

Cloudy systems

— Taking the most out of the HPC Cloud



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Recap: defining cloud computing

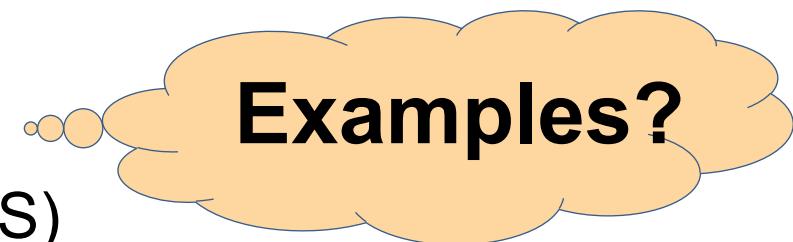
Essential characteristics:

- 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?

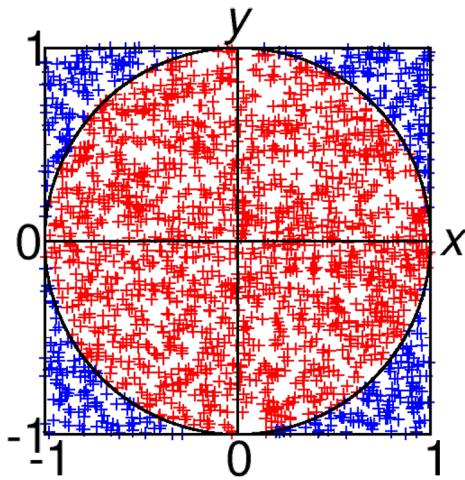
...elasticity

- 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

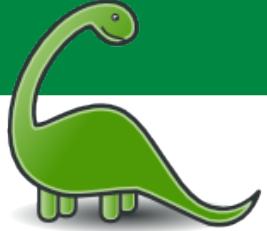
3.- Demo



Scaling possibilities



The concept (I)



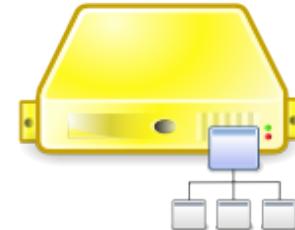
Your **application**
may need more...



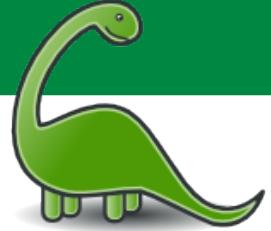
Scale up

vs.

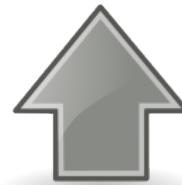
Scale out



The concept (II)



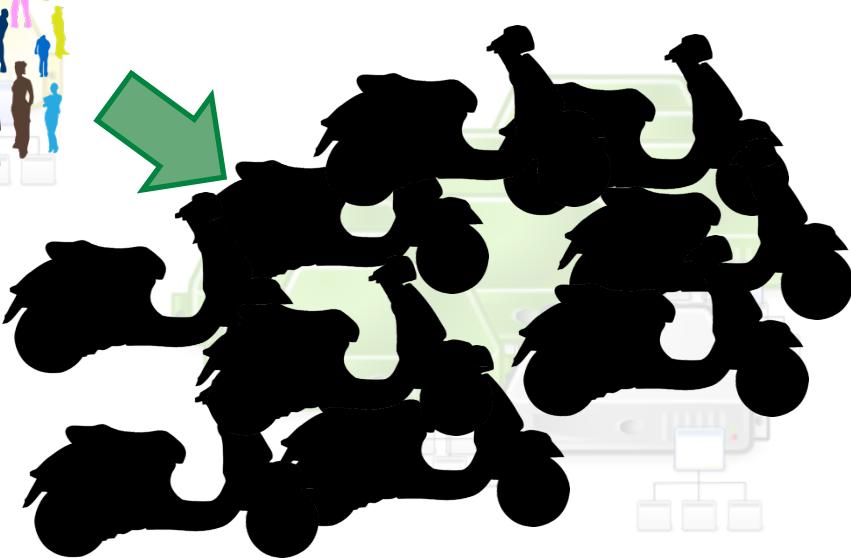
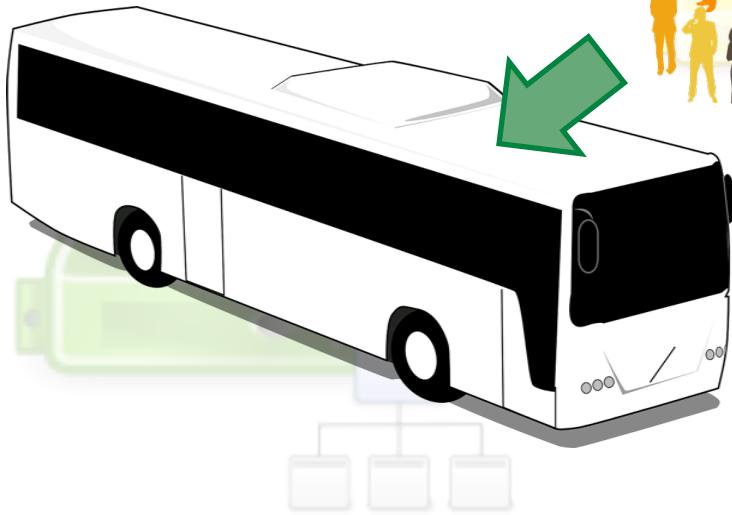
e.g. **transport people**
may need more room...



