The Sky's the Limit:

Preserving Research Data with Clouds

describing

HEP Legacy Data Project

Network-Enabled Programs Project

funded by

canarie

Canada's Advanced Research and Innovation Network
Le réseau évolué de recherche et d'innovation du Canada

HEP Legacy Data Project team

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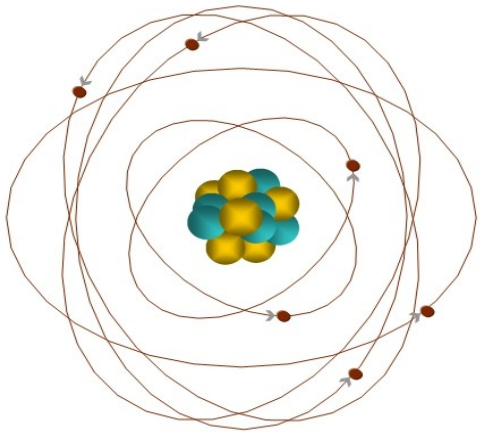
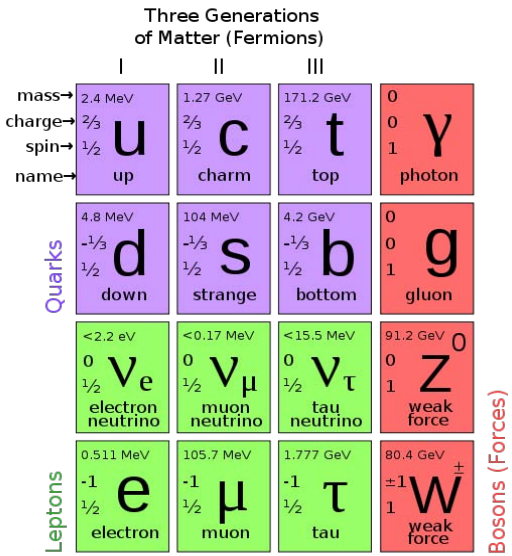
...and not forgetting our photographer

Ian Gable (UVIC)

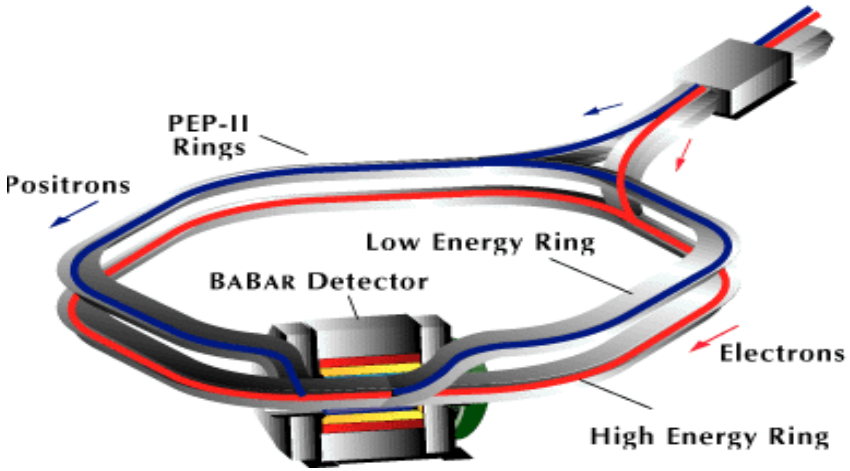
The Big Bang and matter/anti-matter asymmetry

- Big Bang produce matter & anti-matter
- But today only matter
- Where did all the anti-matter go?

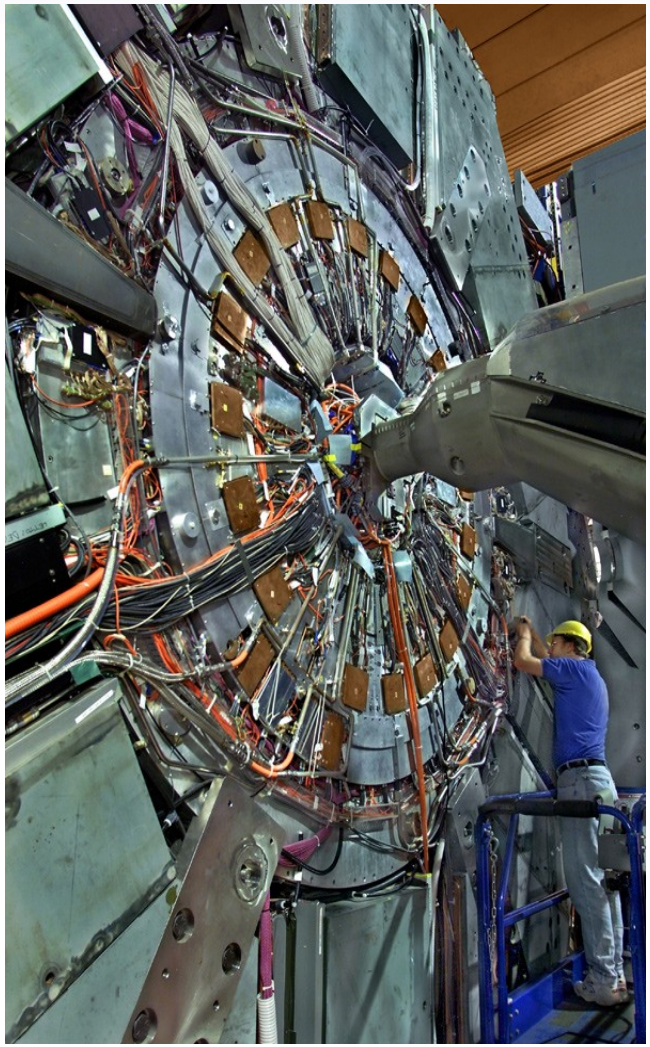




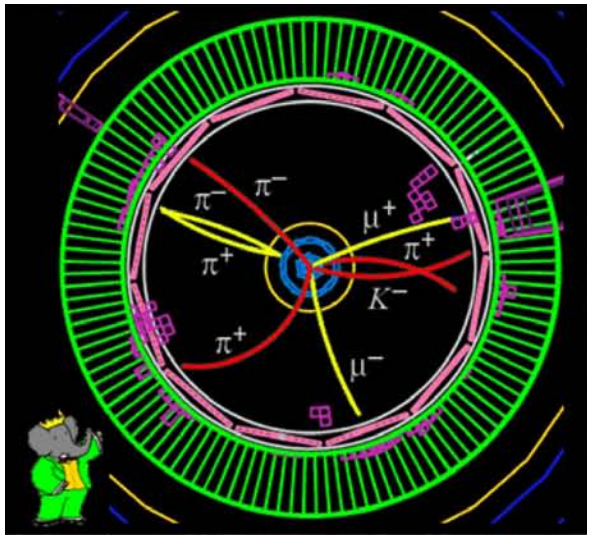
SLAC colliding matter with anti-matter



Recording the data with the BaBar detector



- Electron/positron collision
- ~500 TB data captured, 2000 to 2008



The Language of Particle Physicists

Mathematics & Histograms

$$A = \sum_{(ijk)}^{\text{cyclic}} \frac{-8J_r\Delta_{21}[\Delta_{31}\lambda_k(\lambda_k-\Delta_{31})+A_k^{(1)}]}{\tilde{\Delta}_{jk}^2\tilde{\Delta}_{ki}^2}\cos\left(\frac{\tilde{\Delta}_{ij}L}{4E}\right)\sin\left(\frac{\tilde{\Delta}_{jk}L}{4E}\right)\sin\left(\frac{\tilde{\Delta}_{ki}L}{4E}\right)$$

