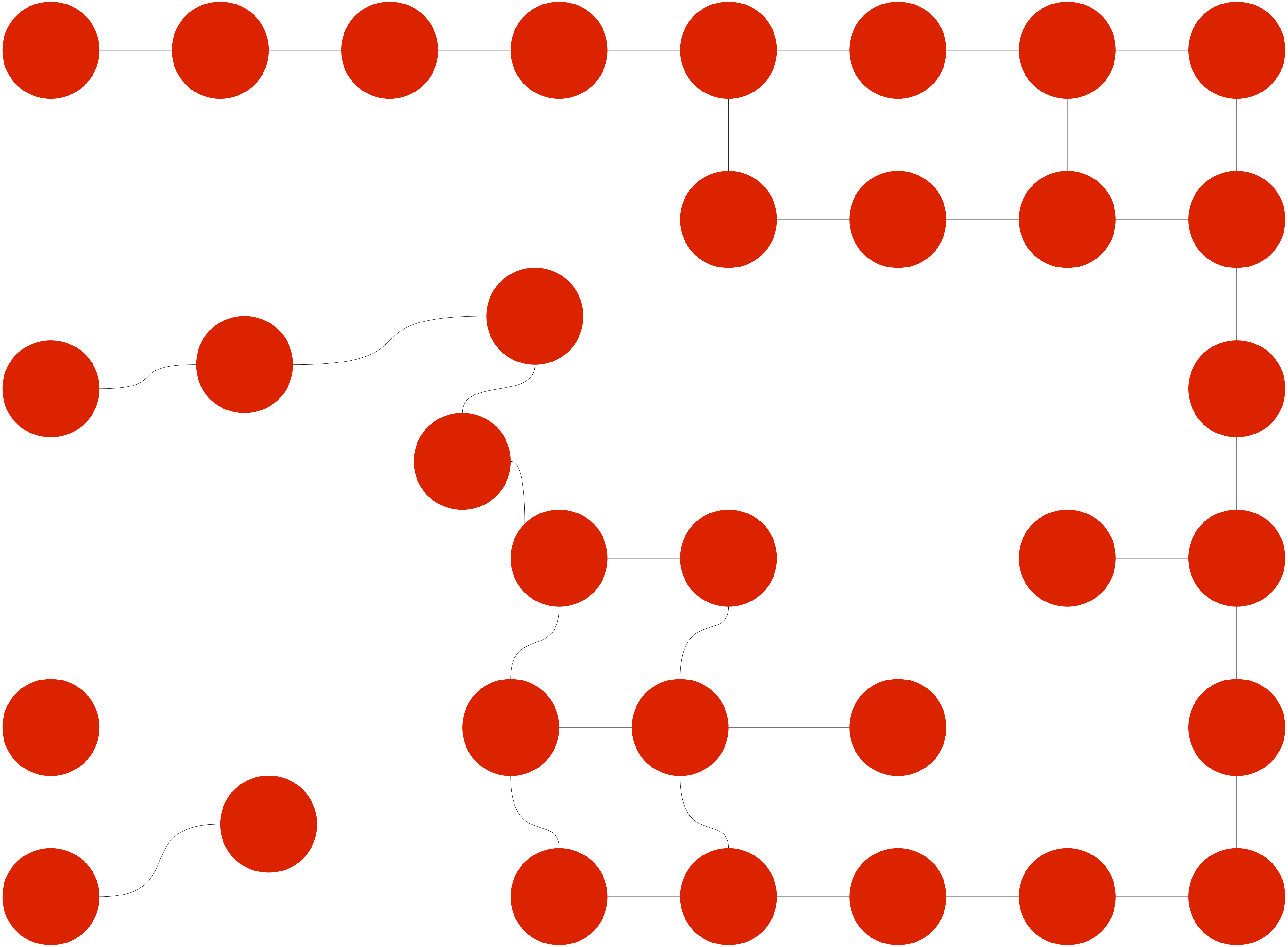
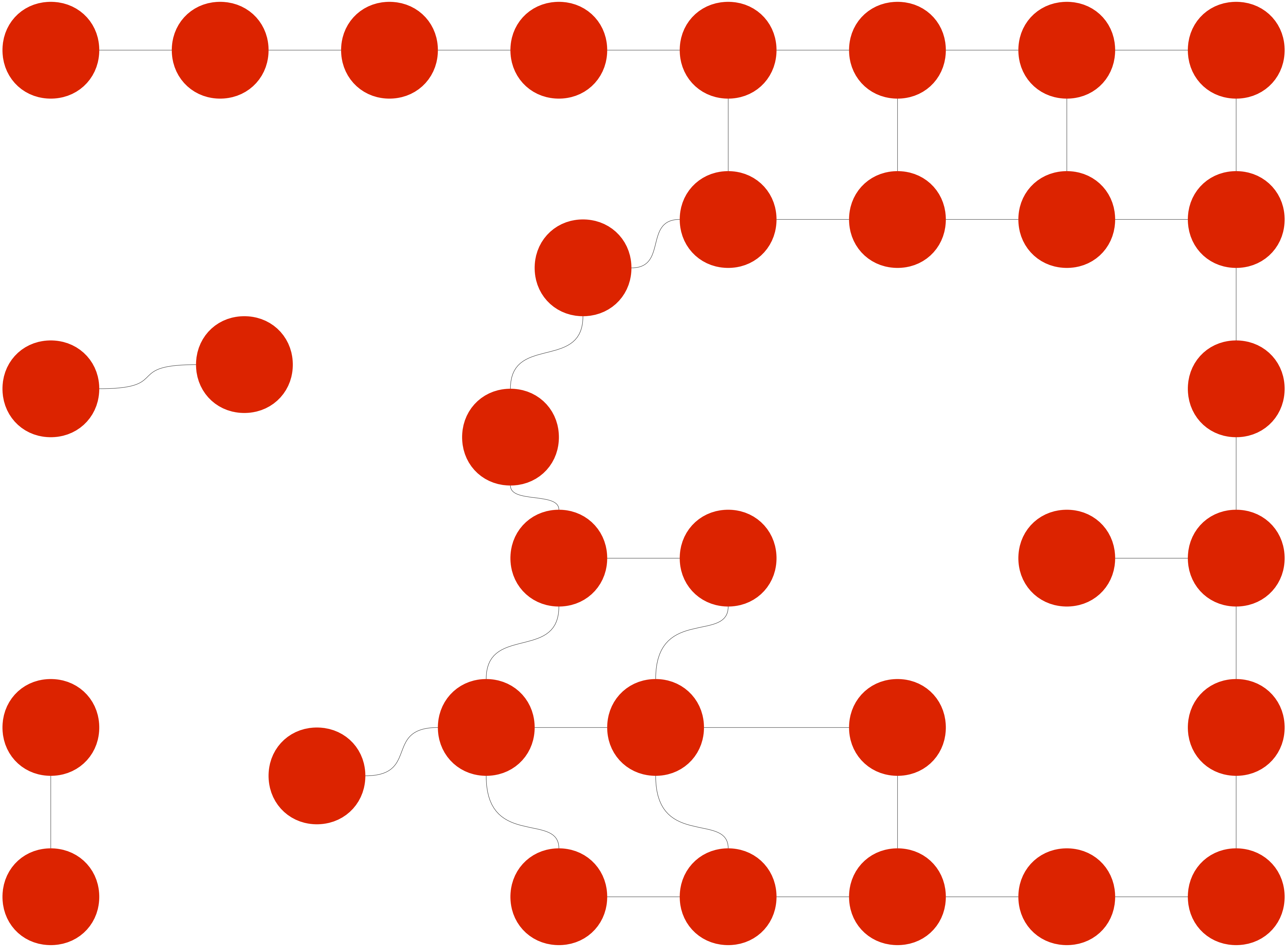