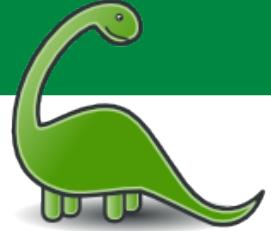
Scale up

vs.

Scale out



The concept (and III)



e.g. **transport people**

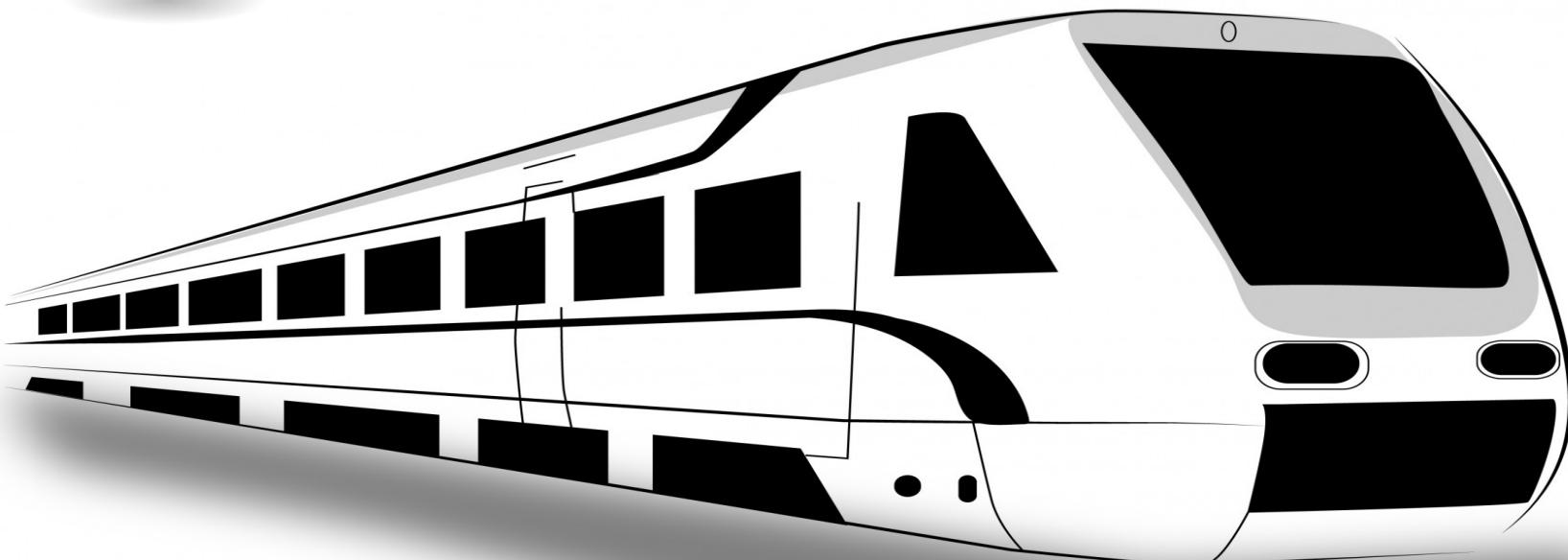
may need more room...