$$B = \frac{8\Delta_{12}\Delta_{23}\Delta_{31}}{\tilde{\Delta}_{12}\tilde{\Delta}_{23}\tilde{\Delta}_{31}}J_r\sin\left(\frac{\tilde{\Delta}_{12}L}{4E}\right)\sin\left(\frac{\tilde{\Delta}_{23}L}{4E}\right)\sin\left(\frac{\tilde{\Delta}_{31}L}{4E}\right),$$

$$C = \sum_{(ij)}^{\text{cyclic}} \frac{-4[s_{13}^2(s_{23}^2c_{13}^2\Delta_{31}^2\lambda_i\lambda_j + C_{ij}^{(1)} + C_{ij}^{(2a)}$$

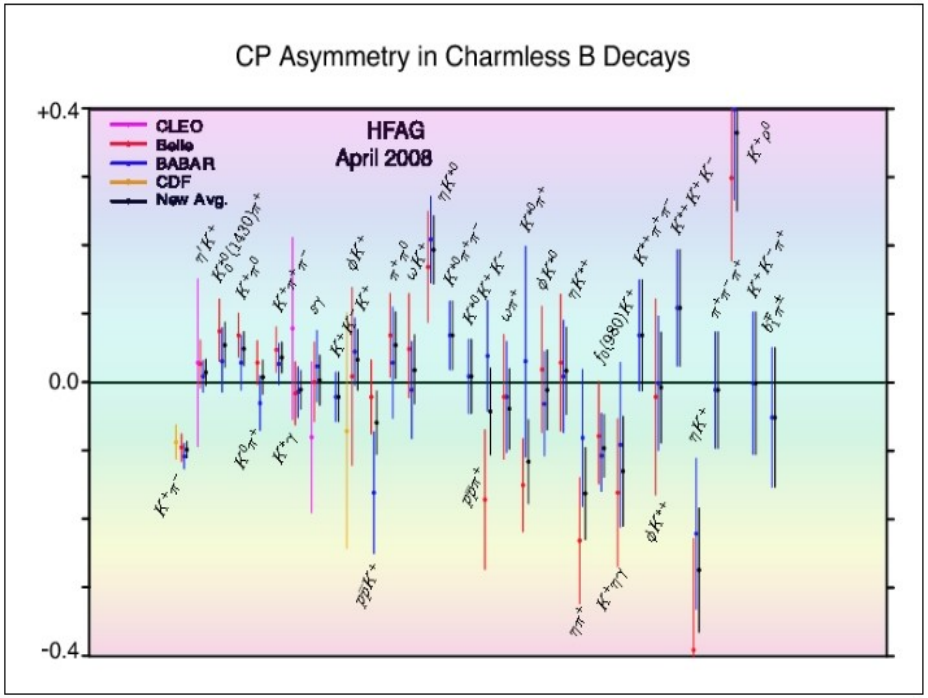
where $J_r = s_{12}c_{12}s_{23}c_{23}s_{13}c_{13}^2$, and

$$A_k^{(1)} = \Delta_{21}\{\Delta_{31}\lambda_k(c_{12}^2-s_{12}^2)+\lambda_k^2s_{12}^2$$

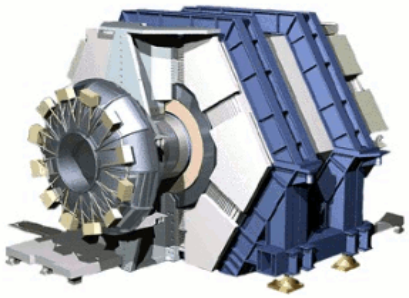
$$C_{ij}^{(1)} = \Delta_{21}\Delta_{31}\{-\lambda_i(\lambda_j s_{12}^2+\Delta_{31}c_{12}^2)$$

$$C_{ij}^{(2a)} = \Delta_{21}^2(\lambda_i s_{12}^2+\Delta_{31}c_{12}^2)(\lambda_j s_{12}^2+$$

$$C_{ij}^{(2b)} = \Delta_{21}^2(\lambda_i-\Delta_{31})(\lambda_j-\Delta_{31})s_{12}^2c_{1}$$



BaBar Software Chain



Data is collected AND simulated.

The event reconstruction program interprets the raw electric charges collected by the detector and uses pattern recognition to form tracks.

Raw Data Files

Reconstructed Events (ROOT)

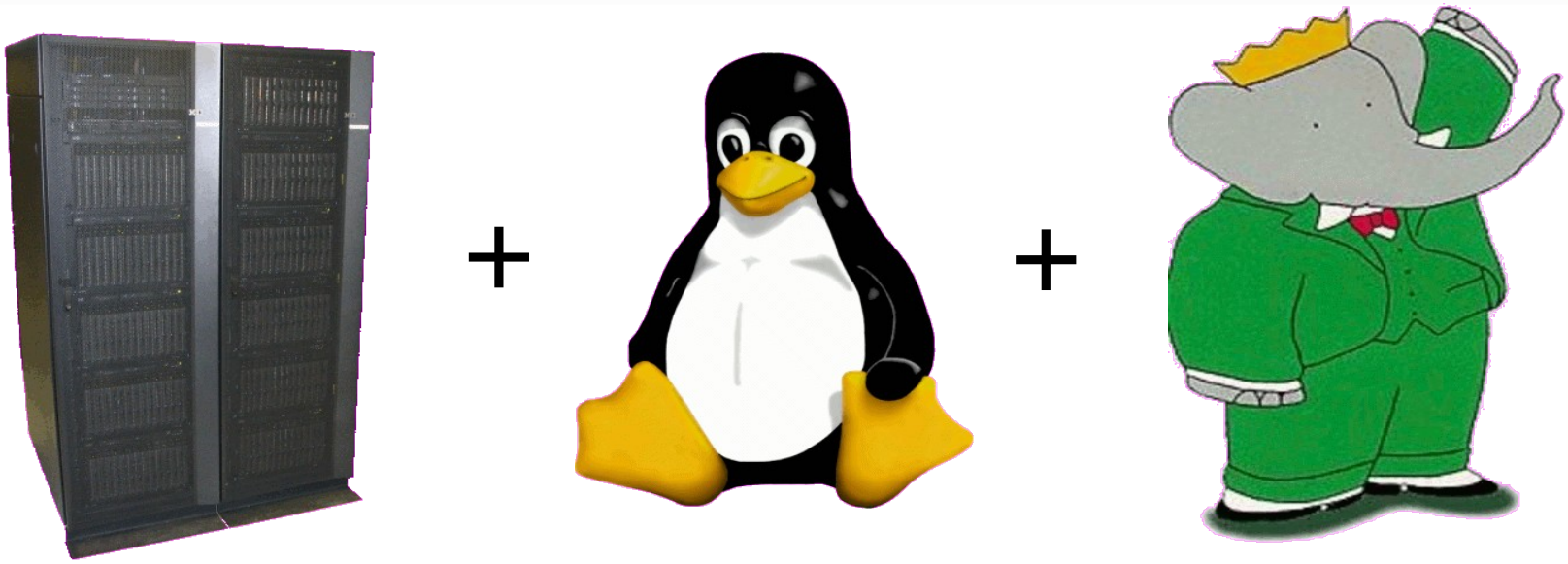
Events are characterized by the topology of the tracks in the detector and new files are created that contain only specific types of events.

