

Cloudy systems

— Taking the most out of the HPC Cloud



Workshop at UvA
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SURF SARA

Recap: defining cloud computing

Essential characteristics:

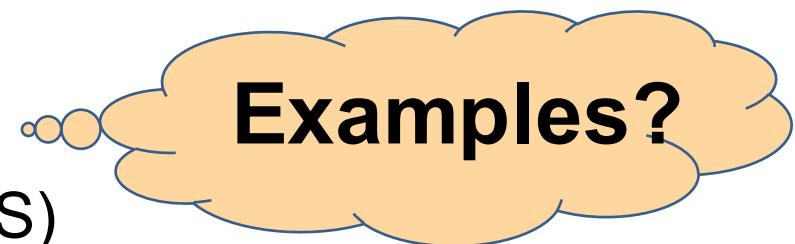
- On-demand **self-service**
- Broad **network access** (ubiquitous + convenient + on-demand)
- Resource pooling
- Rapid **elasticity** ⇒

1. Scaling

2. API
- **Measured service**

Service models:

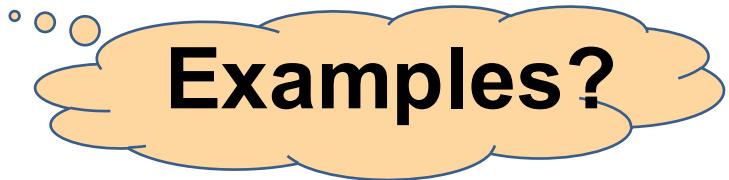
- Software as a Service (SaaS)
- Platform as a Service (PaaS)
- Infrastructure as a Service (IaaS)



But why...?

...scaling

- Sequential run takes forever
- Not enough local resources (e.g.: memory)
- Analyse more data
- Achieve higher accuracy
- ...



Examples?

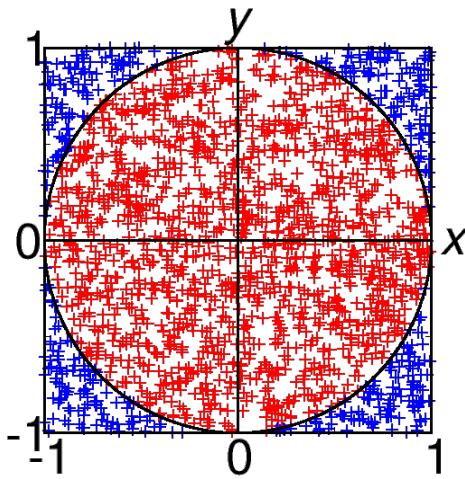
...elasticity

- Booking fixed resources in advance is:
 - A waste
 - Too expensive
 - Unpredictable
 - ...

The naïve approach

Some programs are **already parallel**

- The end-user just needs to run them
- E.g.: Delft3D, XBeach, OpenFoam, Matlab...



Some problems are a matter of running the **same thing** (possibly) **with different parameters**

- You can simply run many of these runs independently at the same time on different computers
- E.g.: a Monte Carlo simulation

Embarassingly parallel problems!

Agenda

1.- Scaling possibilities

2.- API overview

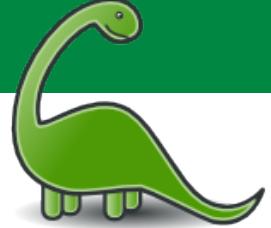
3.- Demo



Scaling possibilities



The concept (I)



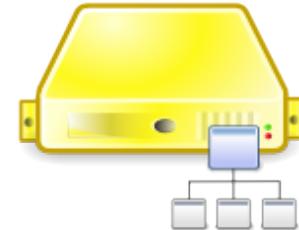
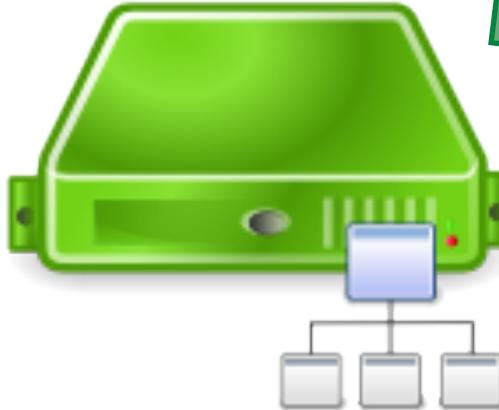
Your **application**
may need more...



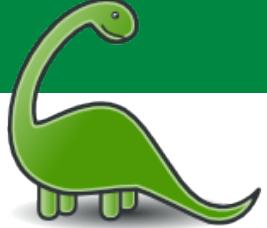
Scale up

vs.

Scale out



The concept (II)



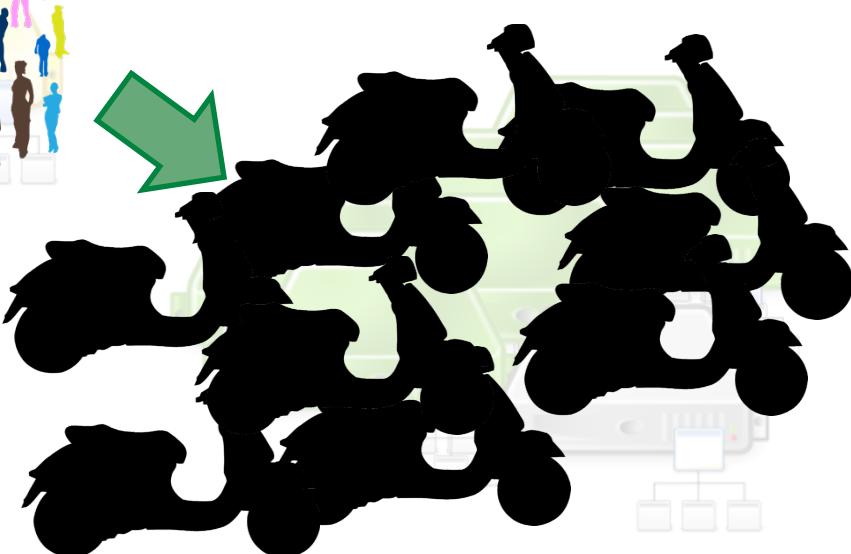
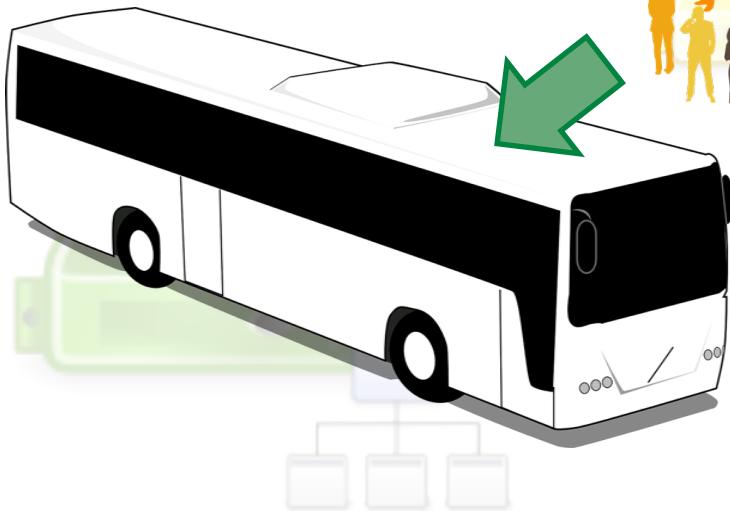
e.g. **transport people**
may need more room...



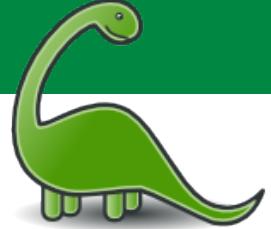
Scale up

vs.