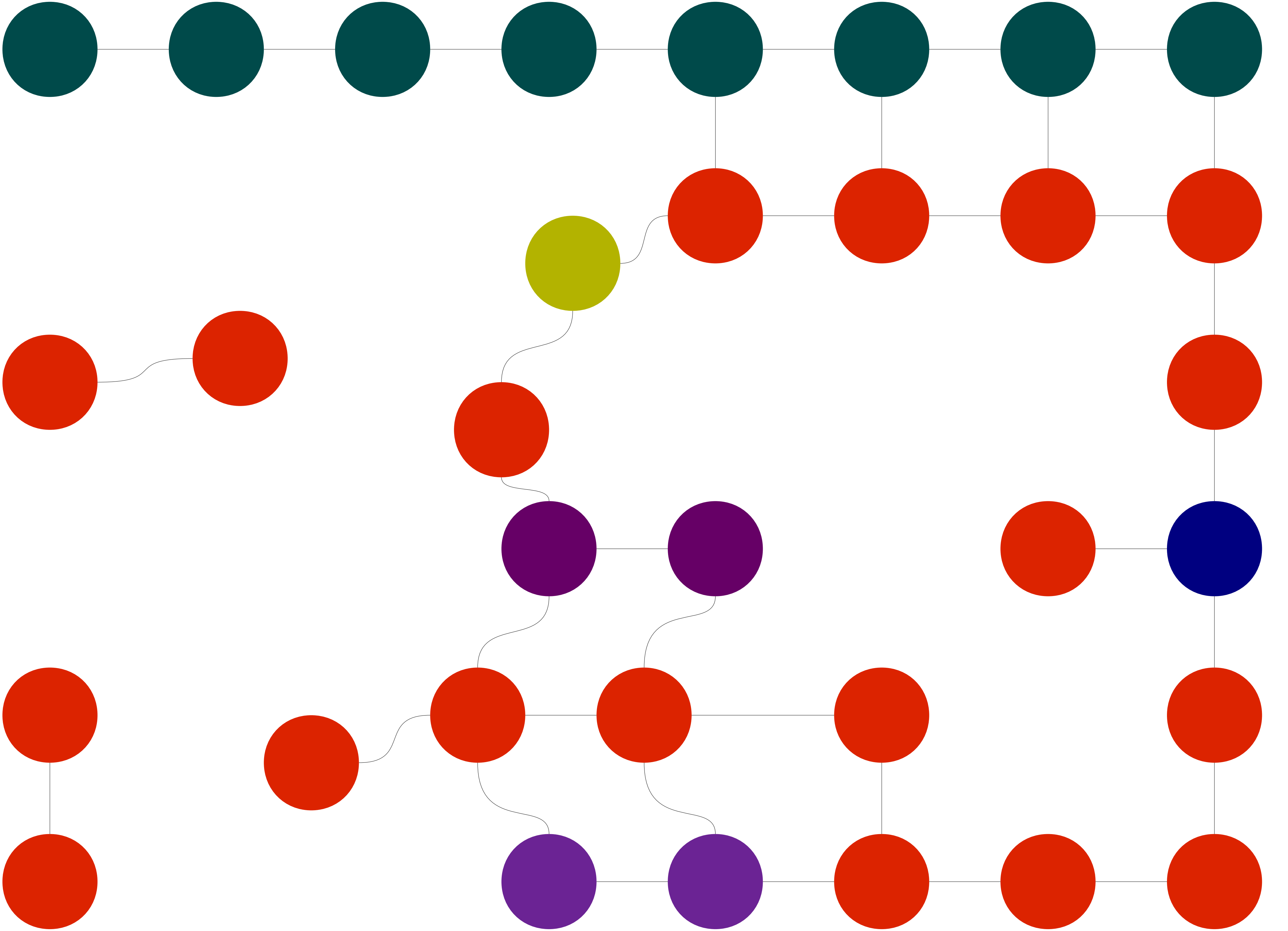