Users write code to examine the tracks in the detector and extract physics from this information.

Skimmed Events (ROOT)

User Output (Histograms, etc...)

BaBar is a Complex Application

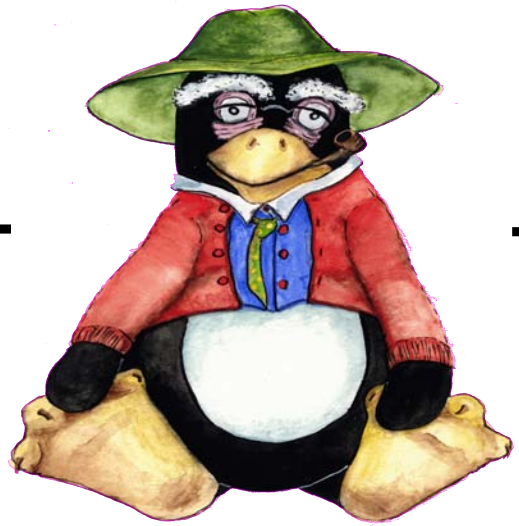


Issues:

- 9.5 million lines of C++ & Fortran
- Requires particular OS, compiler, & library levels
- Certification of environment required
- Not easy to share environment
- Sysadmins almost need to become application specialists

What to do about aging environment?

+



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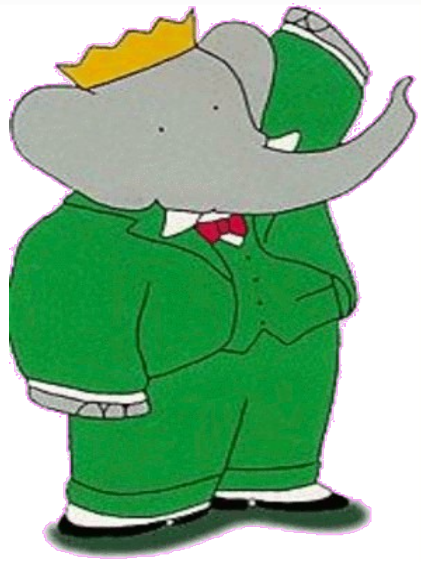
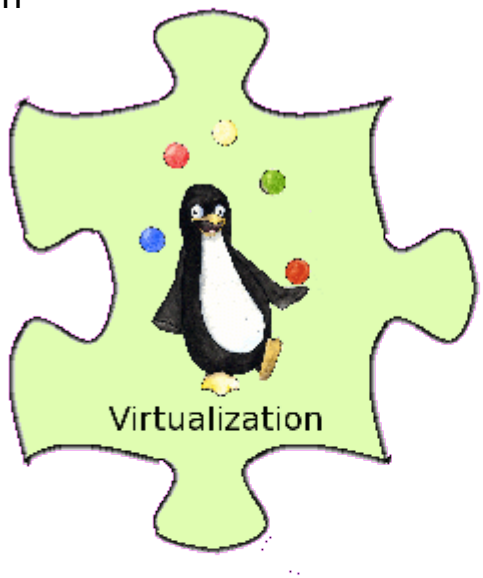


Goals:

- Keep running for the next 5 to 10 years
- Able to use any available resource
- Easy to adopt (for everyone)

Four pieces needed for our solution:

- Application encapsulation
- Image replication
- User control
- Resource utilization
- Xen, KVM, etc.



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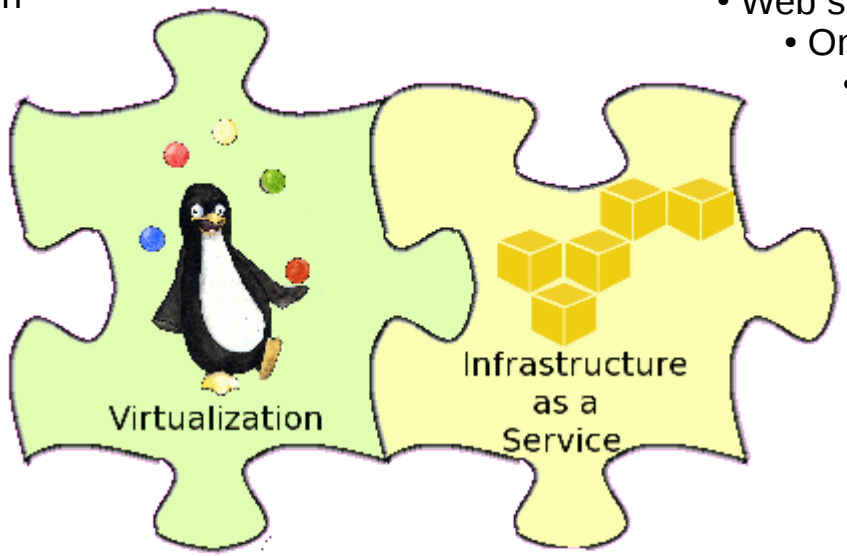

- Web service to manage VMs
  - One interface per cluster
    - Nimbus, Eucalyptus, OpenNebula, EC2