Scale out



The concept (^{and III})



e.g. **transport people**

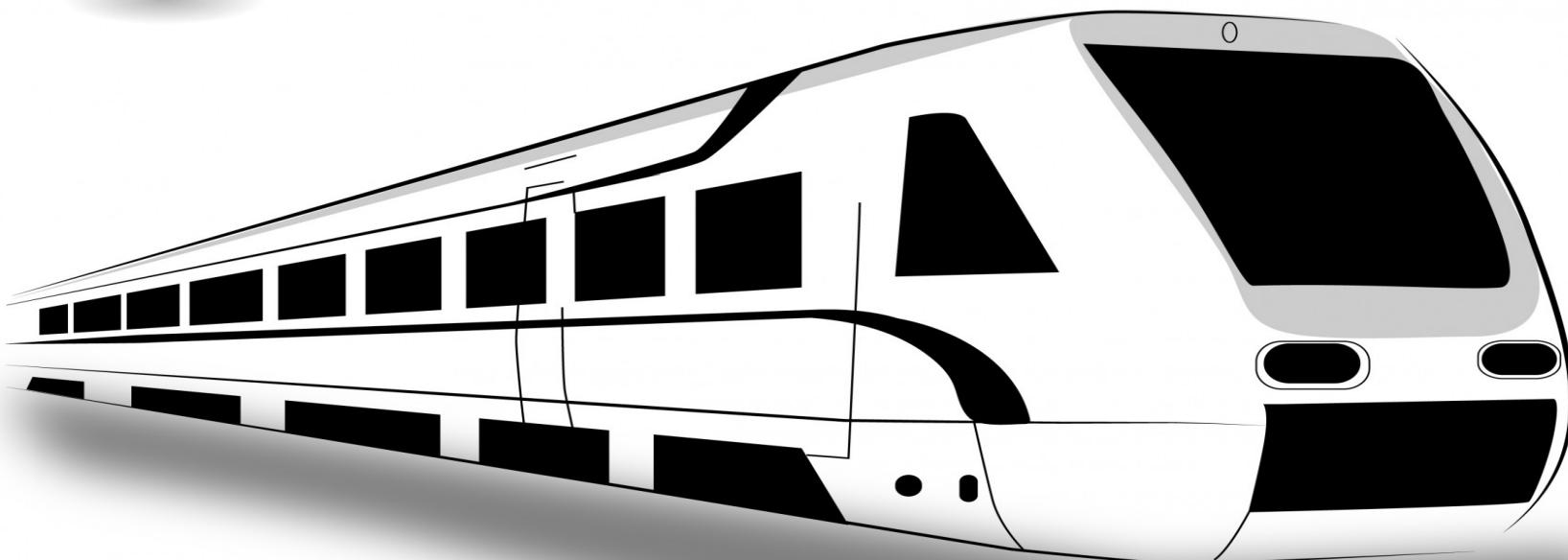
may need more room...



Scale up

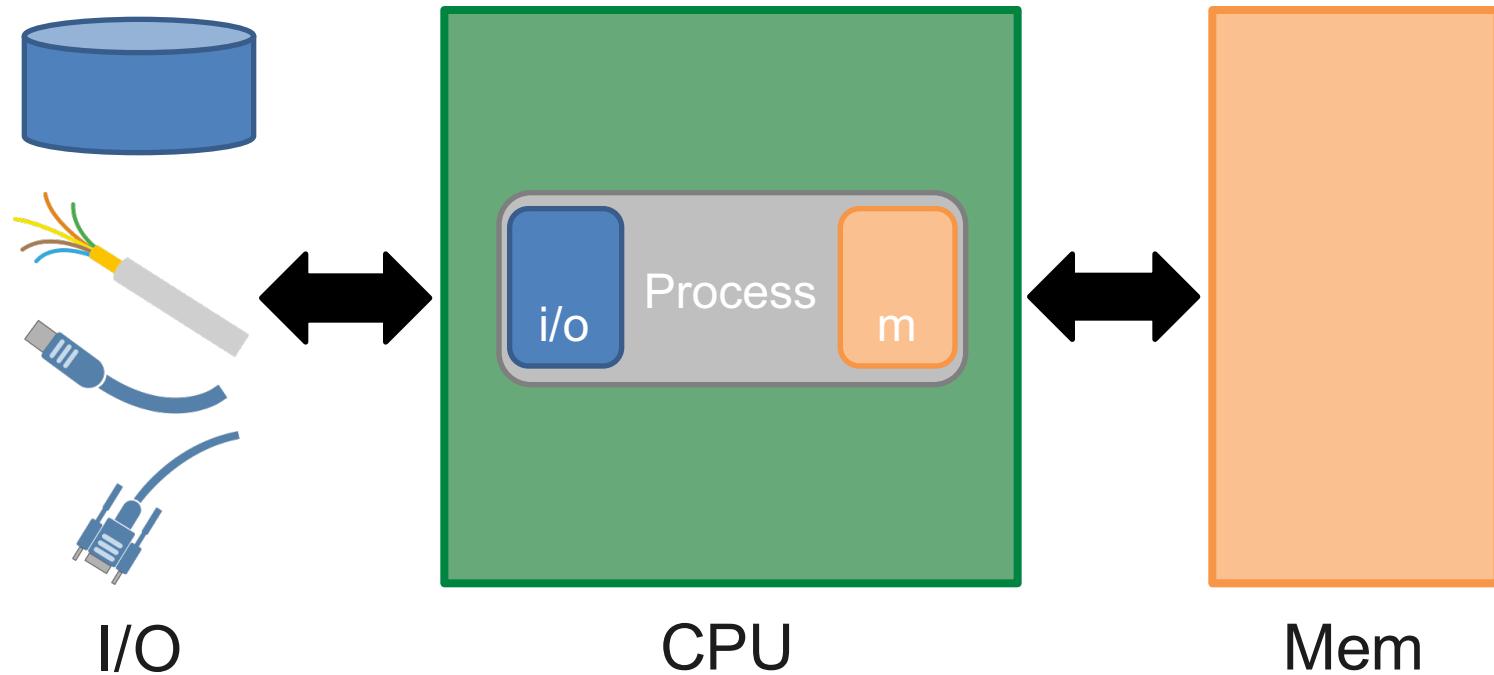
AND

Scale out



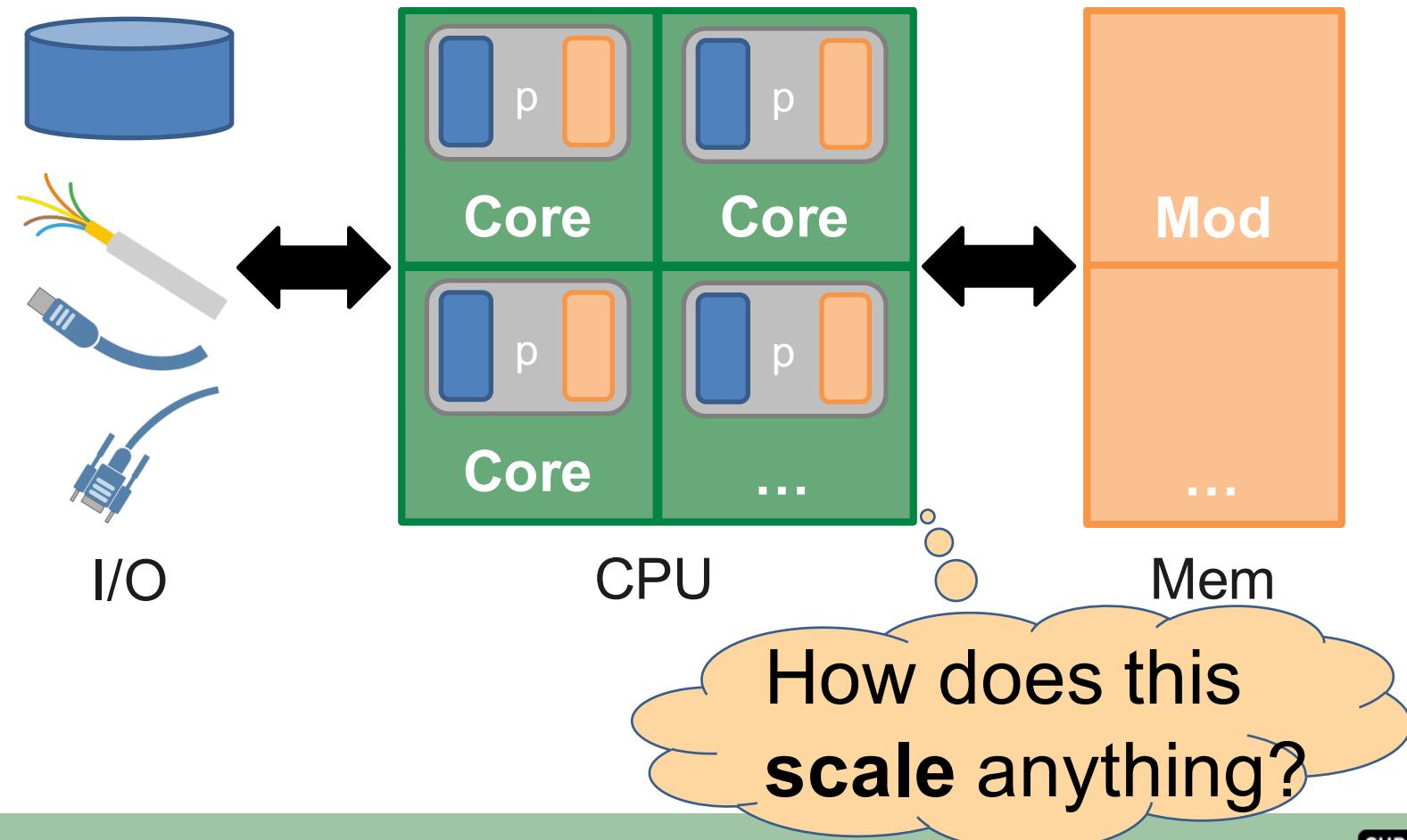
Some theory (I)