Scale up

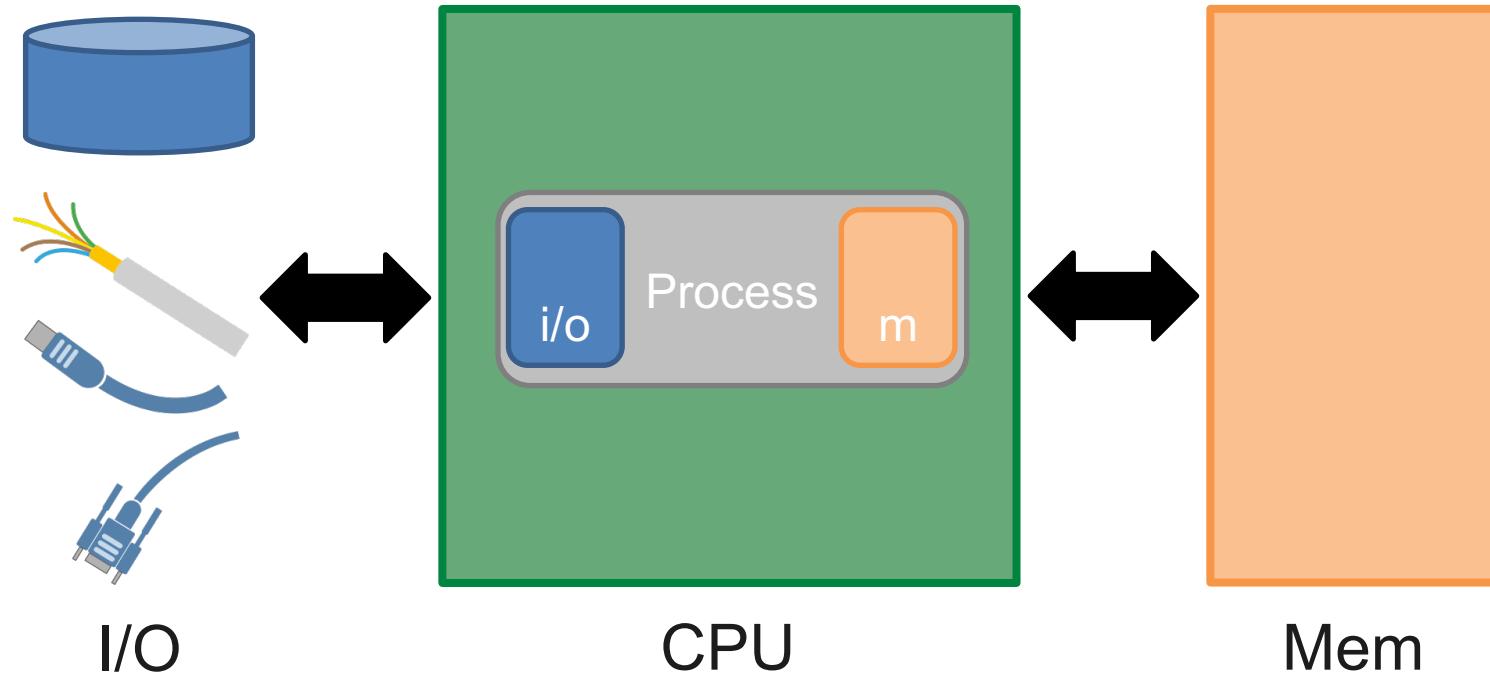
AND

Scale out



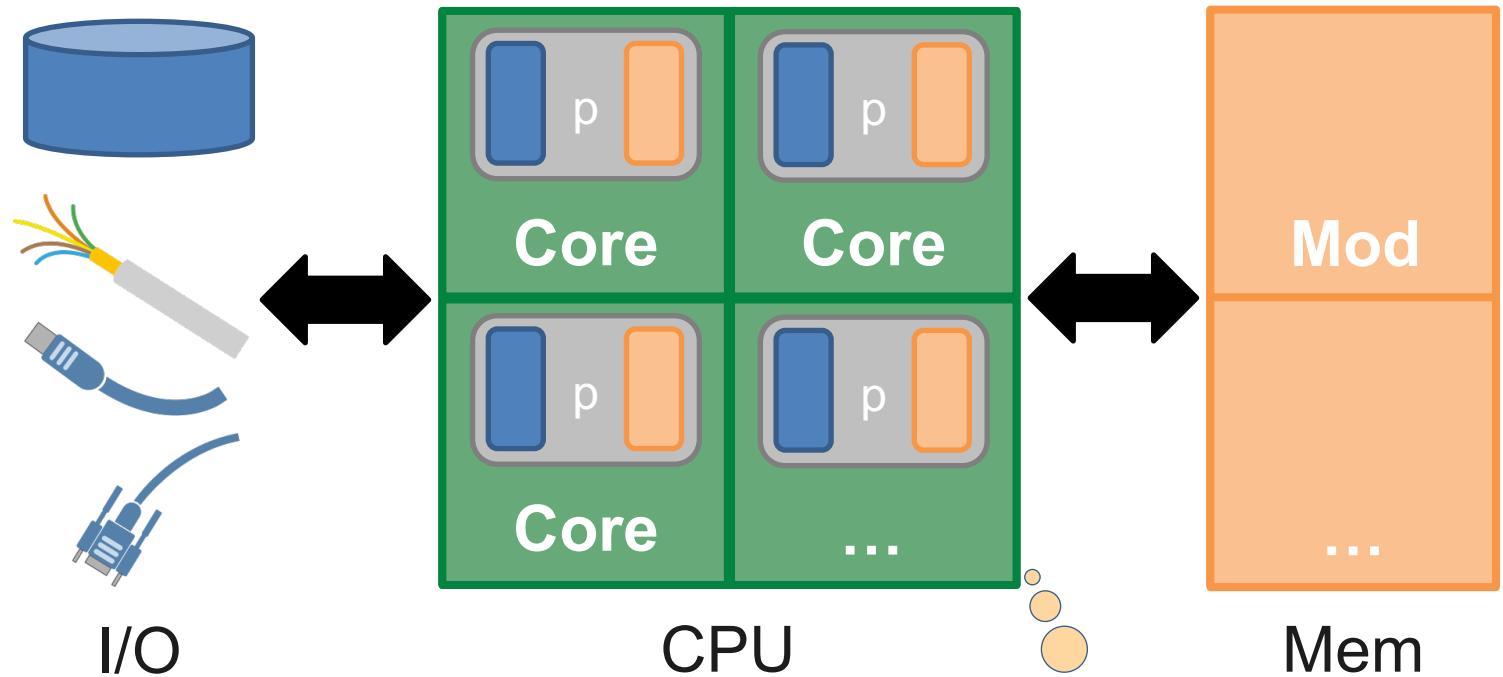
Some theory (I)