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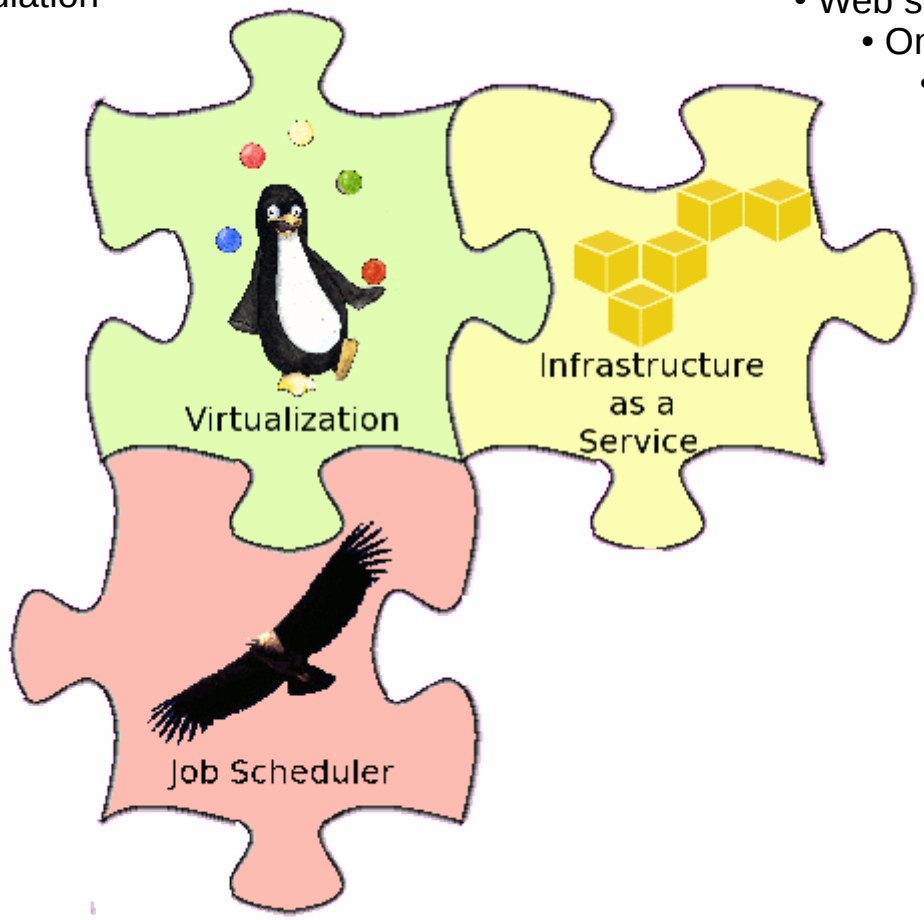

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- Dynamic resources
- Needs good API
- Condor, SGE

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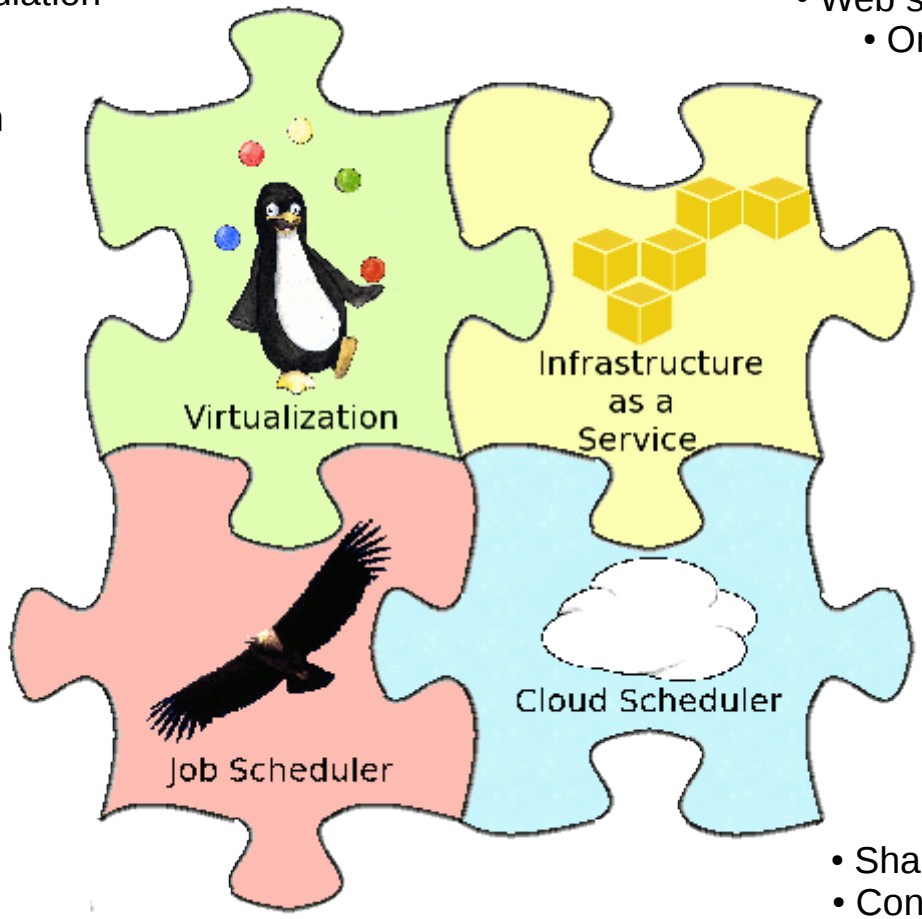

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- One interface per cluster
- Nimbus, Eucalyptus, OpenNebula, EC2

- Dynamic resources
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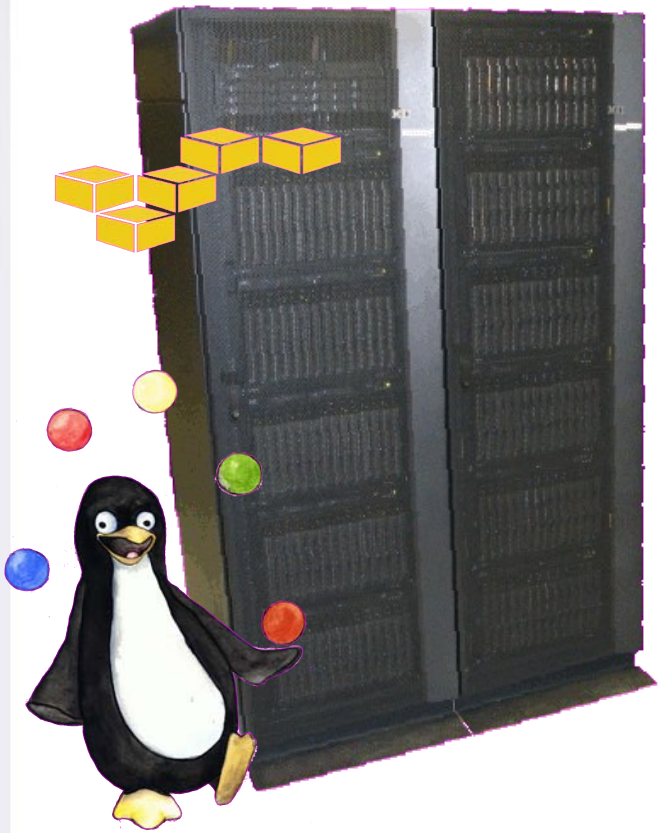
- Condor, SGE