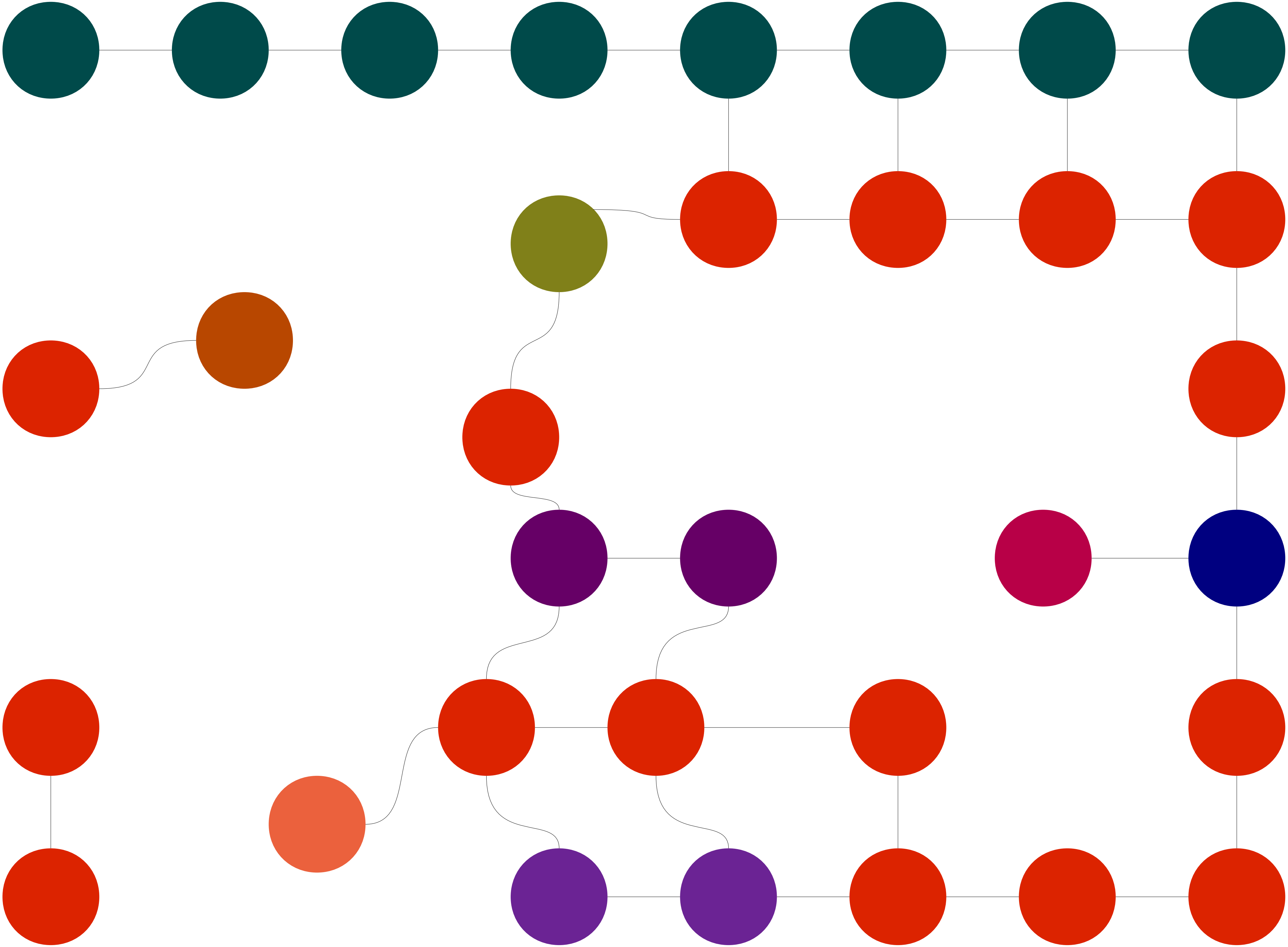


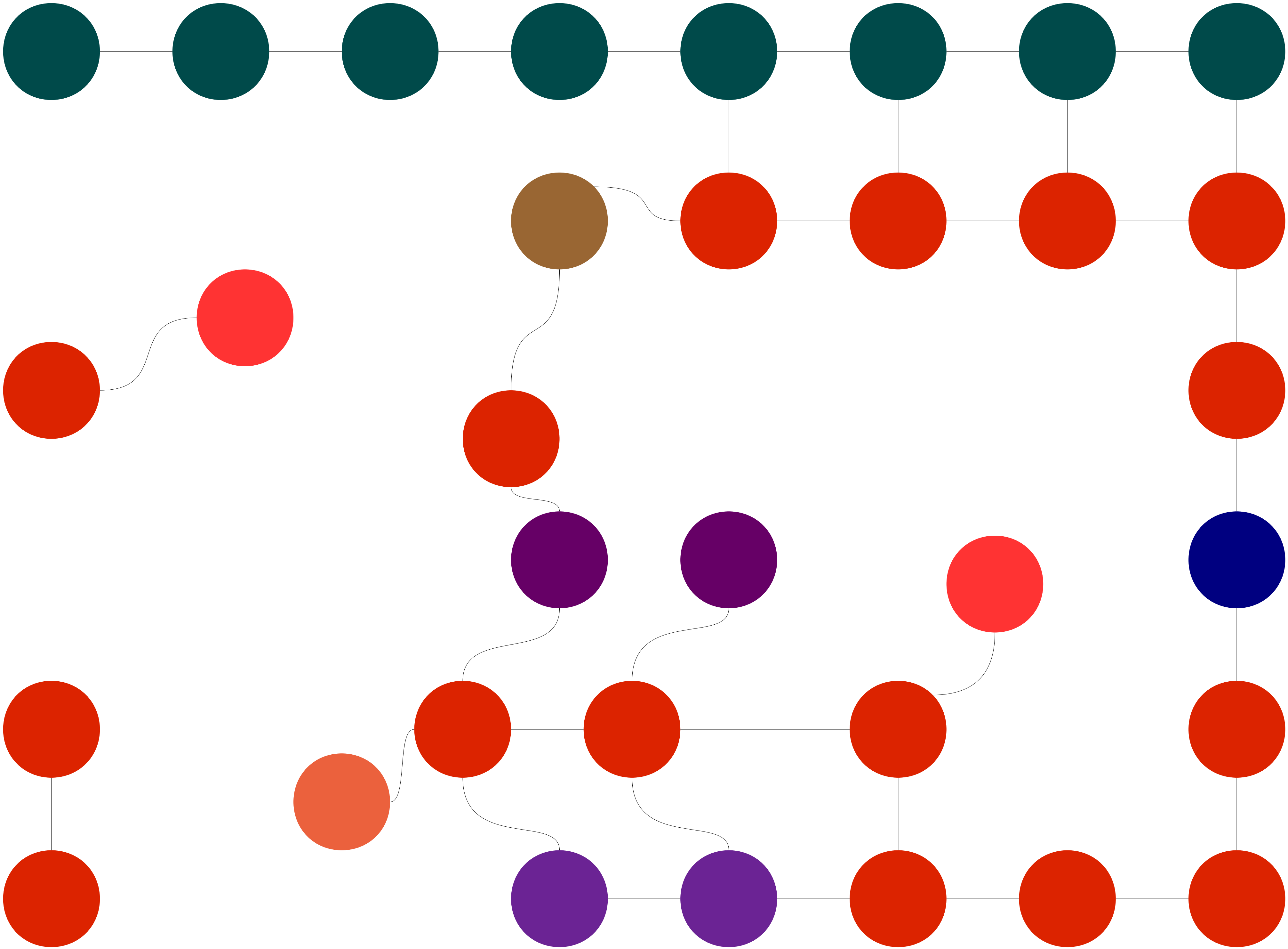






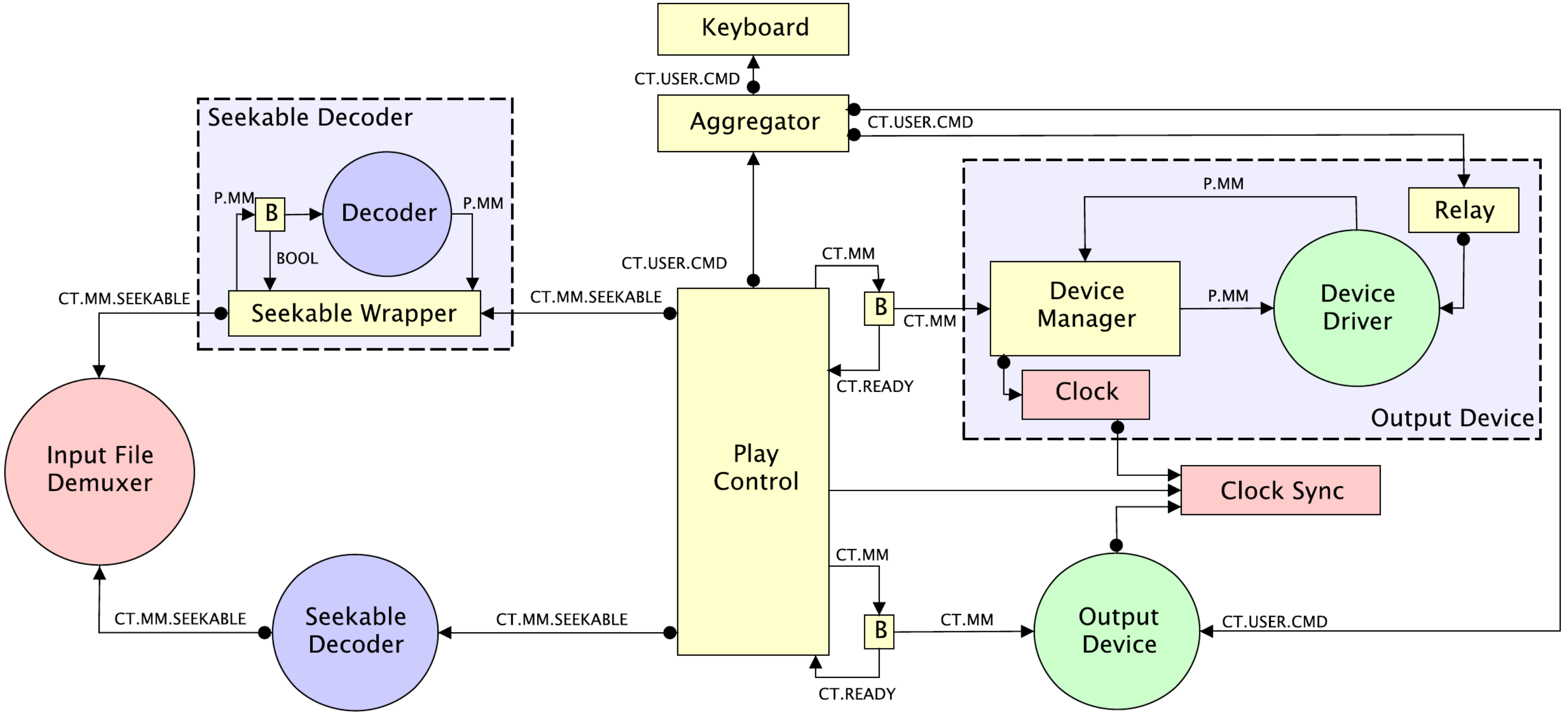






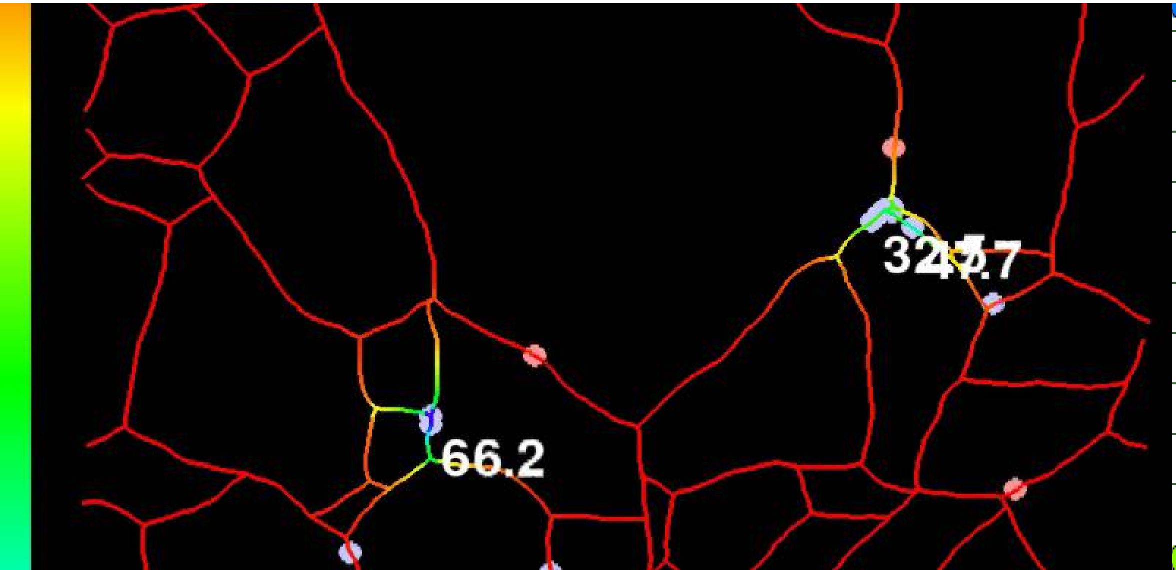
Concurrent programming