Meet: the CPU



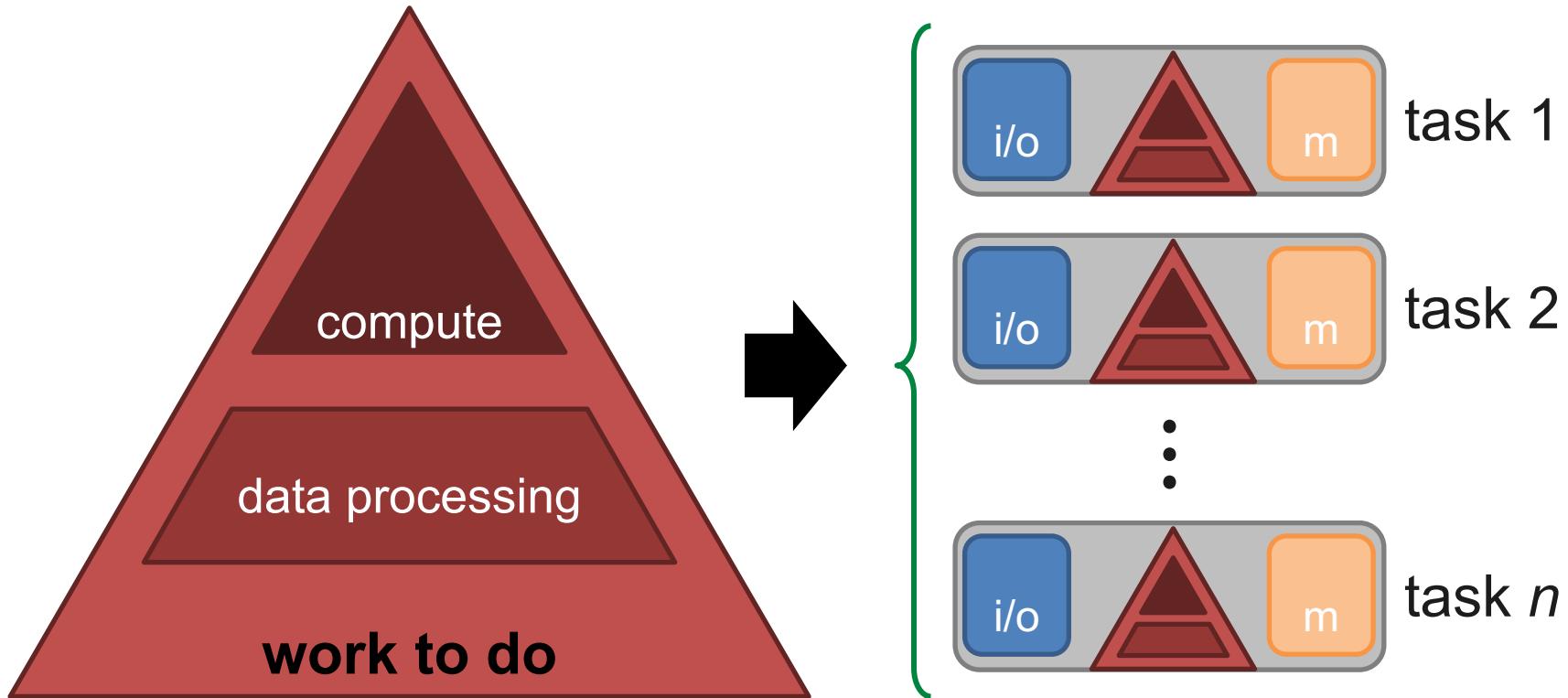
Some theory (and II)

Meet: **parallel** processing



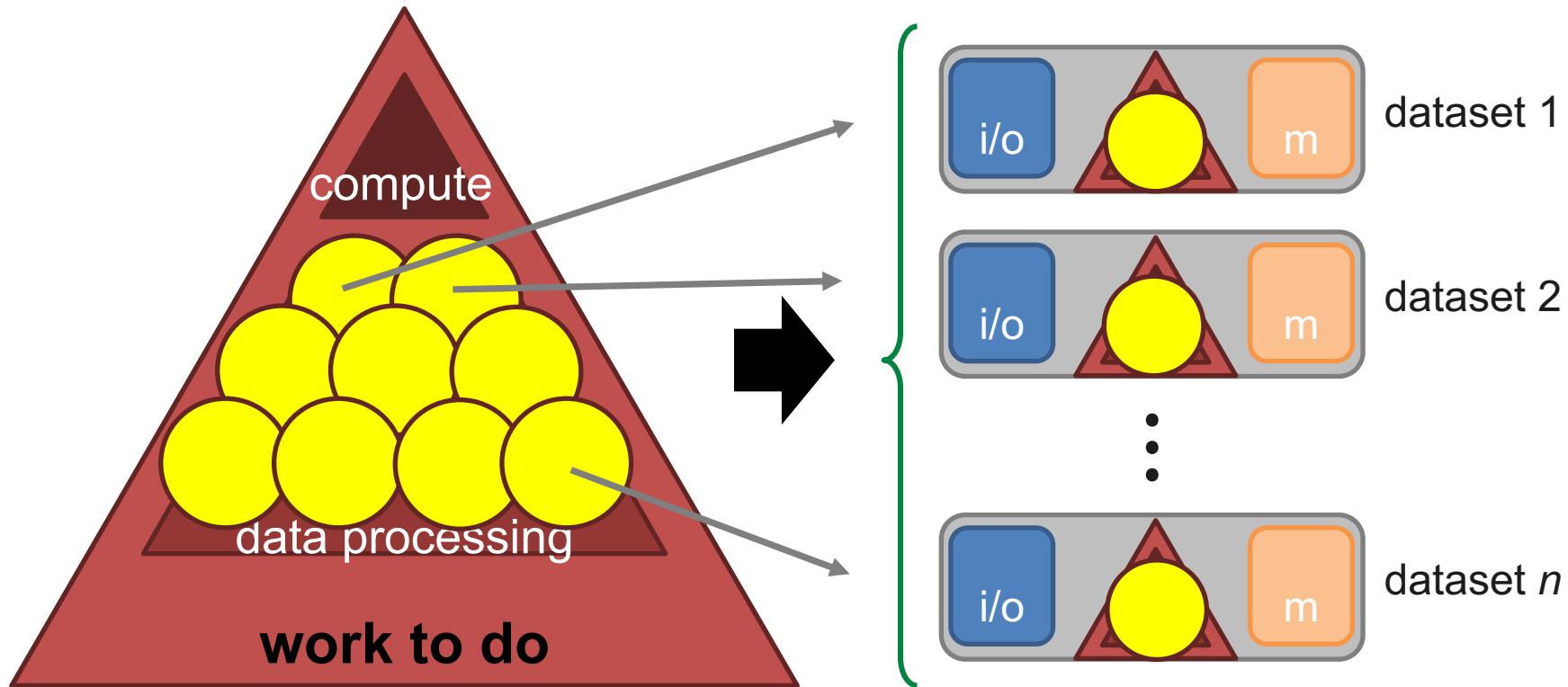
Dividing work (I)