- Shares clouds among users
- Controls distributed clouds

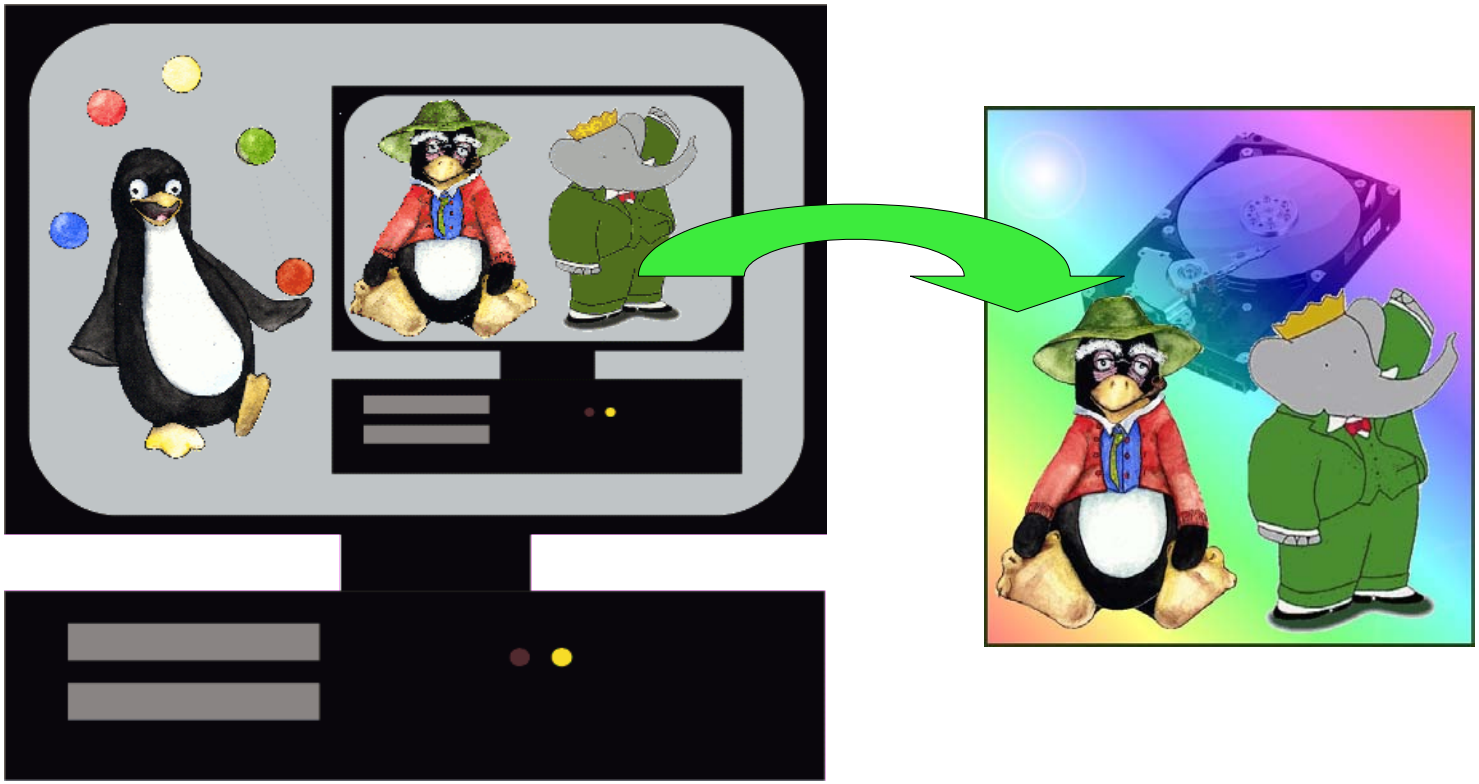
How does it work?

1. Preparation of cloud infrastructure



How does it work?

2. Preparation of virtual machine images



How does it work?

3. User creates a job script

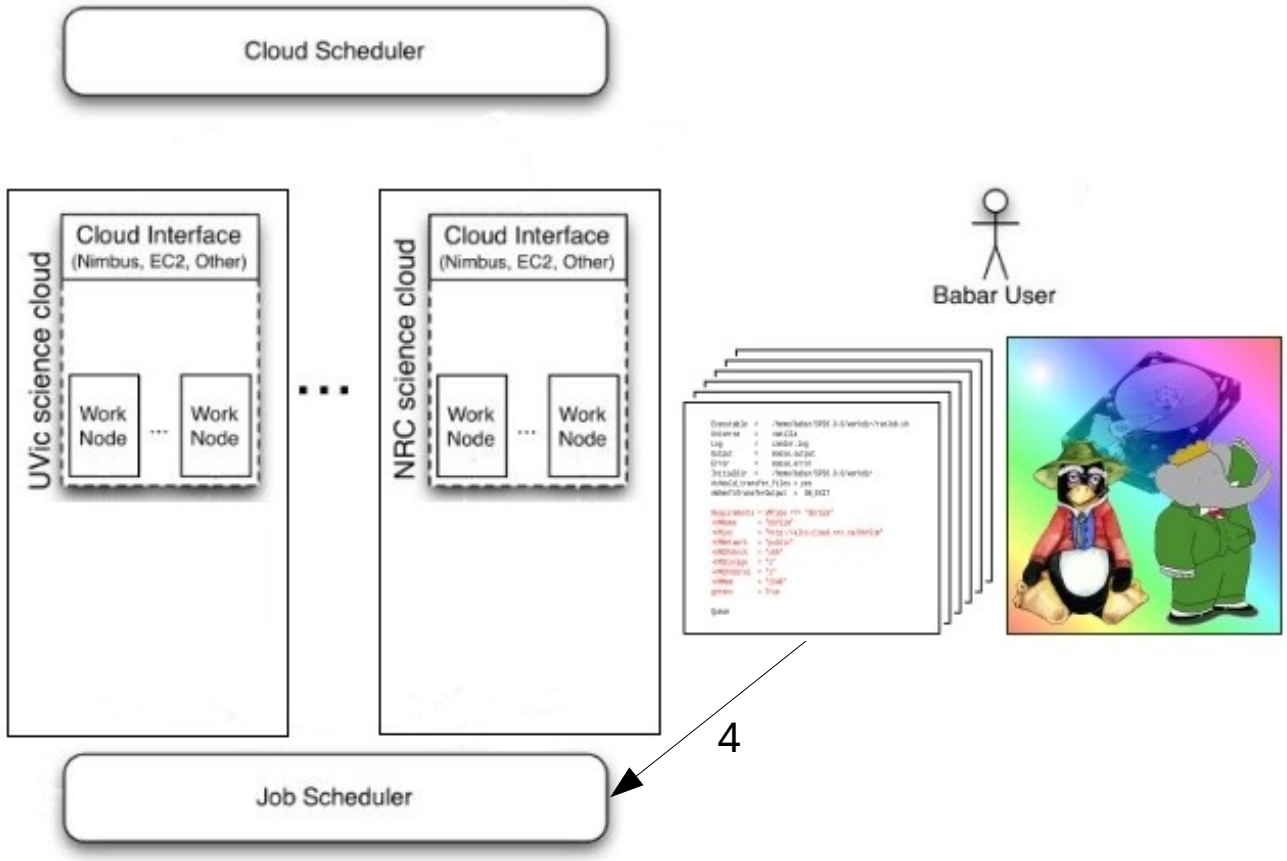
```
Executable  =    /home/babar/SP26.0.0/workdir/runJob.sh
Universe    =    vanilla
Log         =    condor.log
Output      =    moose.output
Error       =    moose.error
InitialDir  =    /home/babar/SP26.0.0/workdir
#should_transfer_files = yes
#WhenToTransferOutput  =  ON_EXIT

Requirements = VMType =?= "bbrSim"
+VMName      = "bbrSim"
+VMLoc       = "http://alto.cloud.nrc.ca/bbrSim"
+VMNetwork   = "public"
+VMCPUArch   = "x86"
+VMStorage   = "1"
+VMCPUCores  = "1"
+VMMem       = "2048"
getenv       = True

Queue
```