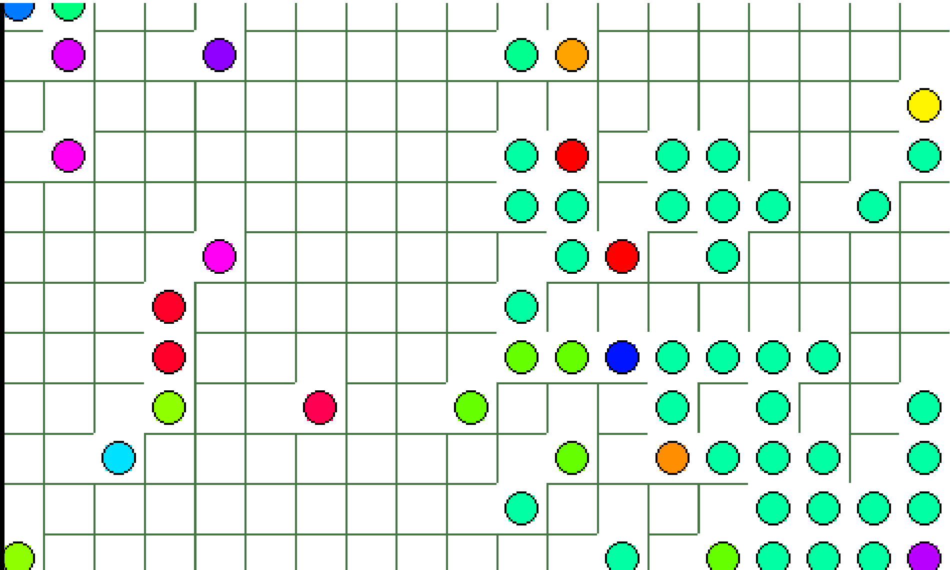
- Design and implement software in terms of **concurrent activities** and **how they interact**
  - Uses include: network servers, robotic control systems, multiplayer games, media processing...