Meet: the CPU



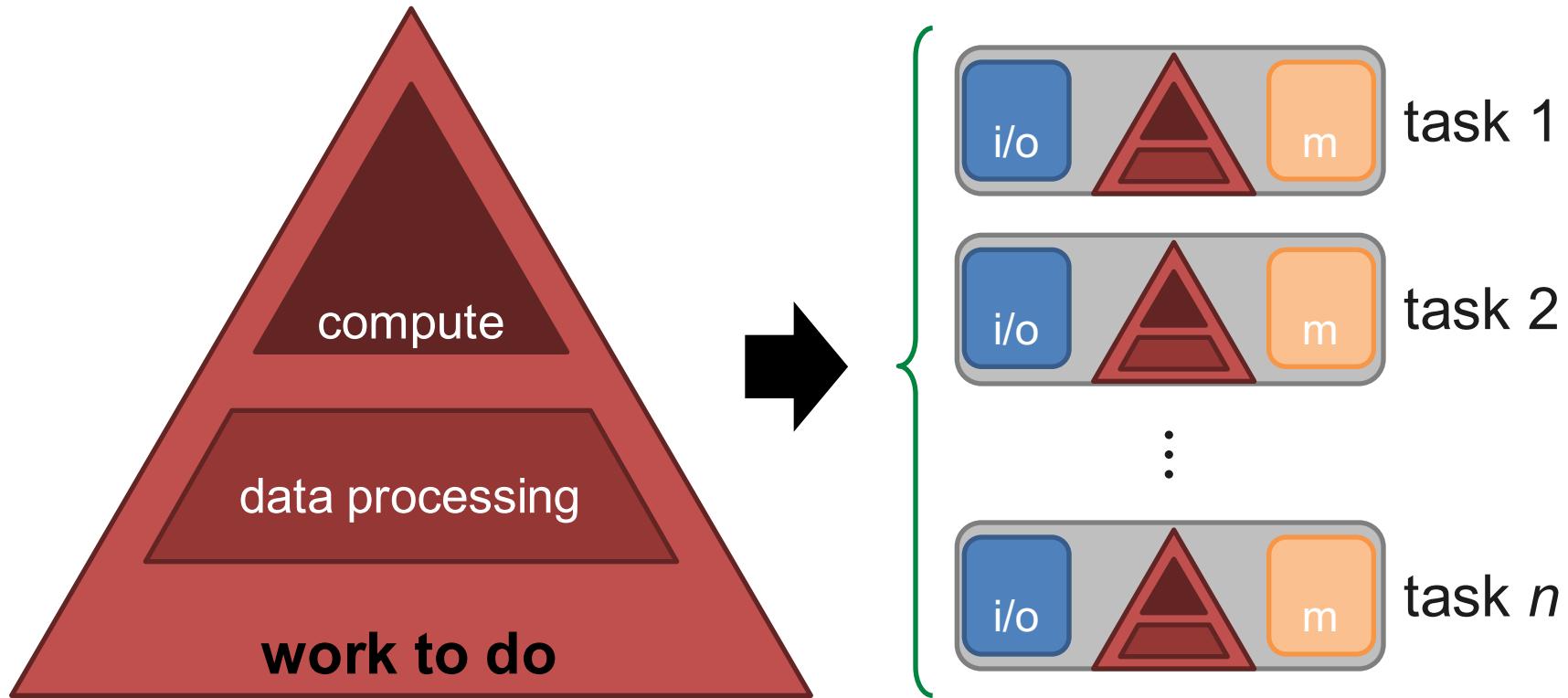
Some theory (and II)

Meet: **parallel** processing



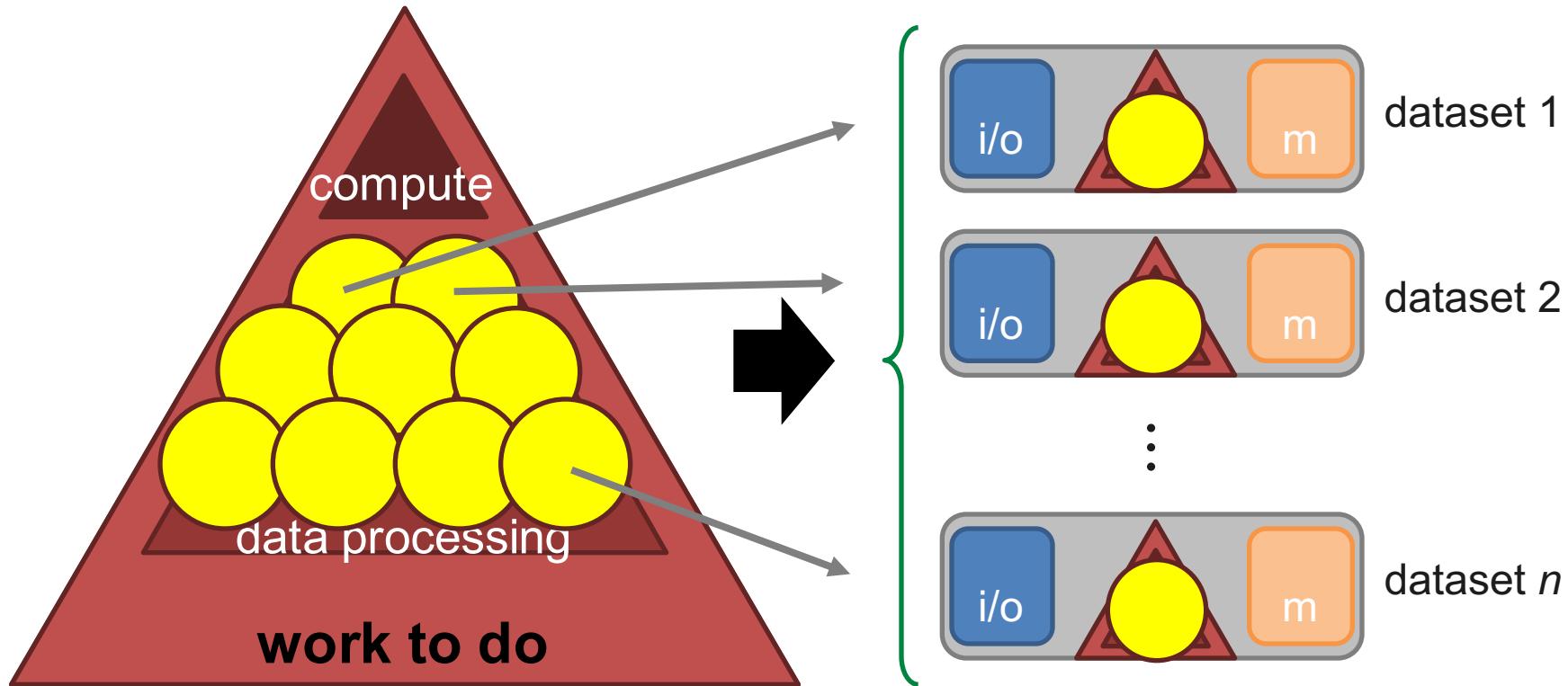
Dividing work (I)