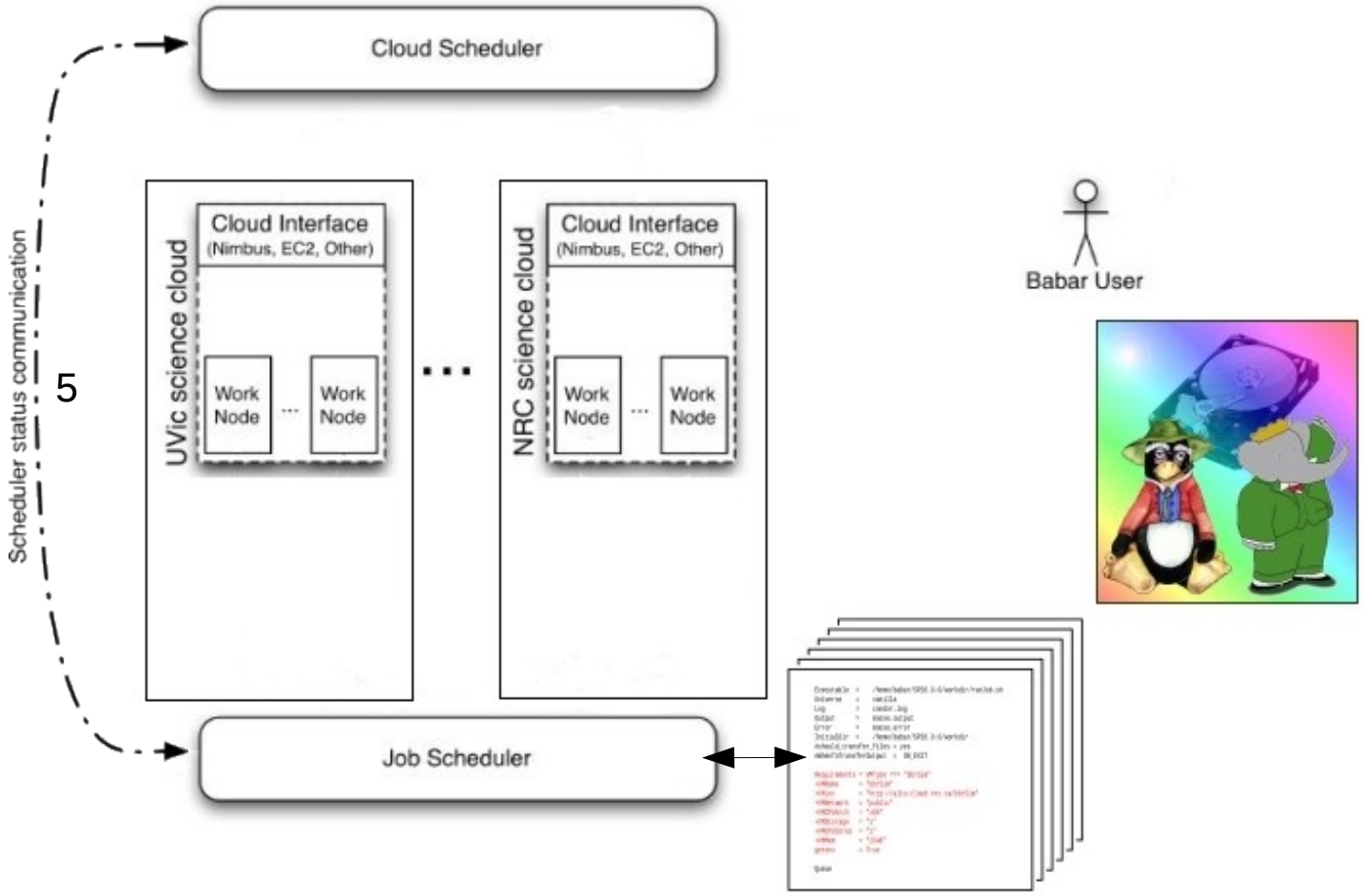
How does it work?

4. User submits jobs to Job Scheduler



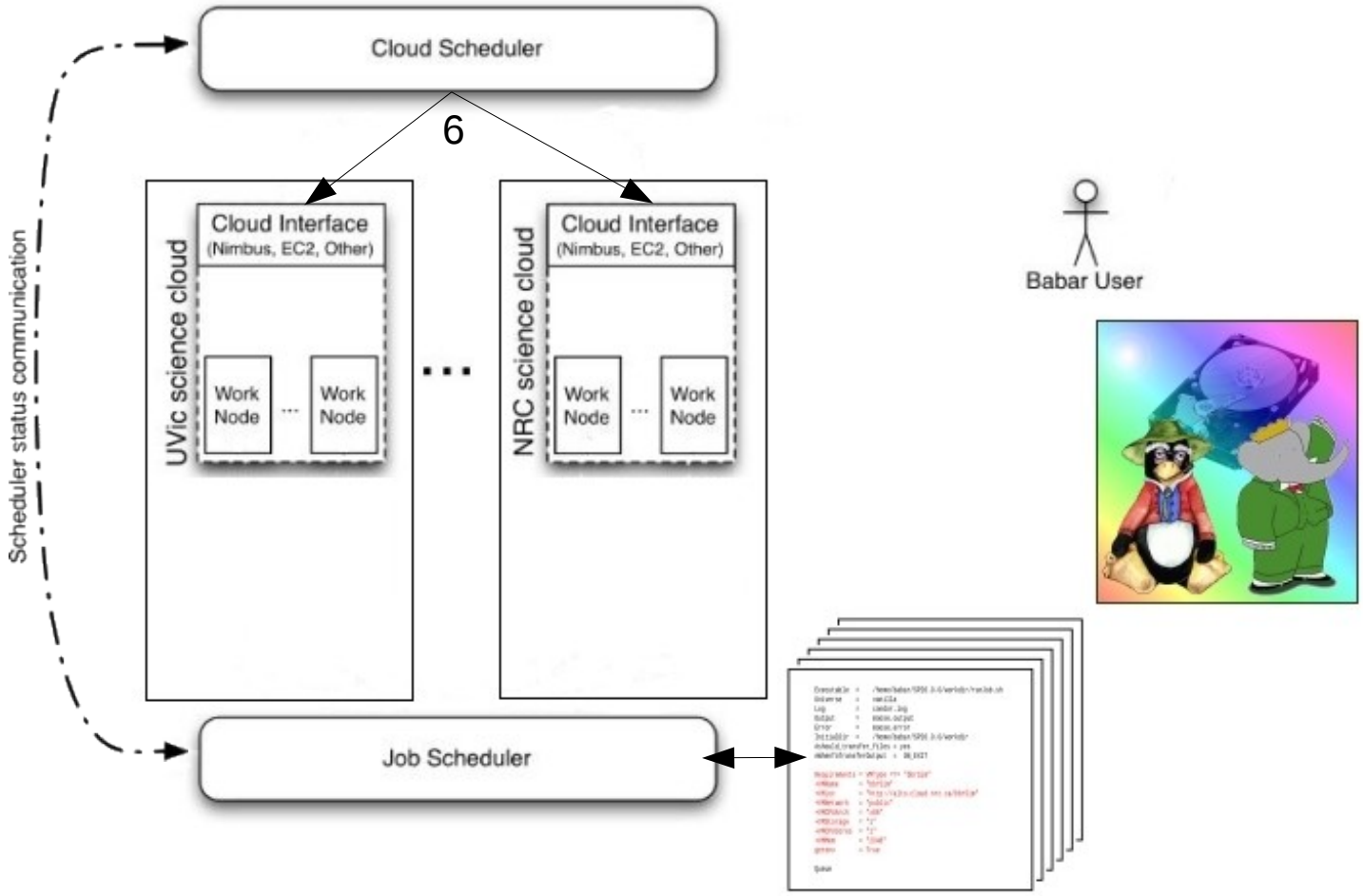
How does it work?