Concurrent programming

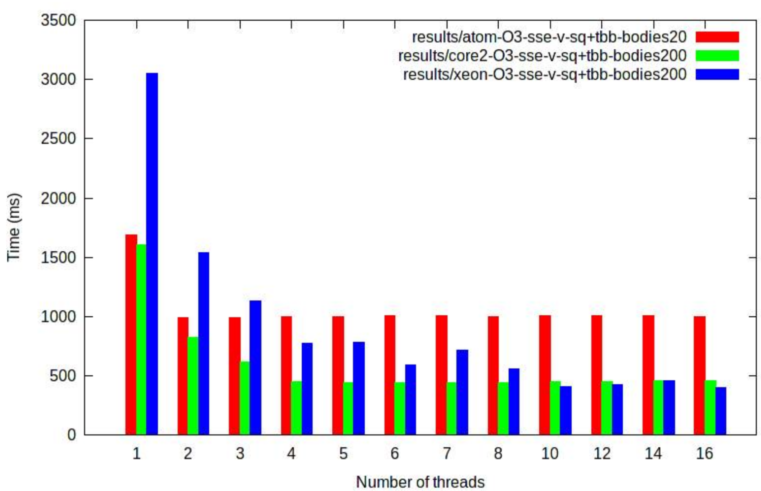
- Activities are “lightweight threads”, with their own **state** and **flow of control**
- Modelling entities as concurrent activities means they can **behave** and **develop** independently
  - No artificial ordering on interactions
  - A heterogeneous system, not a homogenised soup

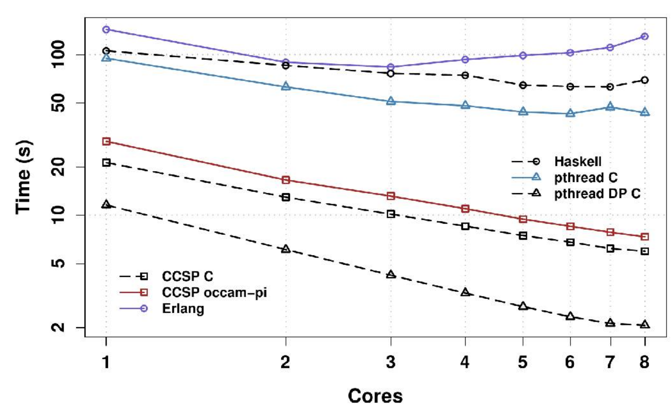




From concurrency to parallelism

- The **runtime system** schedules activities automatically across the available processors
  - … so it exploits the **natural concurrency** of the system you're modelling to execute in **parallel**
- Modern concurrent runtime systems – Intel's TBB, the GHC Haskell runtime, CCSP... – have low activity overheads and excellent **scalability**





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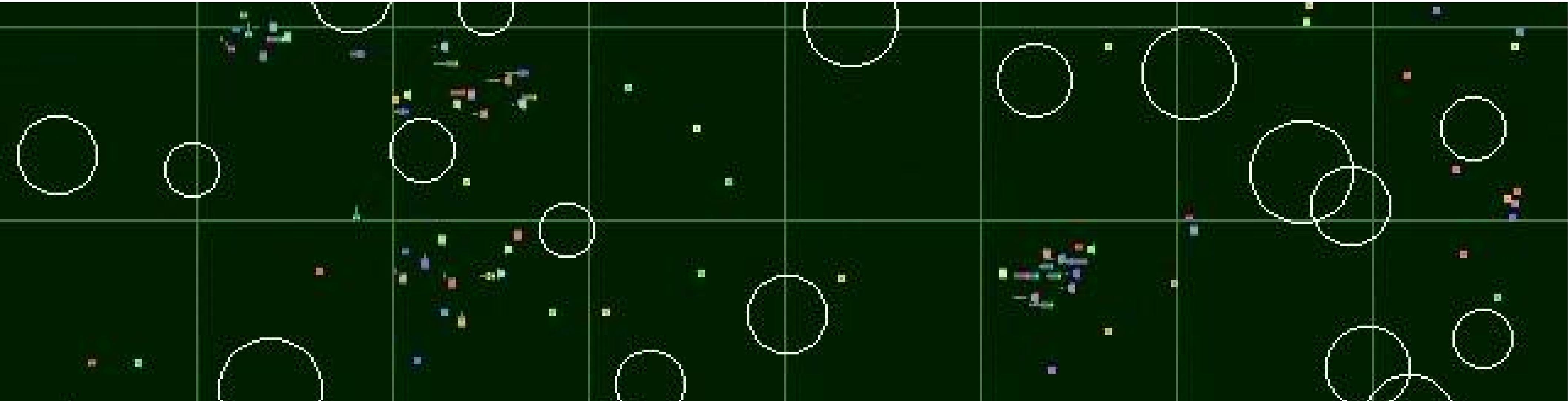
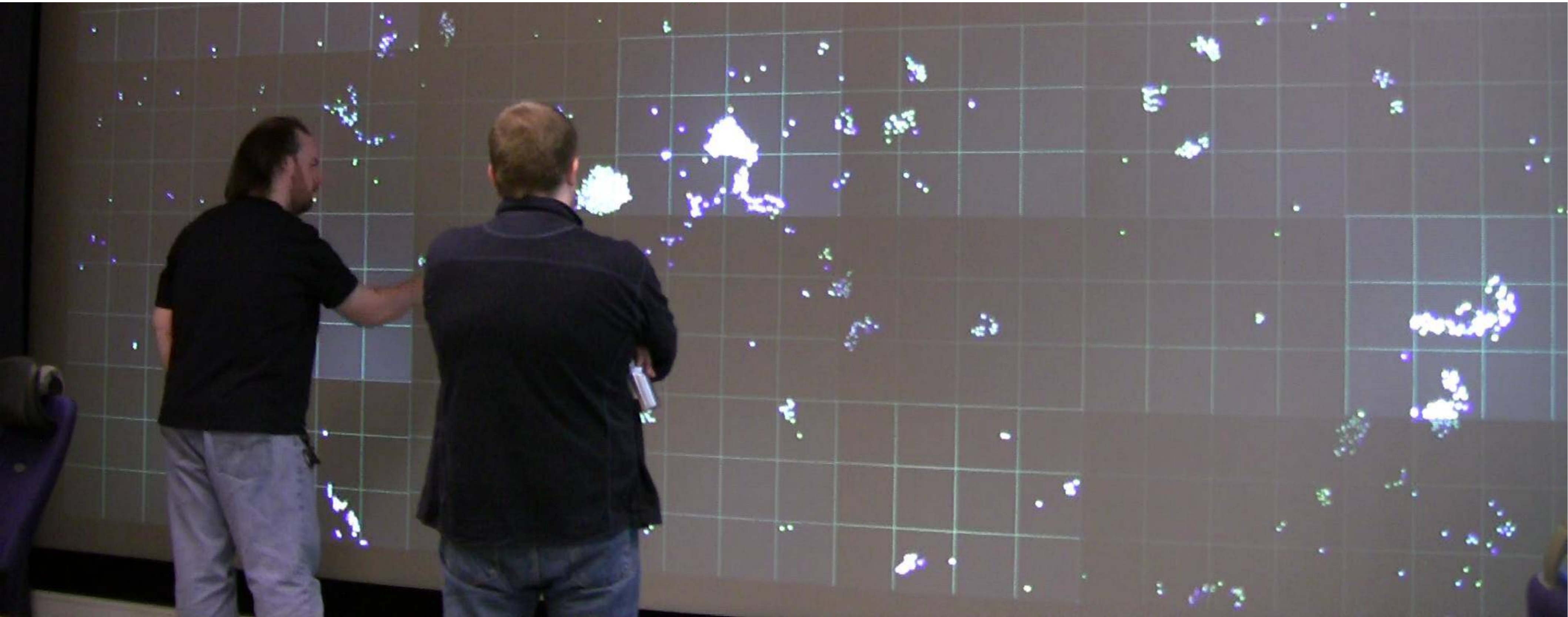
Smart scheduling