Parallelism: task partitioning



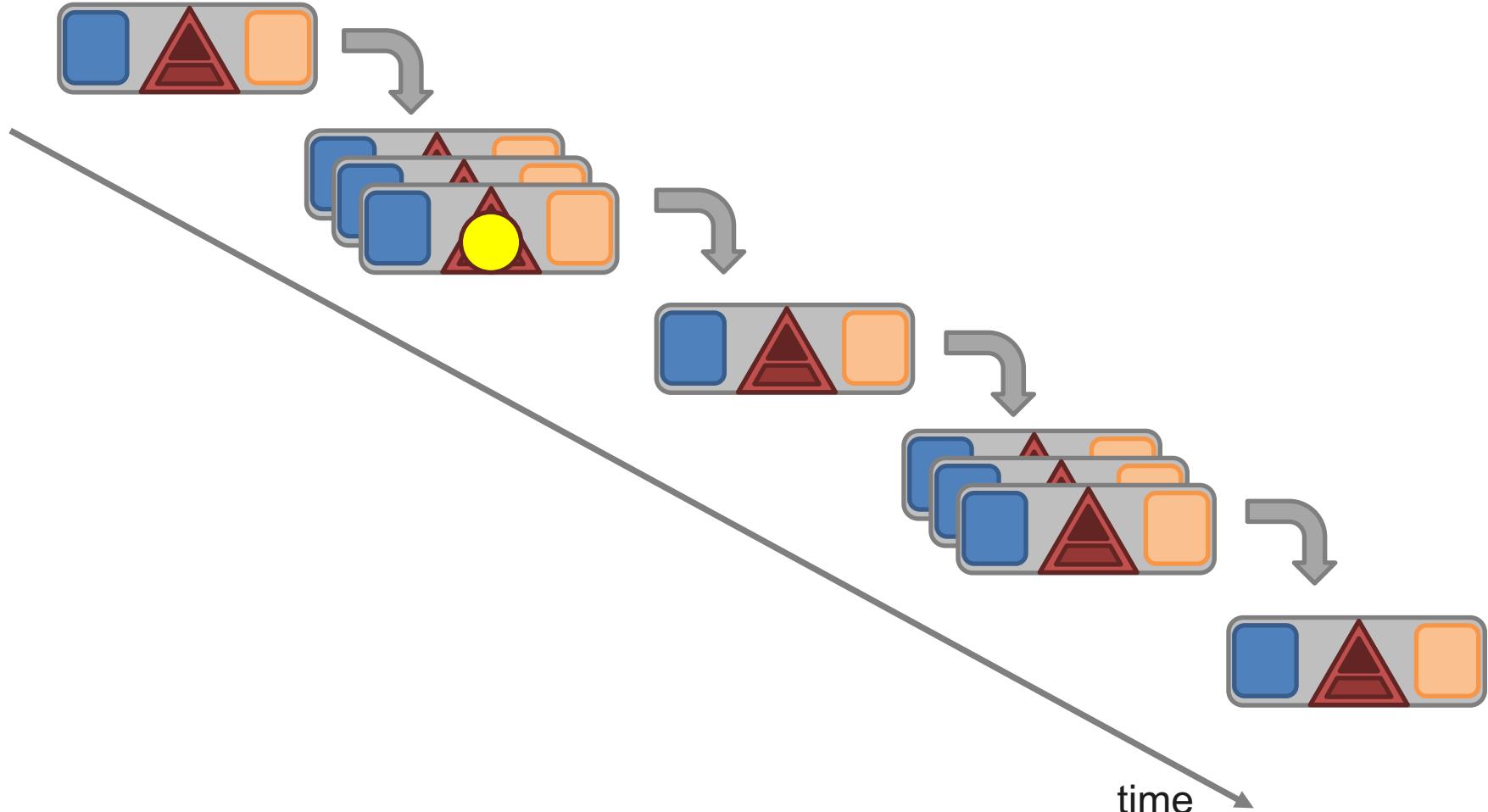
Dividing work (II)

Parallelism: **data** partitioning



Dividing work (and III)

Example: a possible parallel program (or workflow)



Parallel programming

Very complex
to do yourself!