Parallelism: task partitioning



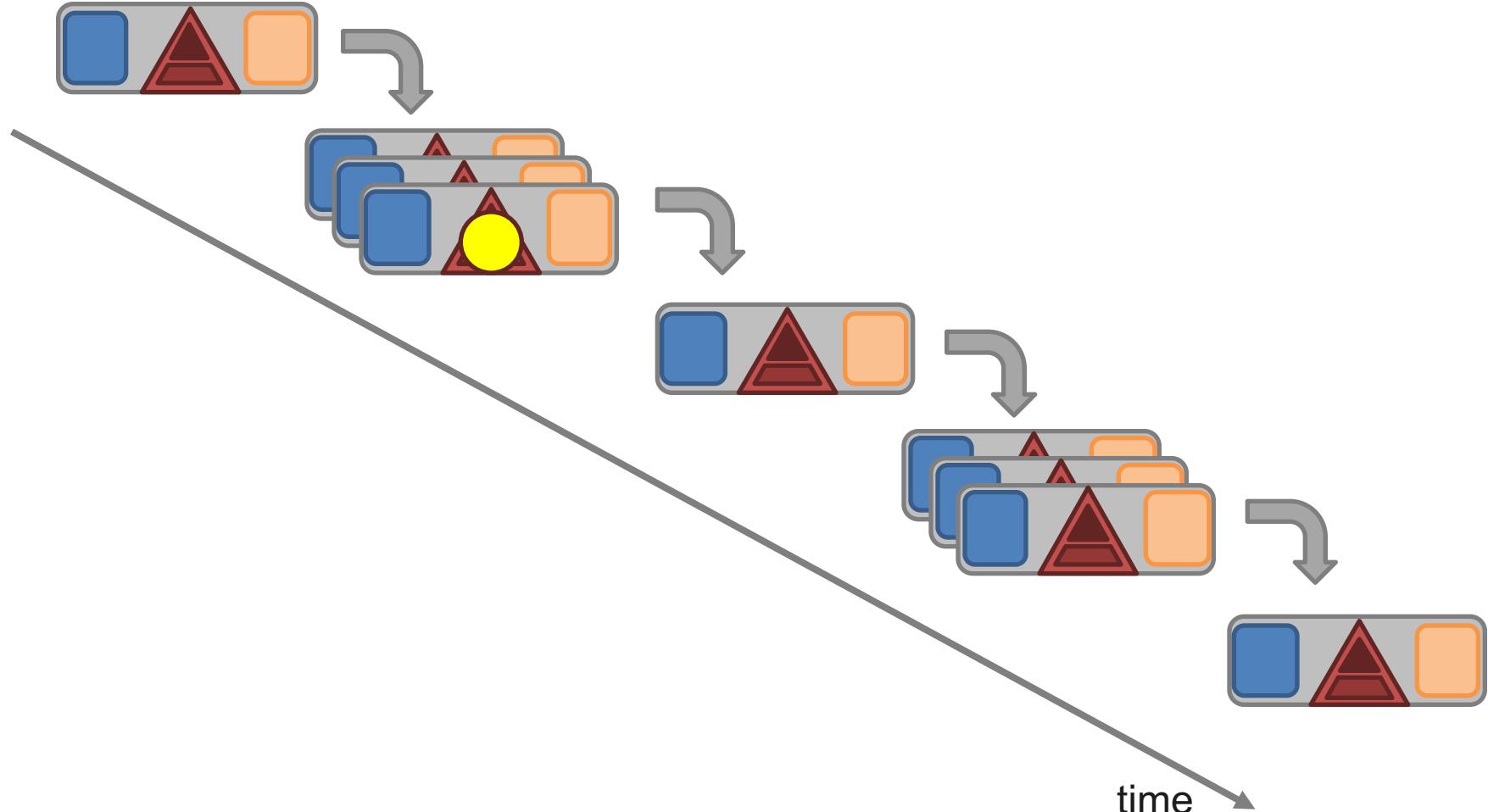
Dividing work (II)

Parallelism: **data** partitioning



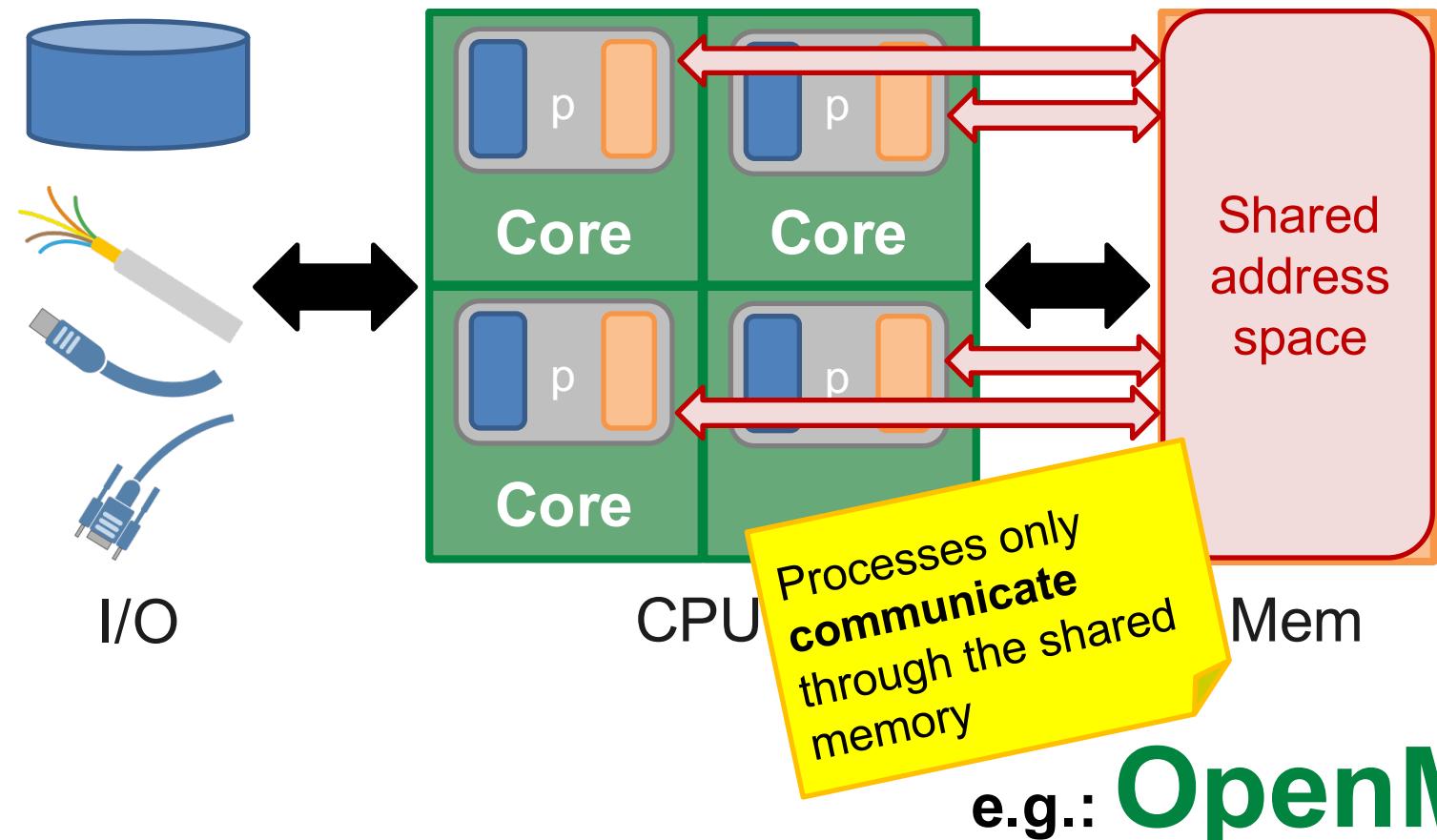
Dividing work (and III)

Example: a possible parallel program (or workflow)



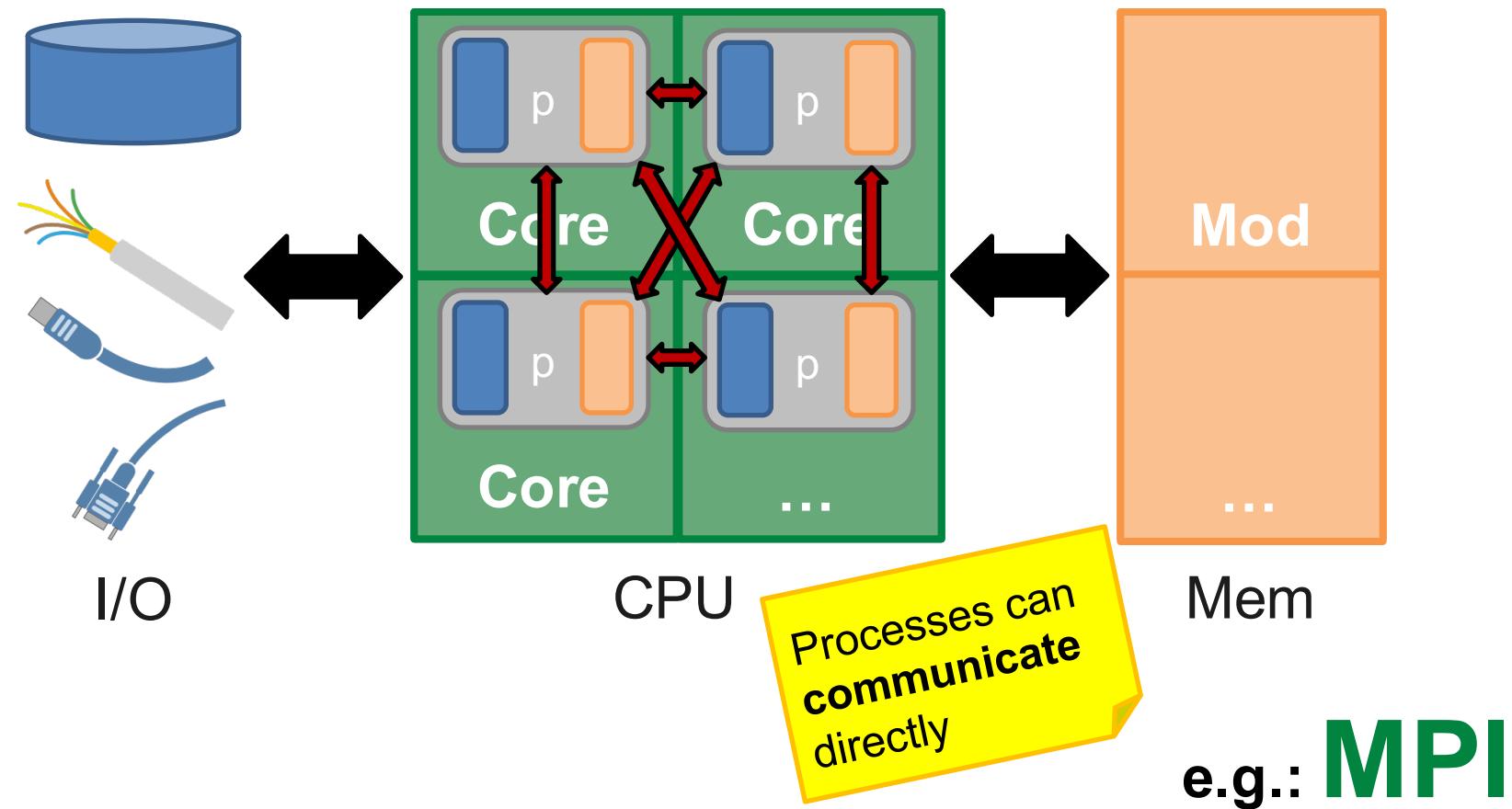
Parallel programming (I)