- Scheduling is done while the program is running
  - More information available: better decisions
- Dynamic load-balancing
  - **Work stealing** finds jobs for idle CPUs
- Informed by interactions between the activities
  - Minimises **contention**, and improves **locality**



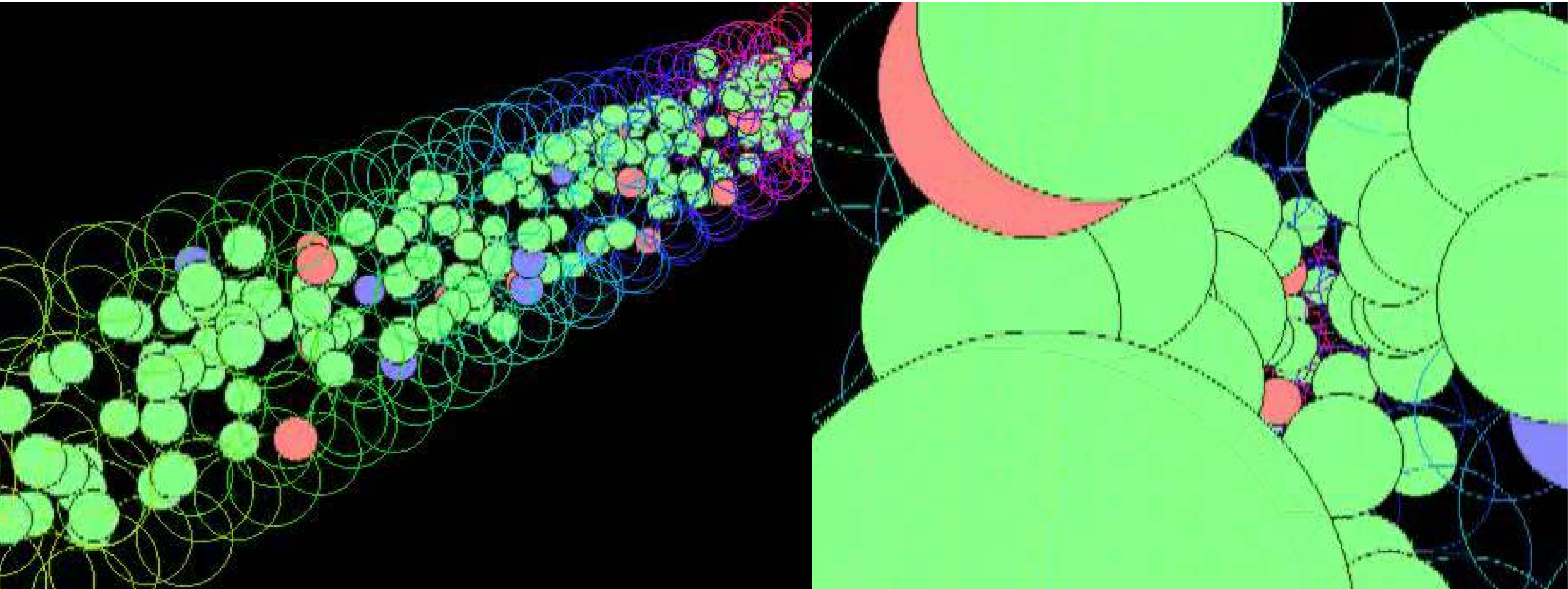
Distributed simulation

- Making the interactions explicit considerably simplifies **distributing** a problem across a cluster of machines
  - Scalable techniques, minimising **latency** effects



Playing games with space

- Spatial interaction is key to our applications
  - Needs to be **dynamic**, **accurate** and **fast**
- We use tricks developed for real-time **collision detection** in computer games



Where next?

- In use on a variety of projects (immunology, cell signalling, electricity networks...) using CoSMoS design patterns
- **This summe**r: cell physics, blood clotting
- **Longer-term**: cancer modelling in CRISP
  - … where spatial interaction and heterogeneity are also major concerns
- **Tools**: developing more appropriate interaction mechanisms for simulations – and making the runtime system space-aware