Technique: **shared memory**

e.g.: **OpenMP**

Technique: **message-passing**

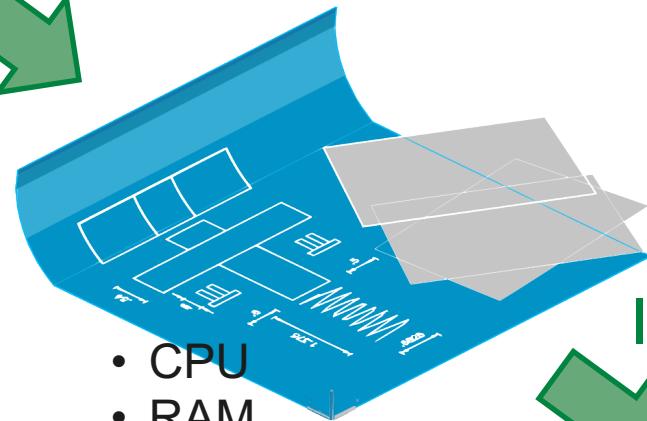
e.g.: **MPI**

IaaS: Your place to run VMs



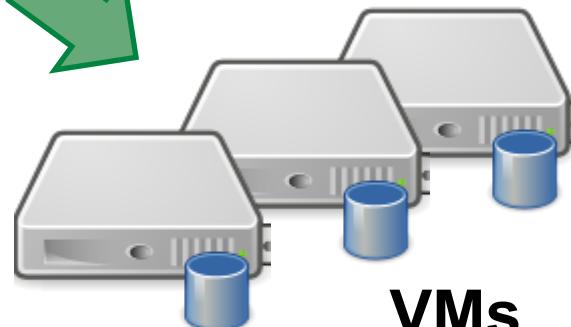
- Data store
- Persistence
- ...