Technique: shared memory



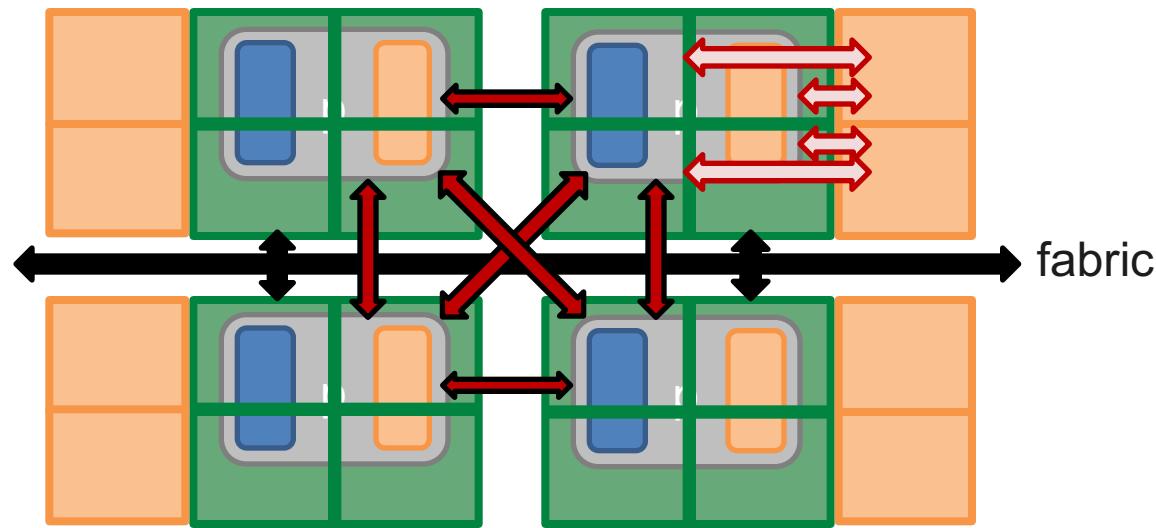
Parallel programming (II)

Technique: message-passing



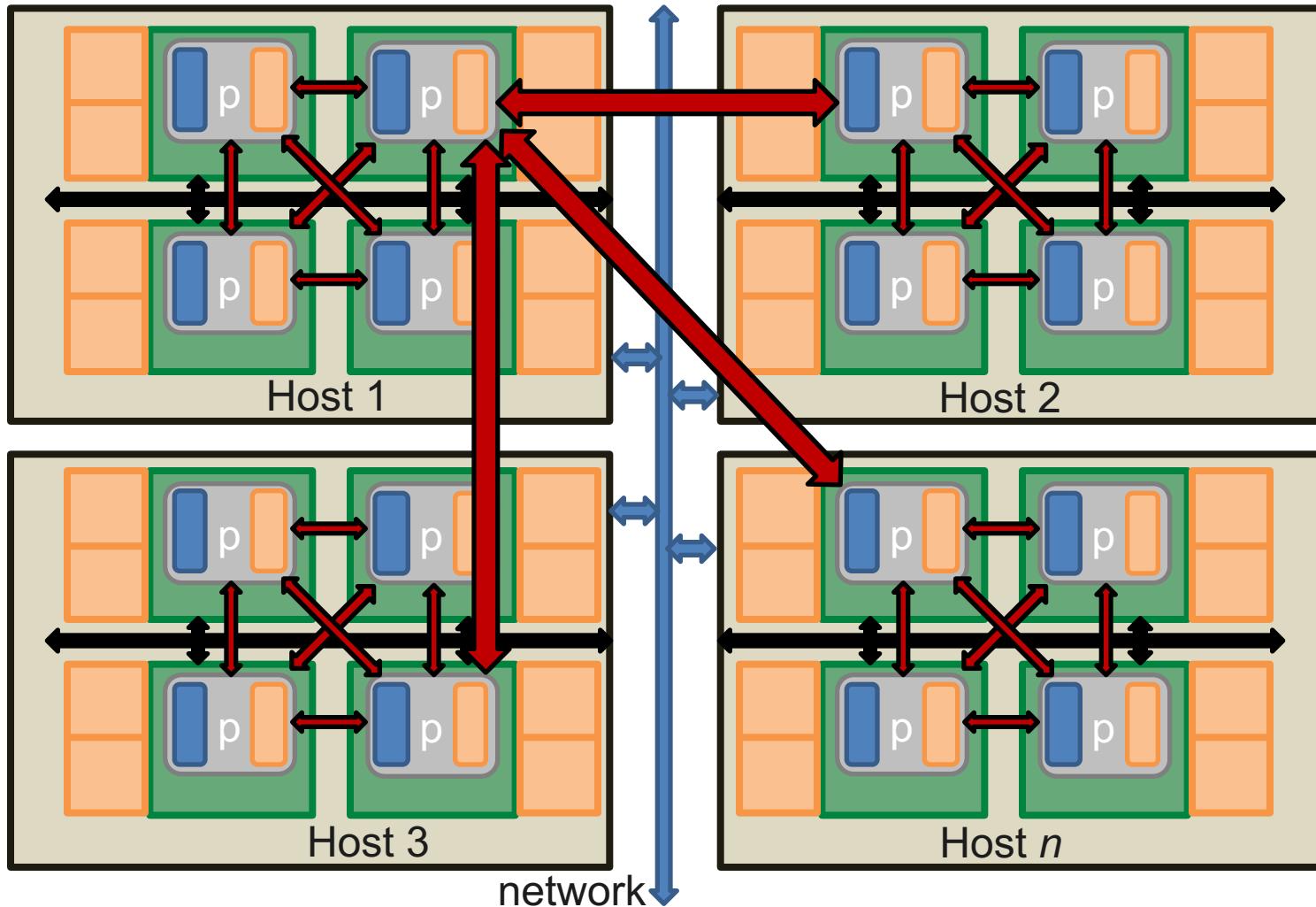
Parallel programming (III)

Combinations: shared memory and message passing



Parallel programming (and IV)

Combinations: multiple physical machines

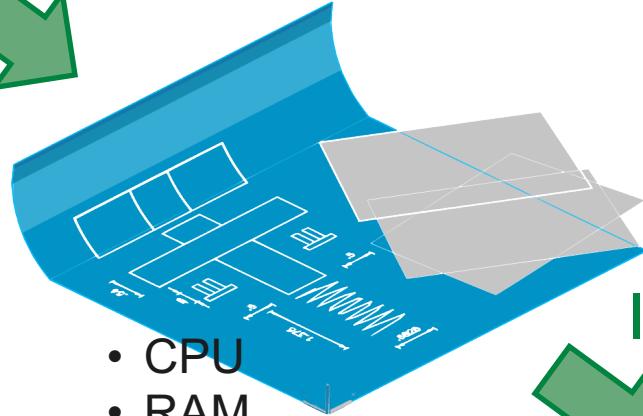


IaaS: Your place to run VMs



- Data store
- Persistence
- ...