5. Cloud Scheduler periodically checks Job Scheduler's Queues



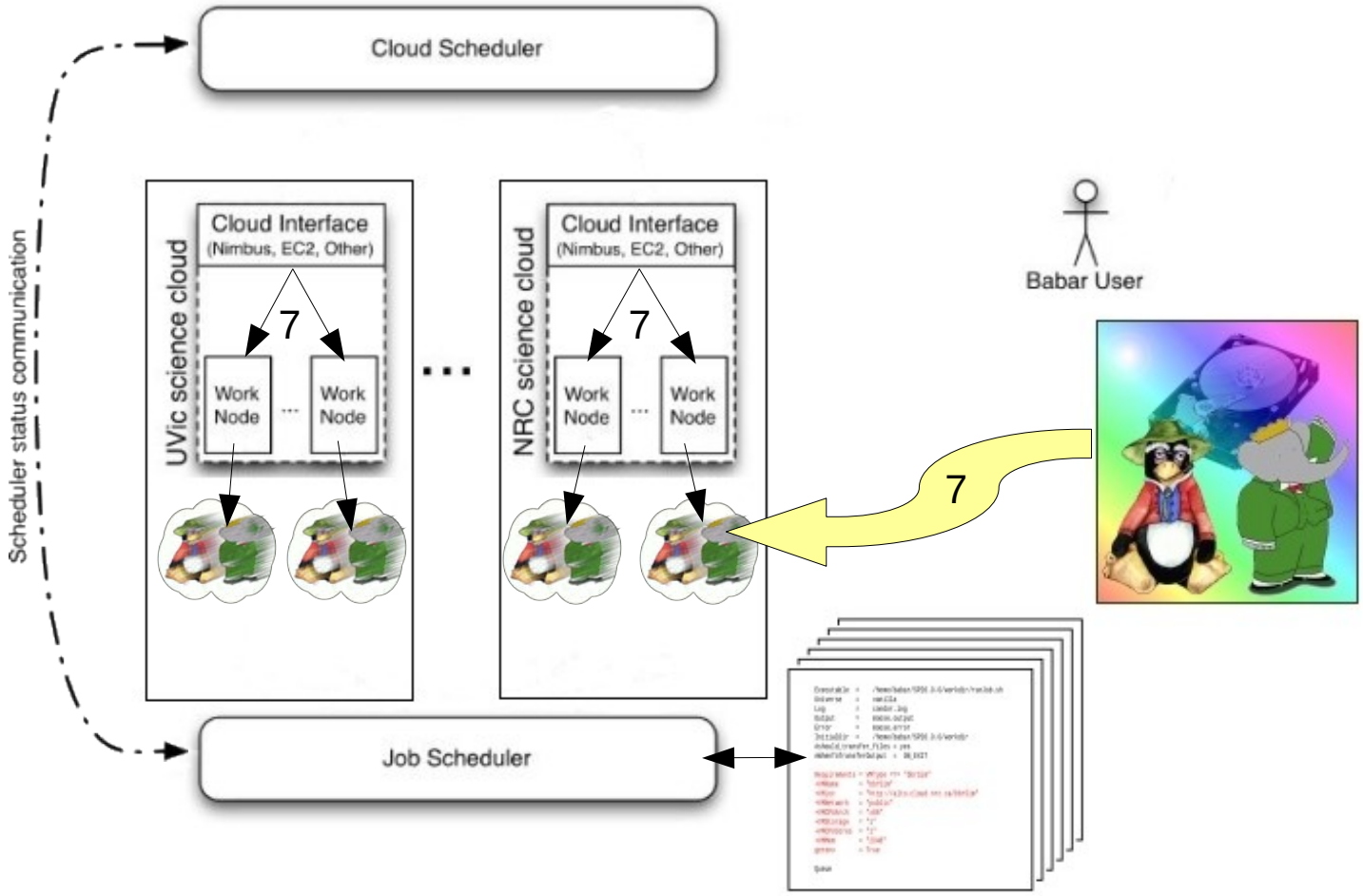
How does it work?