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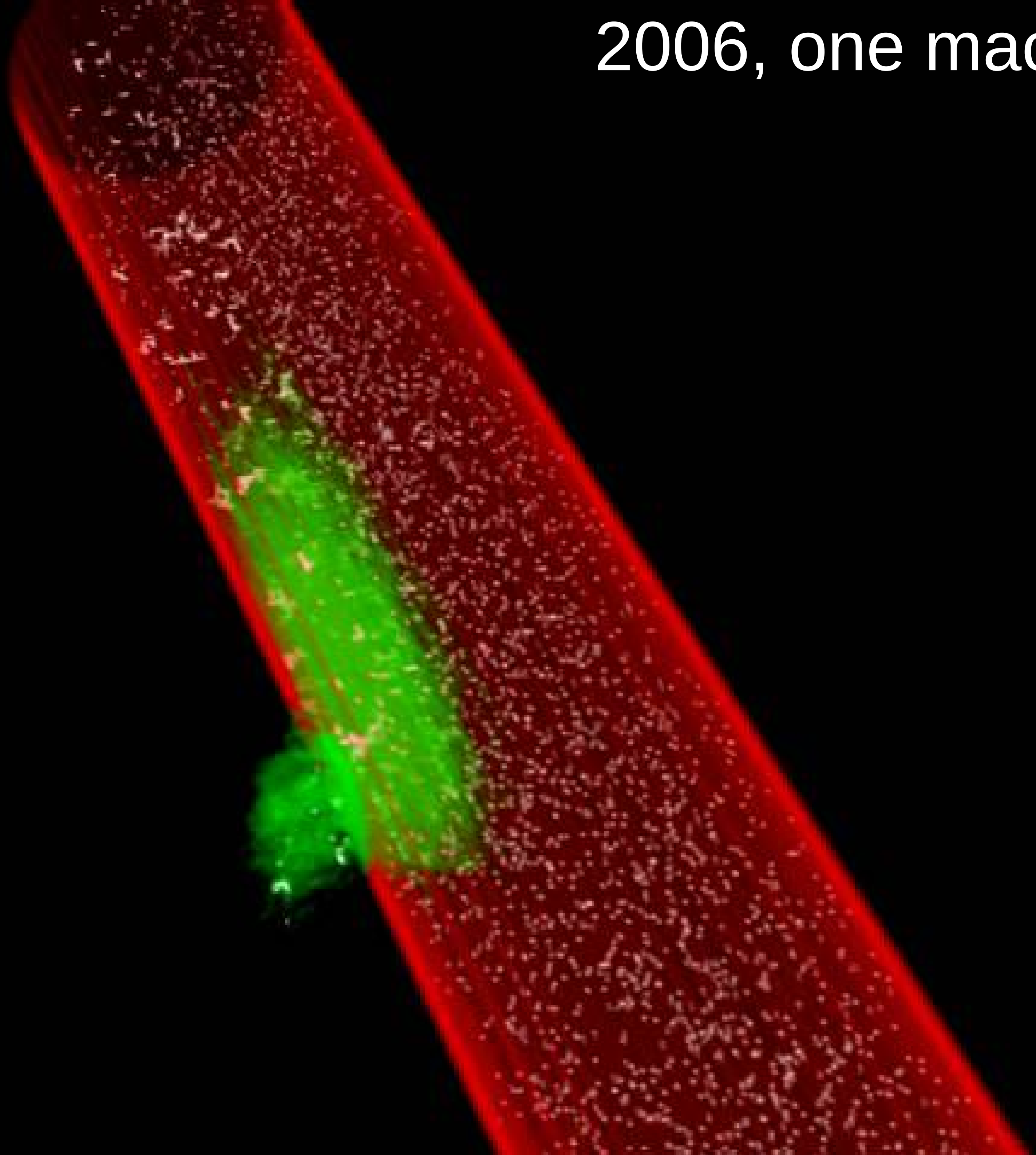
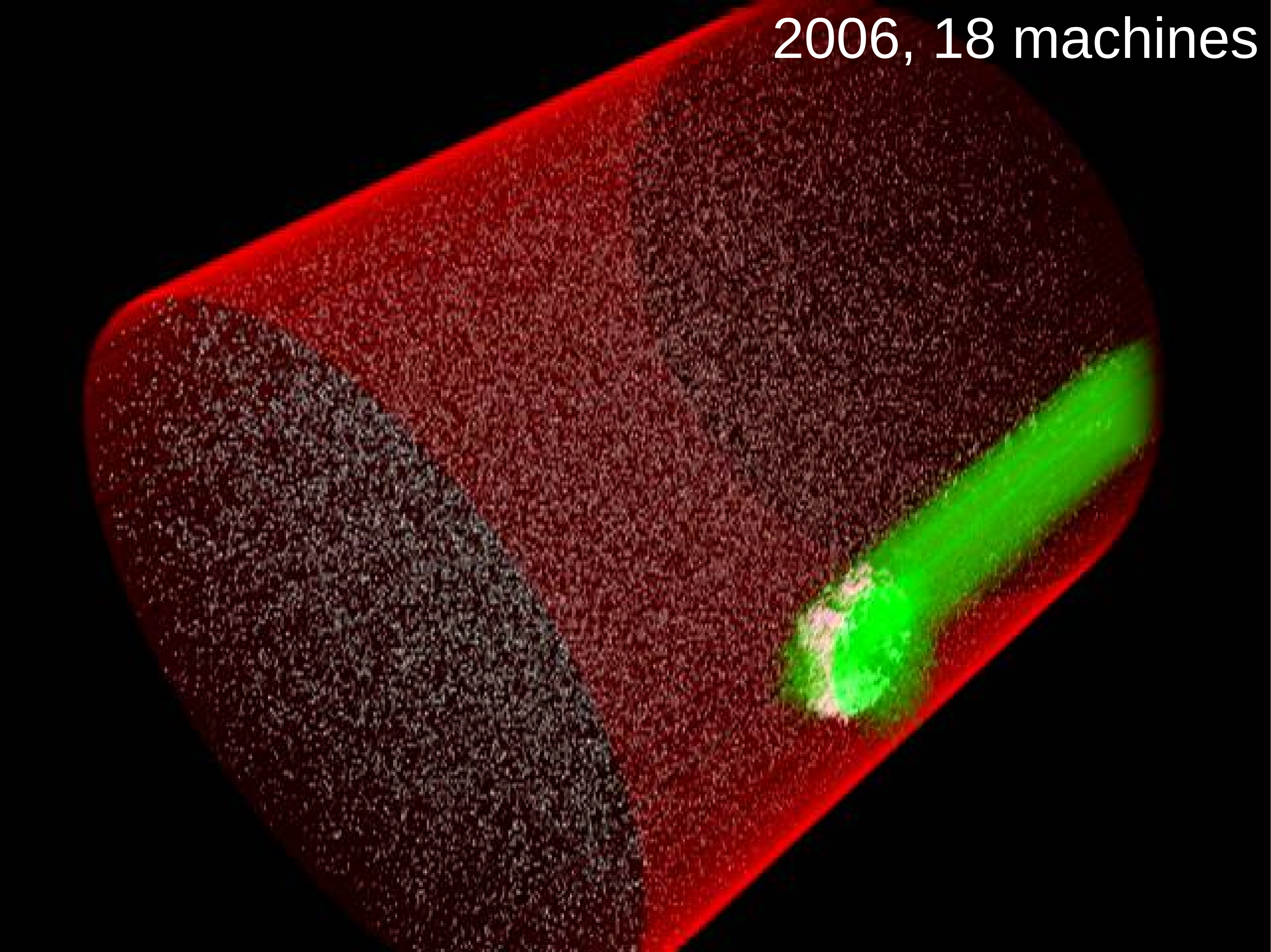
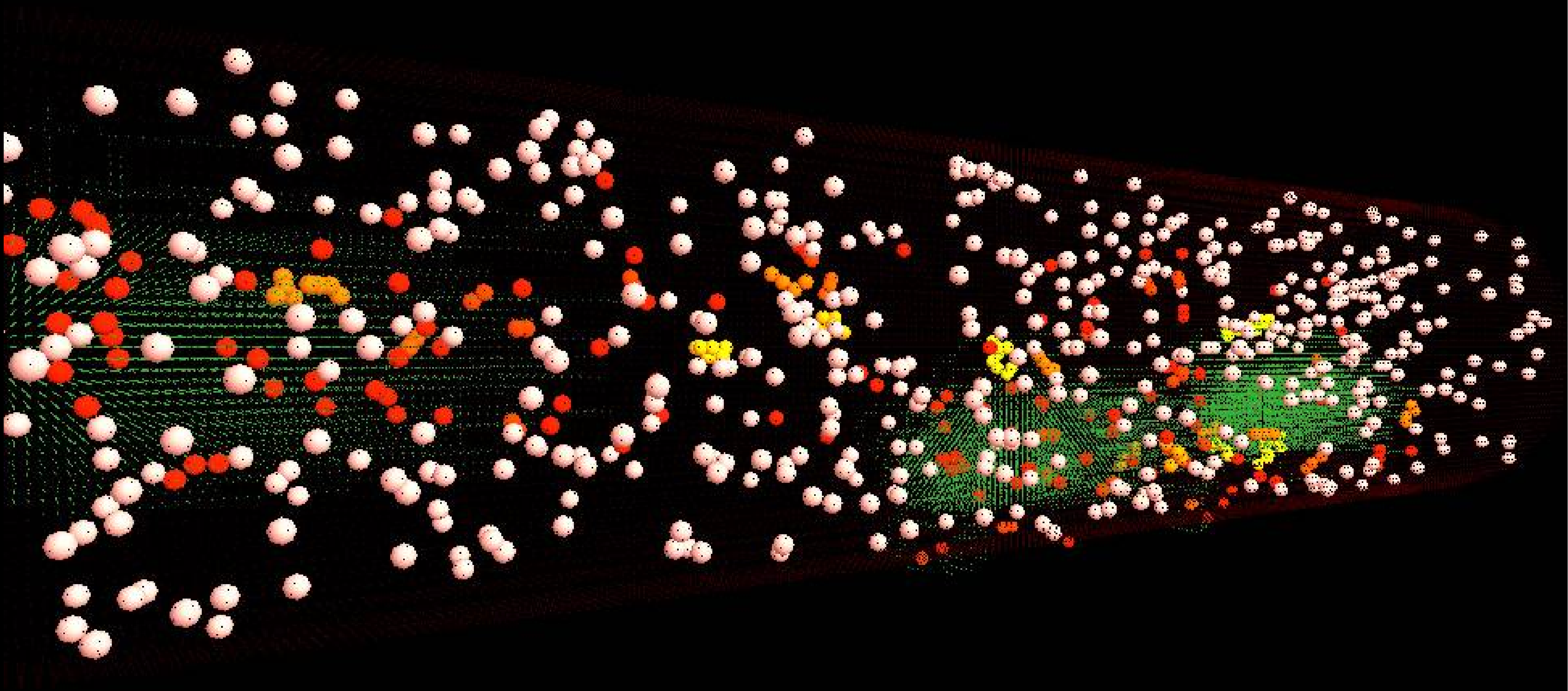
2006, one machine