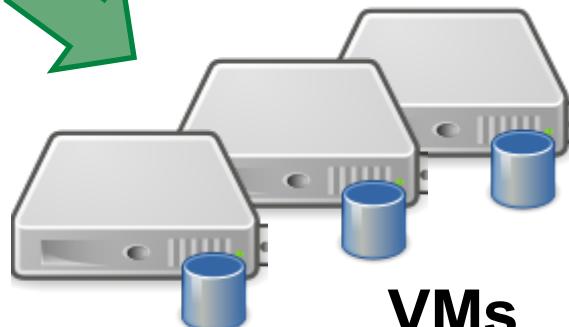
Images



Template

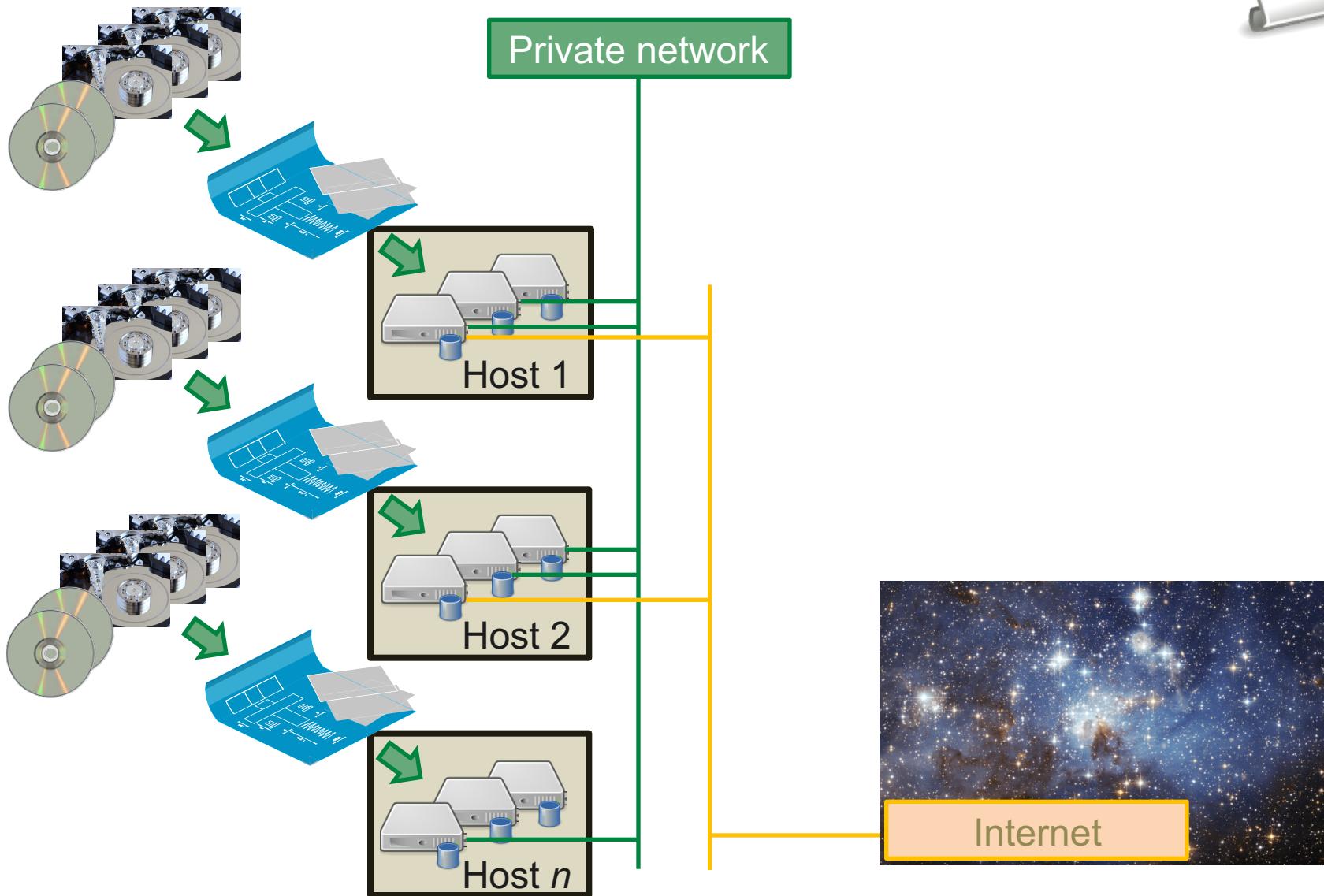
- CPU
- RAM
- I/O
 - Disks
 - Network
- ...