Images



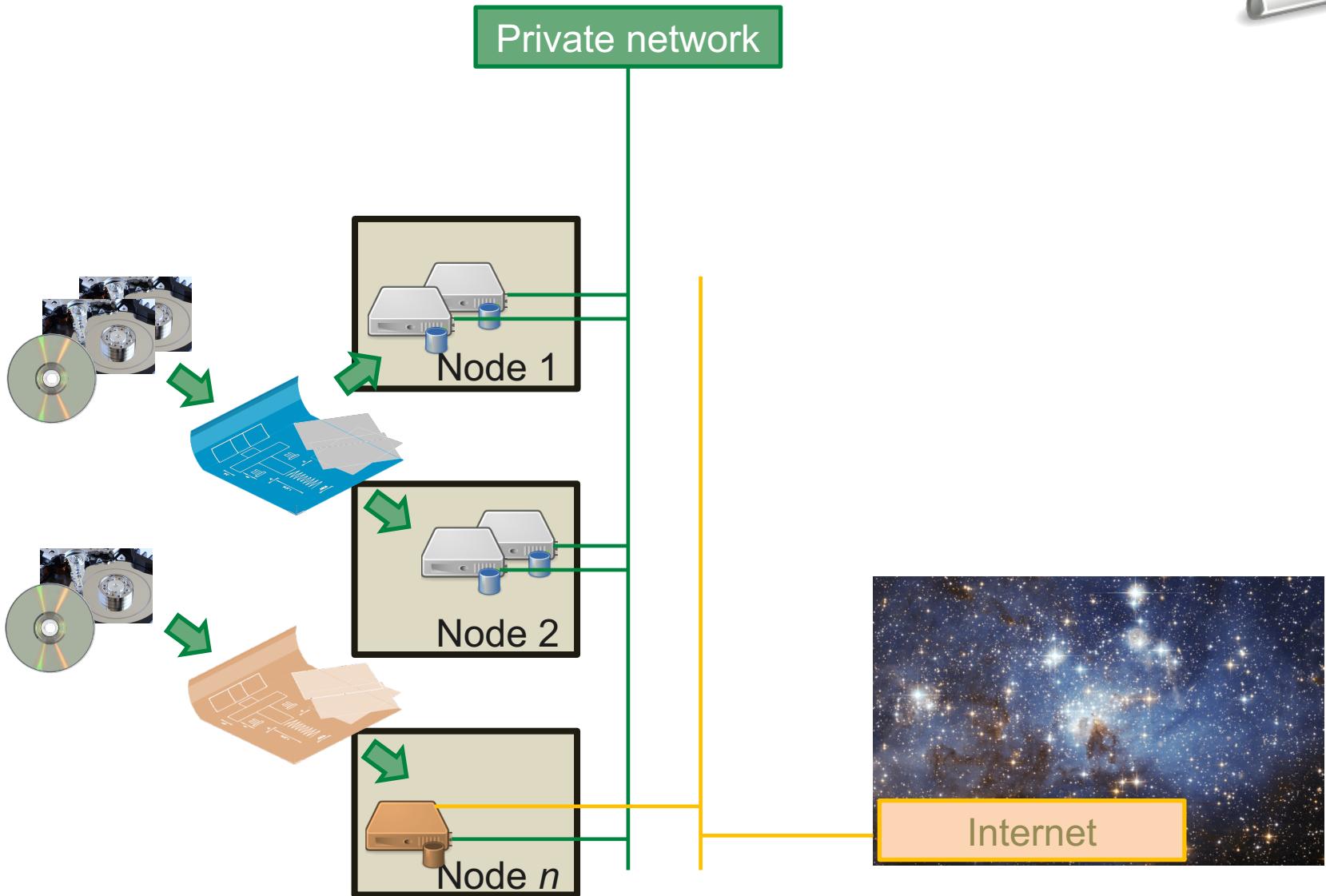
Template

Instantiate



VMs

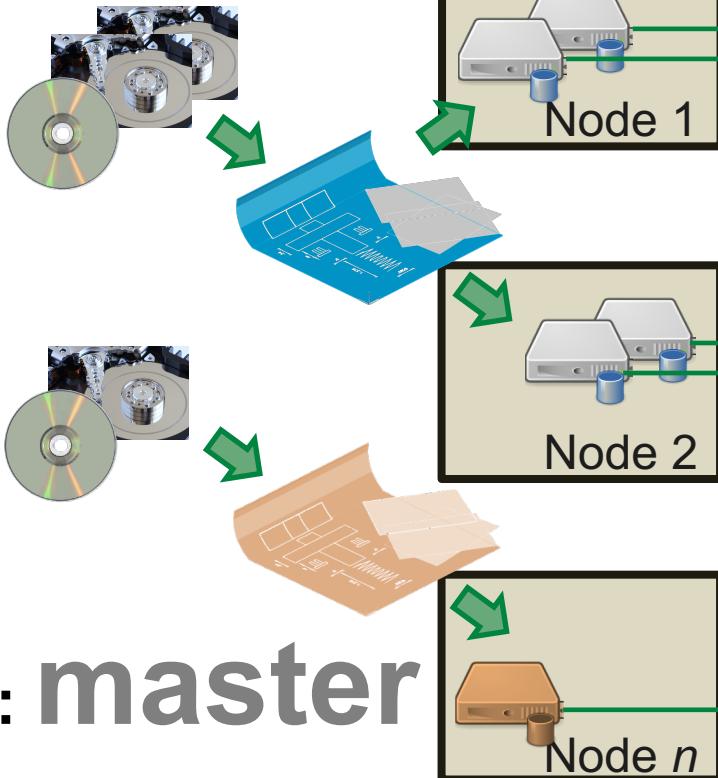
IaaS: your interconnected VMs



IaaS: master-workers set-up



e.g.: **workers**



e.g.: **master**

Each **worker** receives work to do from the master and actually does the heavy lifting

The **master** orchestrates work to/from each of the workers

Some thoughts

Parallel programming can be tricky:

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

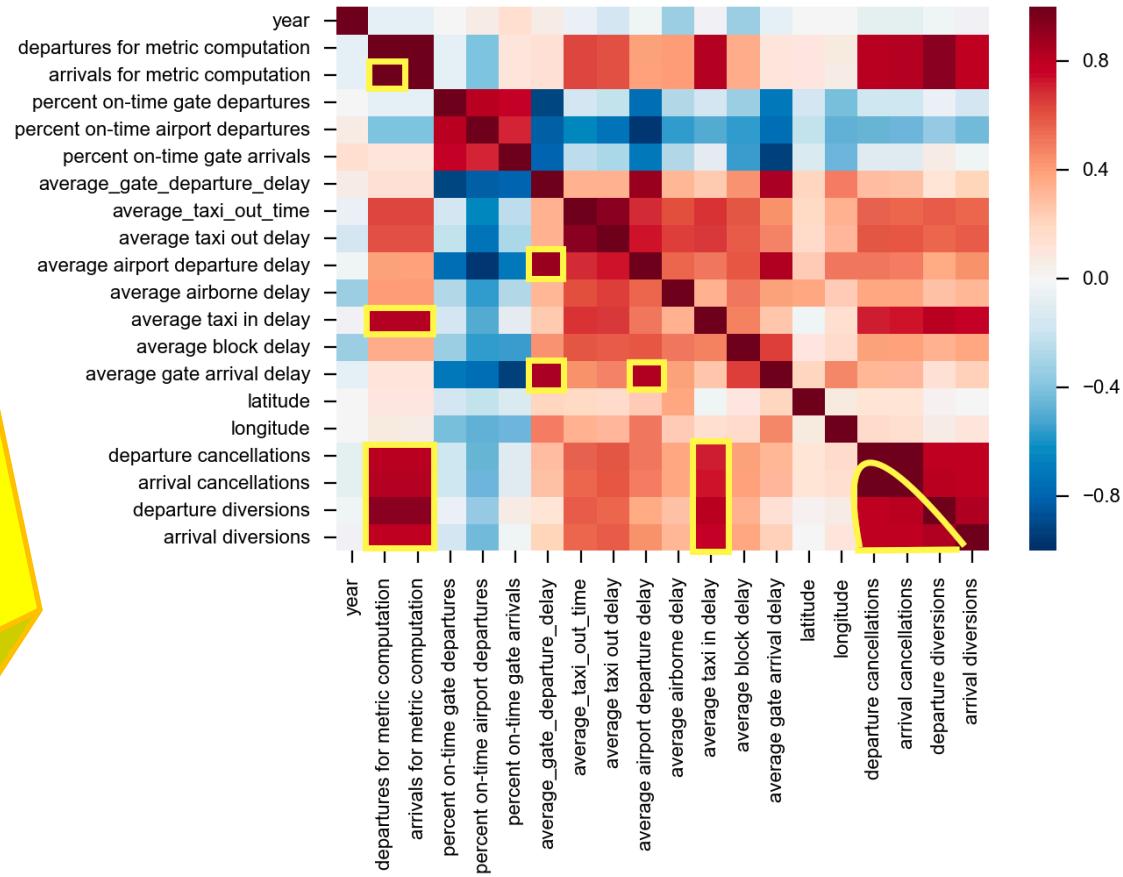
Try to **optimise**:

- 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!** ☺

Principal Component Analysis (PCA) in a nutshell

We want to reduce
the dimensionality
of the data without
losing variance.😊

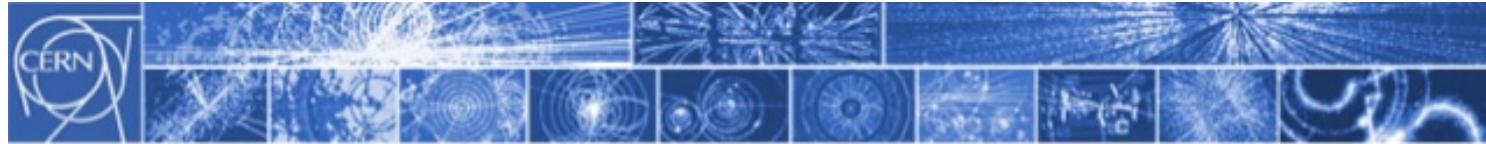


- http://www.stefan-evert.de/PUB/Handout_LA_Trento_3.pdf
- <https://gmaclenn.github.io/articles/airport-pca-analysis/>

API overview

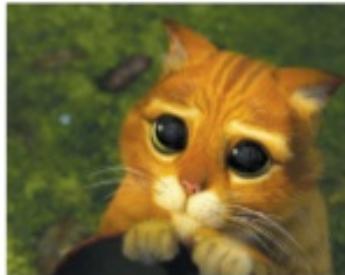


Why automation?



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

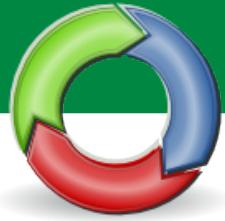


- Cattle are given numbers like `vm0042.cern.ch`
 - They are almost identical to other cattle
 - When they get ill, you get another one
-
- Future application architectures should use Cattle but Pets with strong configuration management are viable and still needed

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:

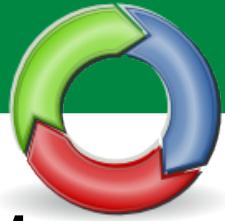
- Images
- Templates
- Virtual Machines
- Quotas
- ...

Demo

3



Example (I)



List my VMs

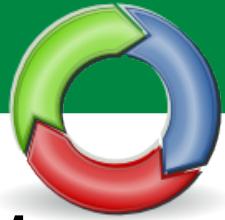
```
class VmList:  
    """A simple list of my VMs"""\n    ONE_ENDPOINT = 'http://ui.hpccloud.surfsara.nl:2633/RPC2'\n    ONE_USER = 'username' # replace this with yours\n    ONE_PASS = 'pass'     # replace this with yours\n    def __init__(self):  
        self.client = oca.Client(  
            self.ONE_USER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

one.vmpool.info

- Description: Retrieves information for all or part of the VMs in the pool.
- Parameters

| 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

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Appendix



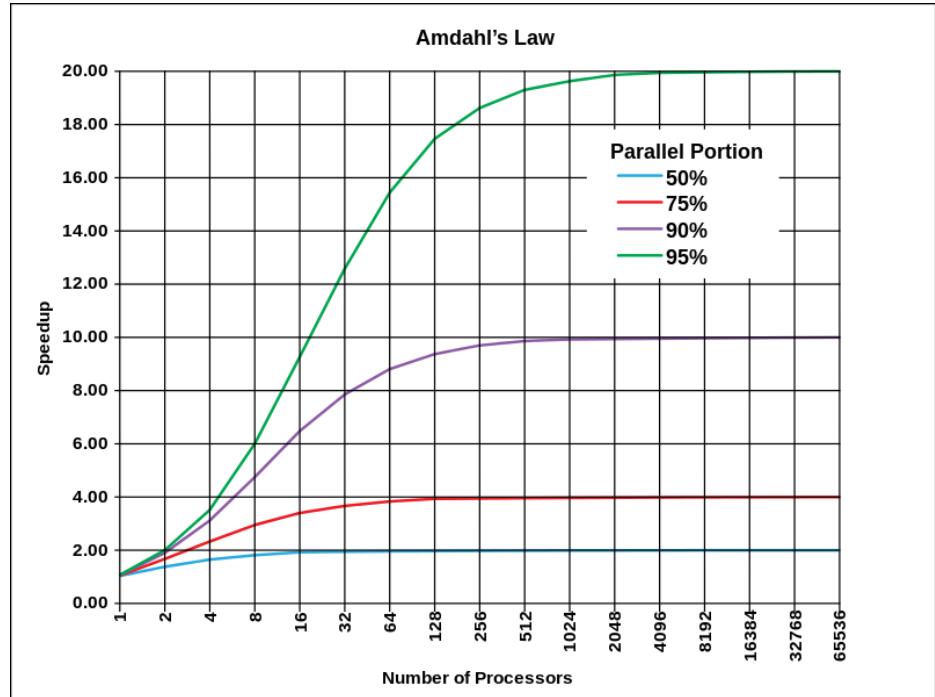
Amdahl's law

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

- $T(s)$: 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.