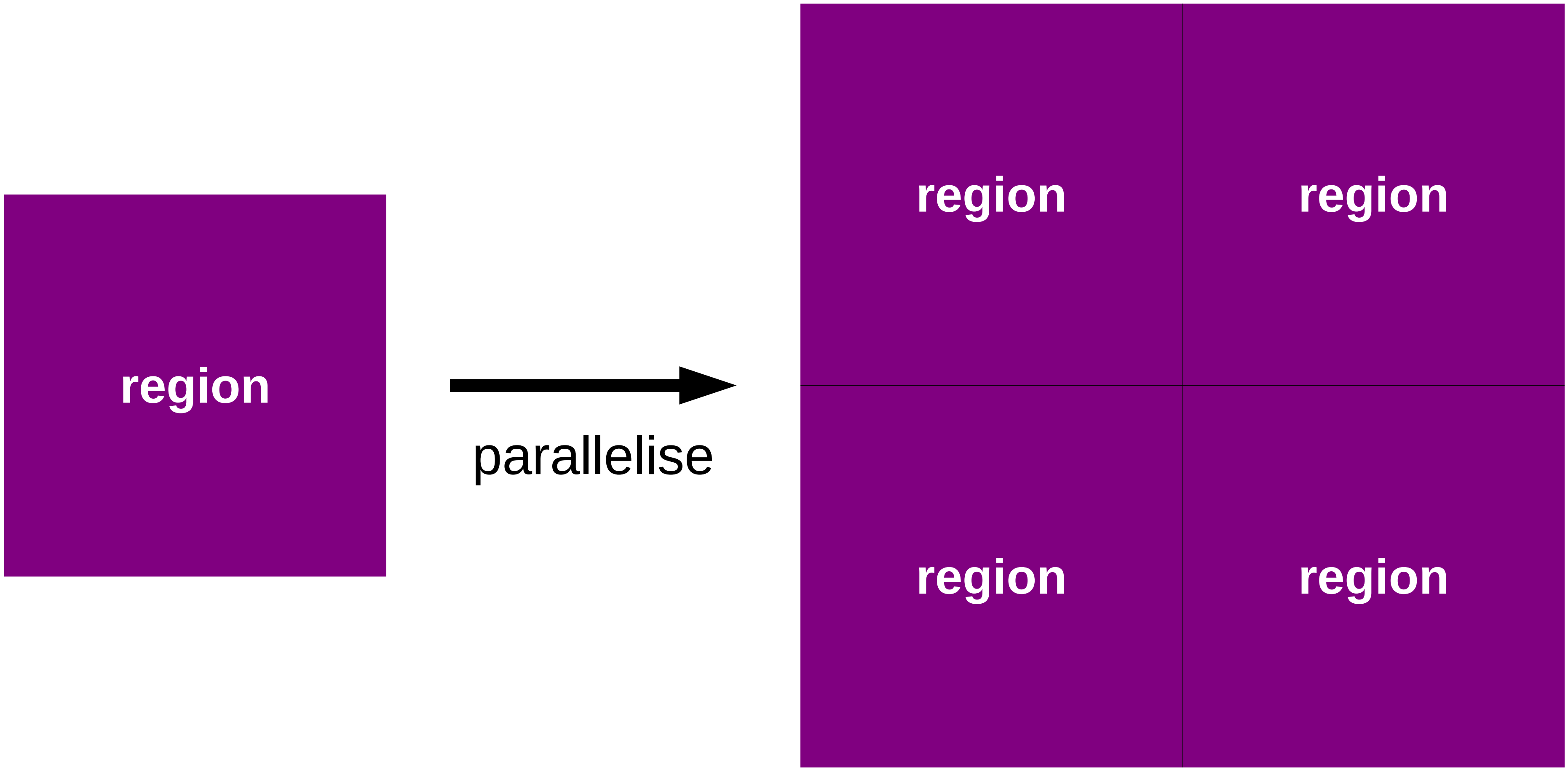



2006, 18 machines

2011, one machine




region


region
parallelise
region
region
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region

Thanks to...

- **CoSMoS** (EPSRC)
  www.cosmos-research.org
  esp. Paul Andrews,
  Carl Ritson, Peter Welch
- **CRISP** (SICSA)
  esp. Jim Bown, Alexey Goltsov,
  Mark Shovman

Any questions?