Instantiate

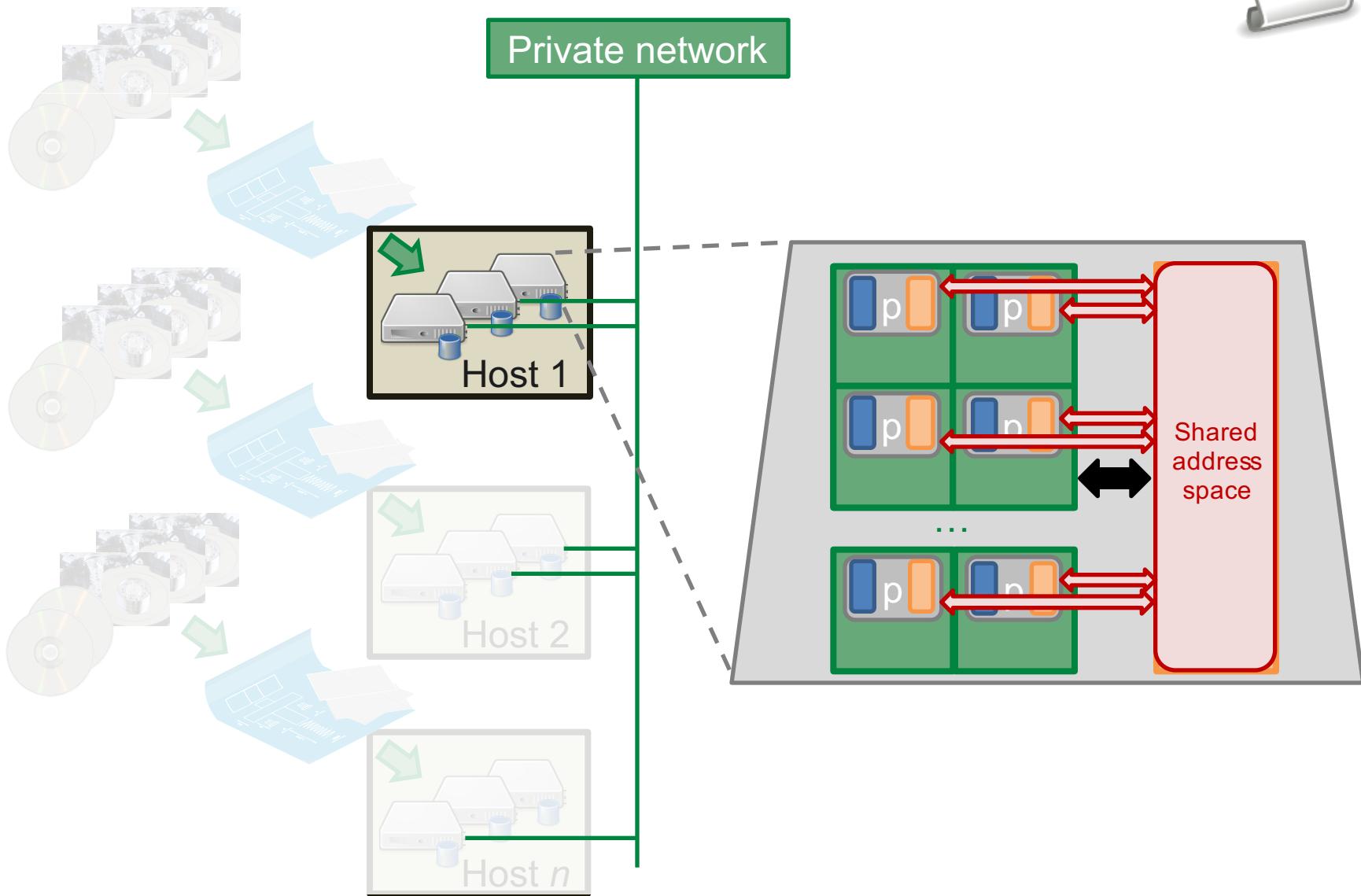


VMs

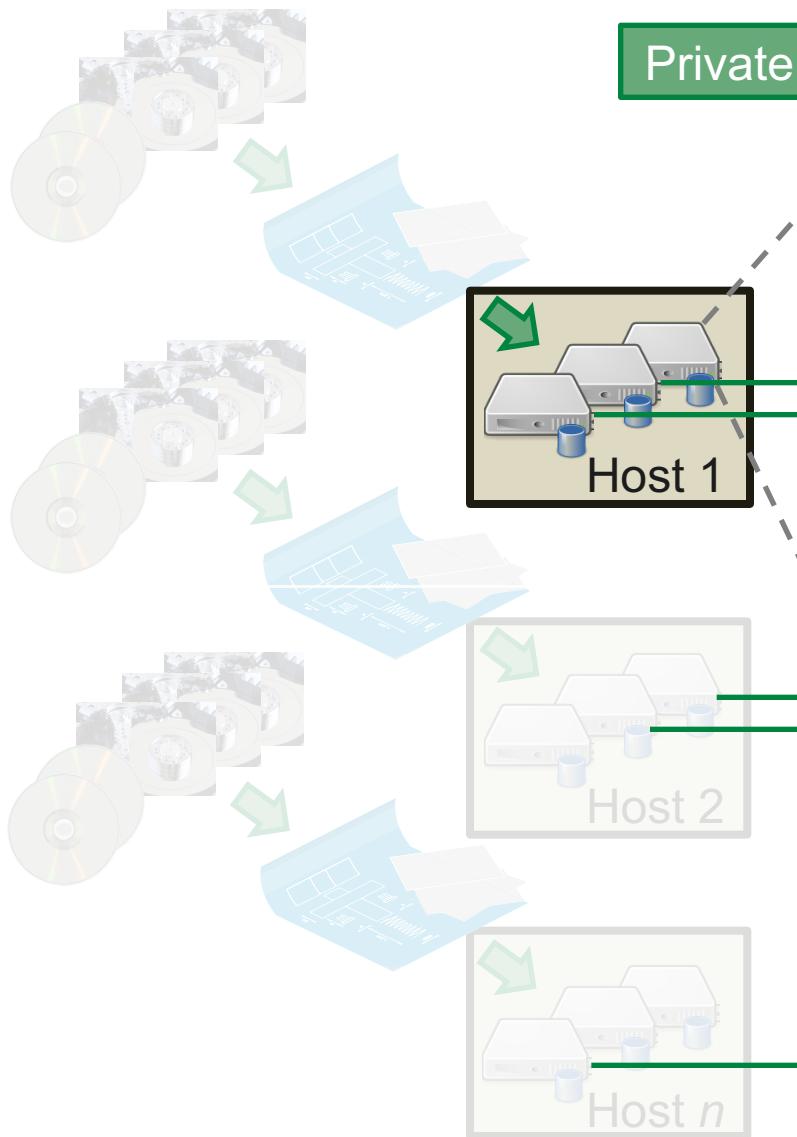
IaaS: your interconnected VMs



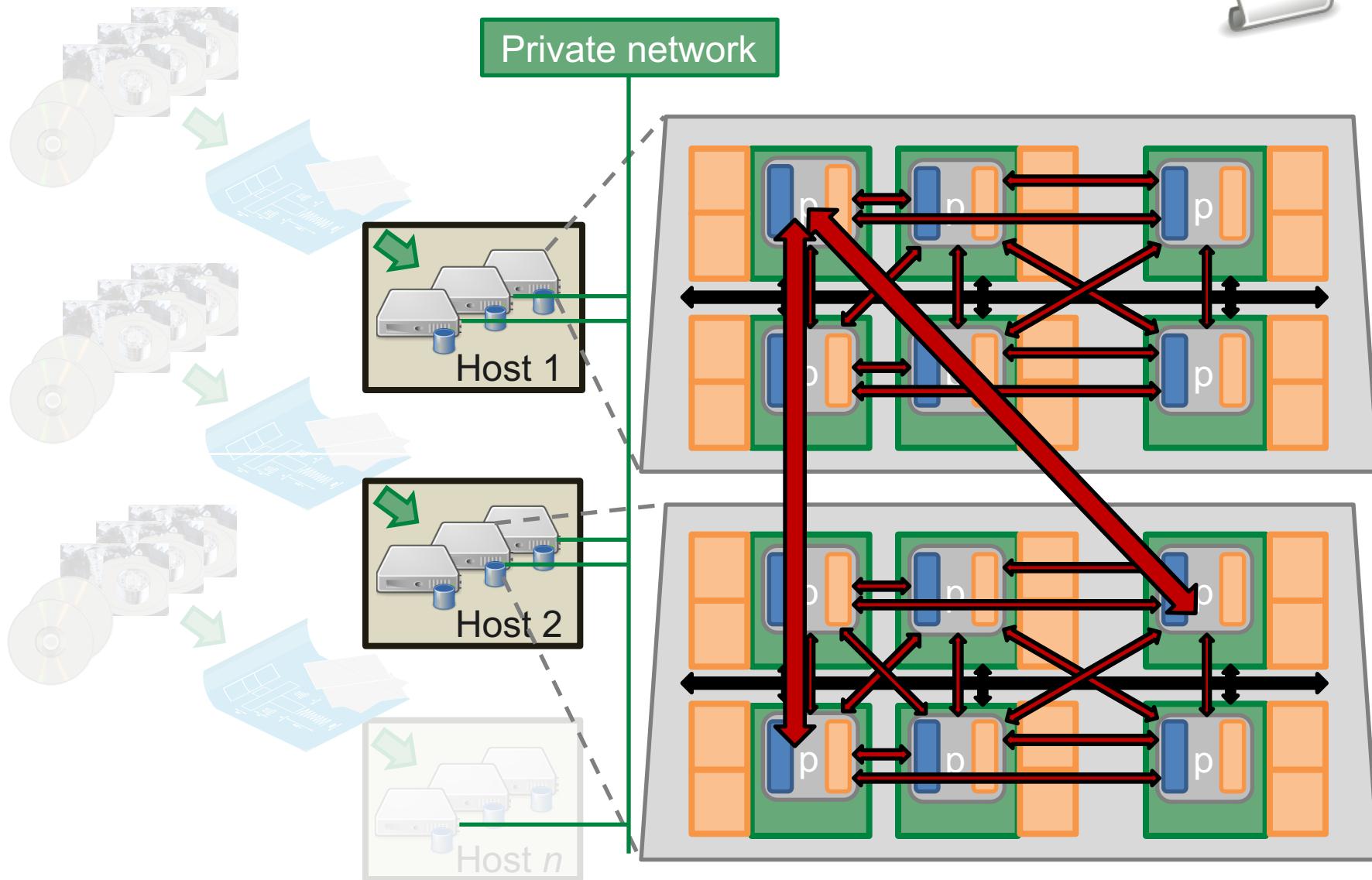
Example: OpenMP



Example: MPI



Example: MPI



Some thoughts

Parallel programming can be tricky:

- Need to know your **algorithm**
- Need to know your **data**
- Need to know your **architecture**

Try to **optimise**:

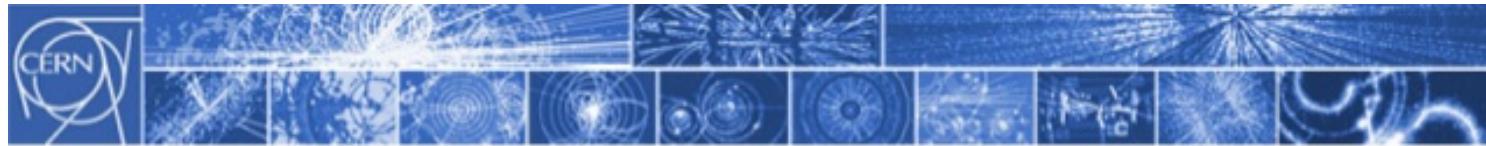
- Identify sequential **bottlenecks**
- Strive for **data** locality
- Identify **latencies**
- Minimise **communication**
- Be wary of **concurrency**:
 - **Deadlocks**
 - **Race conditions**
- Prepare for **failures**: machines, networks, timeouts...

So... you may as well be better off using a naïve approach! ☺

API overview

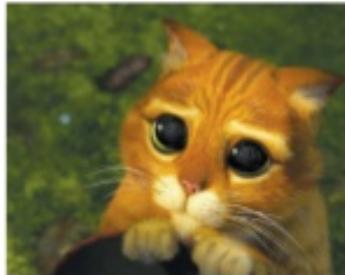


Why automation?



pets vs. cattle

Borrowed from
@randybias at Cloudscaling
<http://www.slideshare.net/randybias/the-cloud-revolution-cyber-press-forum-philippines>



- Pets are given names like `pussinboots.cern.ch`
- They are unique, lovingly hand raised and cared for
- When they get ill, you nurse them back to health



- Cattle are given numbers like `vm0042.cern.ch`
- They are almost identical to other cattle
- When they get ill, you get another one

- Future application architectures should use Cattle but Pets with strong configuration management are viable and still needed

Gavin McCance, CERN

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Description



OpenNebula

XML-RPC over http

- bindings for Java, Ruby (also Python, NodeJS...)
- **Methods** like `one.<object>.<action>`
 - e.g.: `one.vm.rename`
 - **Pools**, like: `one.vmpool.info`
- **Parameters**, position-based
- **Output**, a 3-tuple (A, B, C) where:
 - A: correct or error response
 - B: returned info (if correct);
error message (if error)
 - C: numeric error code

Operate/query on:

- Images
- Templates
- Virtual Machines
- Quotas
- ...

Demo

3



Example (I)



List my VMs

```
class VmList:  
    """A simple list of my VMs"""\n    ONE_ENDPOINT = 'http://ui.hpccloud.surfsara.nl:2633/RPC2'\n    ONE_USER = 'username' # replace this with yours\n    ONE_PASS = 'pass'     # replace this with yours\n    def __init__(self):\n        self.client = oca.Client(\n            self.ONE_USER + ':' + self.ONE_PASS, self.ONE_ENDPOINT)\n\n    def fetch_vms(self):\n        xml_string = self.client.call('vmpool.info', -3, -1, -1, -2)\n        root = ET.fromstring(xml_string)\n        return root\n\nif __name__ == '__main__':\n    xml = VmList()\n        .fetch_vms()\n    print(XmlUtil\n        .prettyify(xml))
```

| one.vmpool.info | | |
|-----------------|-----------|--|
| Type | Data Type | Description |
| IN | String | The session string. |
| IN | Int | Filter flag - <= -3: Connected user's resources - -2: All resources - -1: Connected user's and his group's resources - > = 0: UID User's Resources |
| IN | Int | When the next parameter is >= -1 this is the Range start ID. Can be -1. For smaller values this is the offset used for pagination. |
| IN | Int | For values >= -1 this is the Range end ID. Can be -1 to get until the last ID. For values < -1 this is the page size used for pagination. |
| IN | Int | VM state to filter by. |

Example (and II)



List my VMs
(output)

```
<VM_POOL>
  <VM>
    <ID>164</ID>
    <UID>247</UID>
    <GID>108</GID>
    <UNAME>ander</UNAME>
    <GNAME>workshop</GNAME>
    <NAME>Ubuntu-15.04</NAME>
    ...
    <LCM_STATE>3</LCM_STATE>
    <TEMPLATE>
      <CPU>...</CPU>
      ...
      </TEMPLATE>
    </VM>
    <VM>...</VM>
    ...
  </VM_POOL>
```

Request: <https://e-infra.surfsara.nl>
UI: <https://ui.hpccloud.surfsara.nl>
Doc: <https://doc.hpccloud.surfsara.nl>

Credits

Images: Wikipedia, Science Park, RRZE icons, NIST, nVidia, Ceph, publicdomainpictures.net, publicdomainvectors.org, cs.unc.edu/~weicheng
Slides: SURFsara colleagues, CERN

Ander Astudillo
[<ander.astudillo@surfsara.nl>](mailto:ander.astudillo@surfsara.nl)

<<EOF



Practicalities:

Start at: <http://doc.hpccloud.surfsara.nl/UvA-course-20160615>

Work *in pairs*

each with your own credentials on your own laptop

Follow *the instructions at your own pace*

*focus on **Part B** and **Extras** after lunch*

Call *Natalie, Markus, Nuno and Ander*

for: a) doubts; b) when feeling stuck; c) “food for brain” hints

UI: <https://ui.hpccloud.surfsara.nl>

Project: surfcursus

Username: surfcourseXZ

Password: hpc@cloudXZ

tutorial

SURF SARA

Appendix



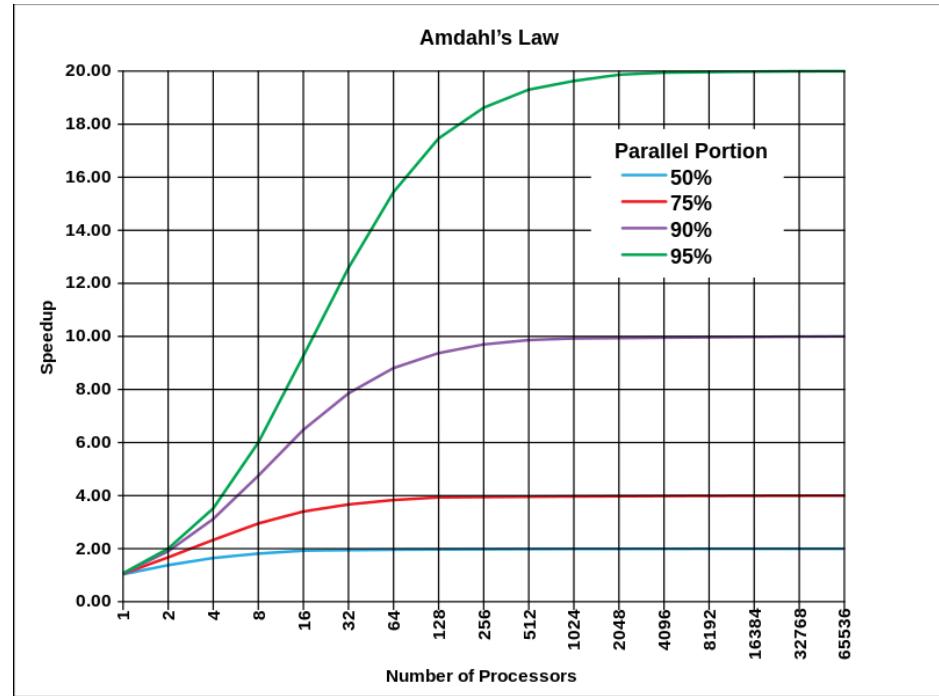
Amdahl's law

$$T(s) = (1 - p)T + \frac{p}{s}T.$$

- $T(s)$: running time after an improvement of s
- s : speedup factor of parallel part
- p : % of the program that is parallel
- T : original running time
- W : fixed workload

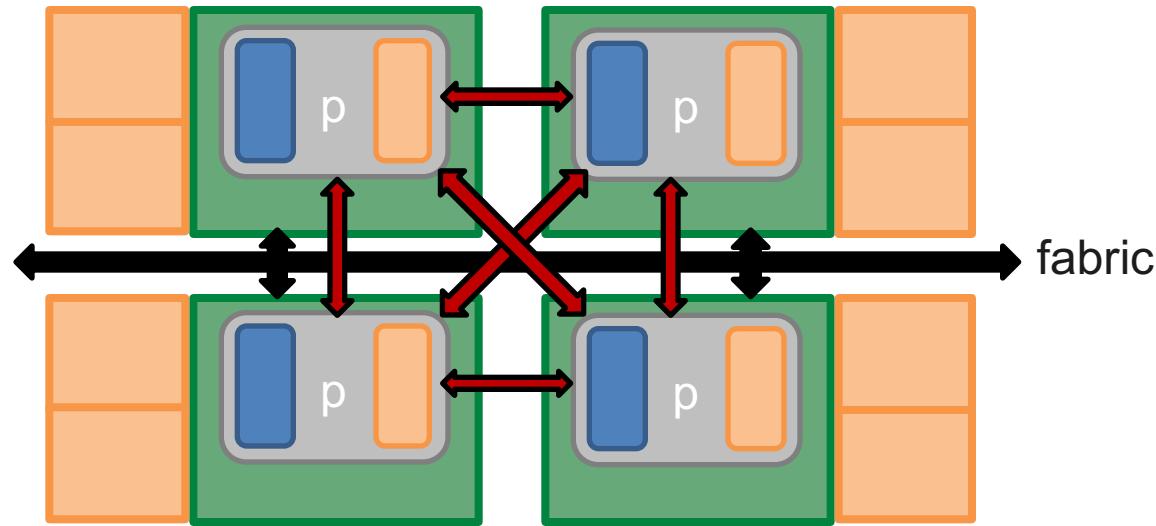
It's mainly the **algorithm** that defines speedup; rather than the amount of processors

$$S_{\text{latency}}(s) = \frac{TW}{T(s)W} = \frac{T}{T(s)} = \frac{1}{1 - p + \frac{p}{s}}.$$



Speedup is limited by the serial part of the program. E.g., if 95% of the program can be parallelised, the theoretical maximum speedup using parallel computing would be 20 times.

NUMA



Processes
communicate
over the fabric