6. Cloud Scheduler requests deployment of VMs



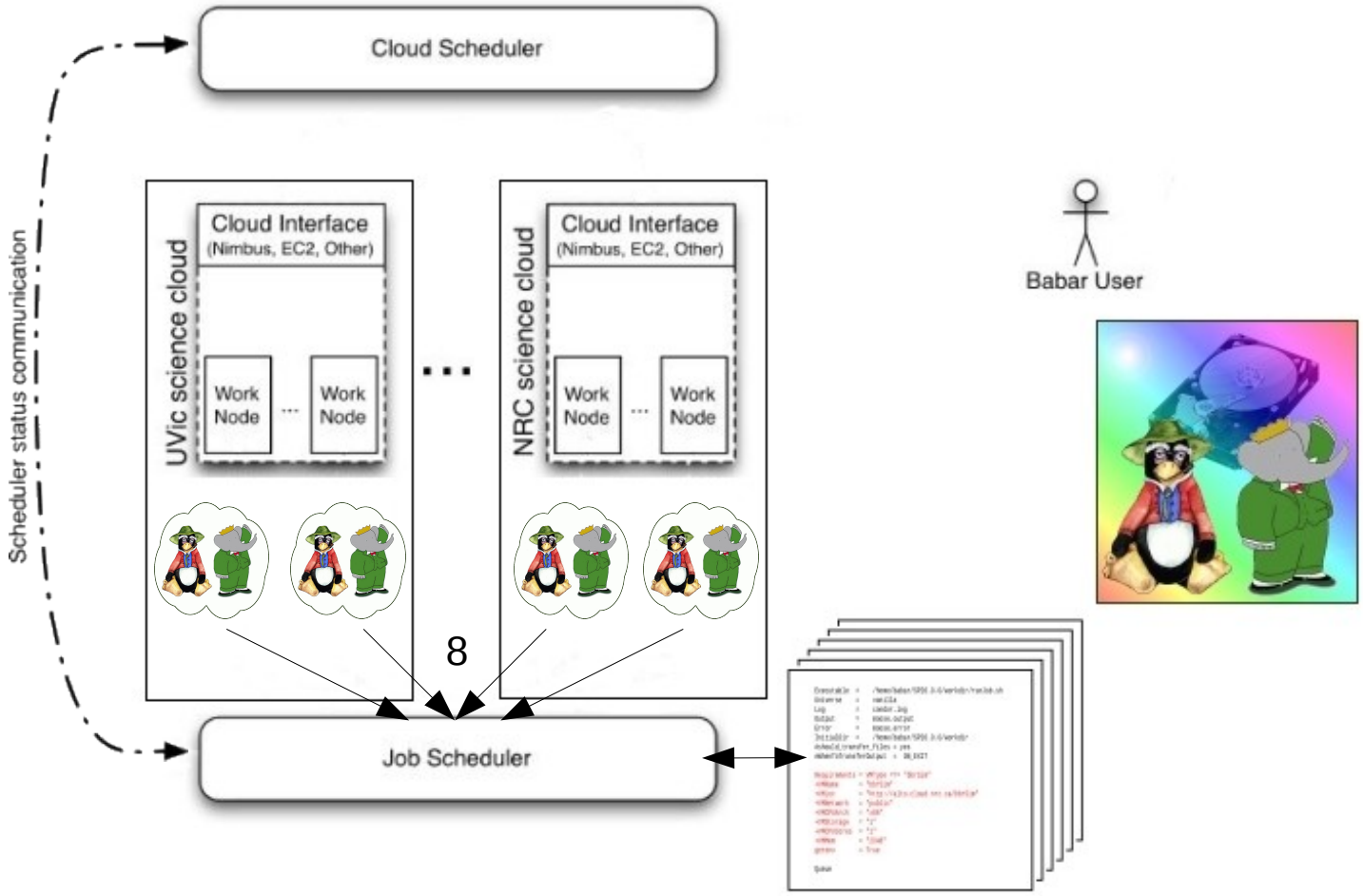
How does it work?

7. IaaS deploys the requested VMs



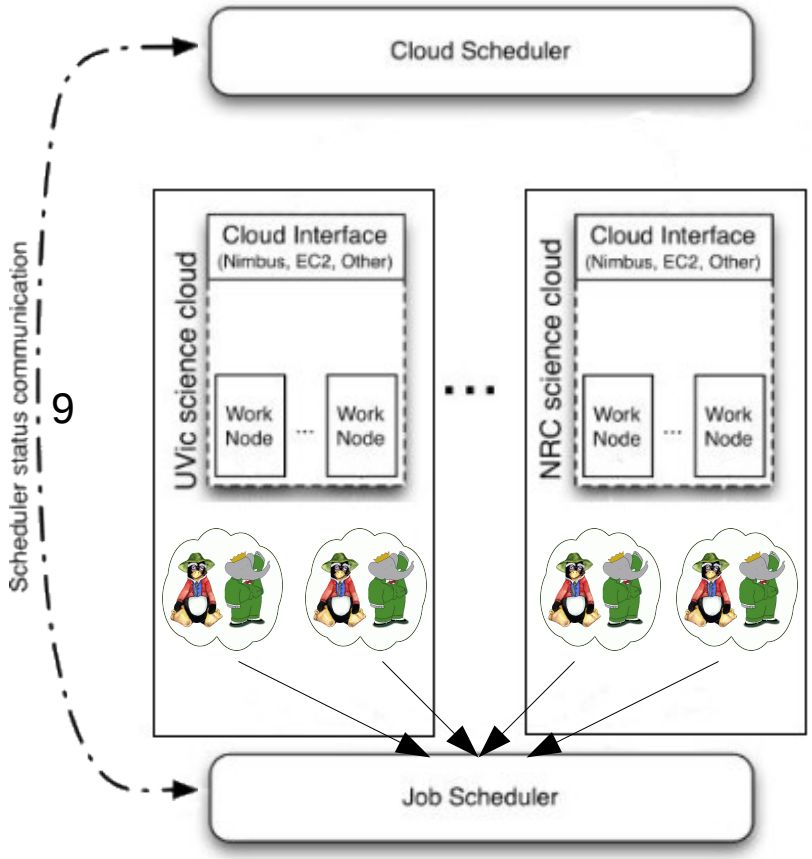
How does it work?

8. The VMs register with the Job Scheduler & jobs run



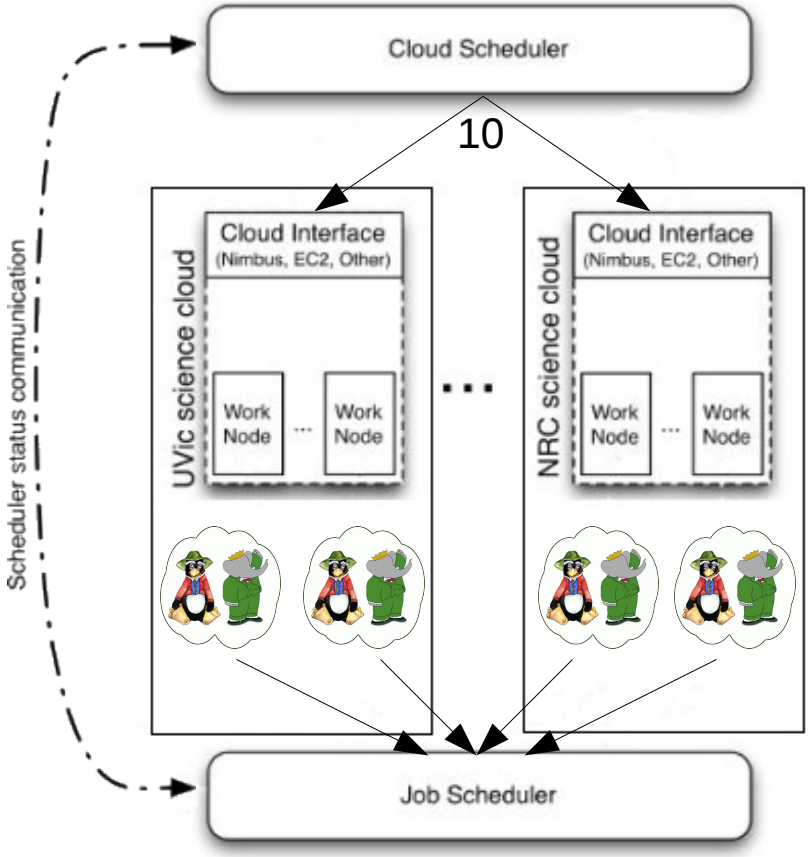
How does it work?

9. Cloud Scheduler detects idle VMs



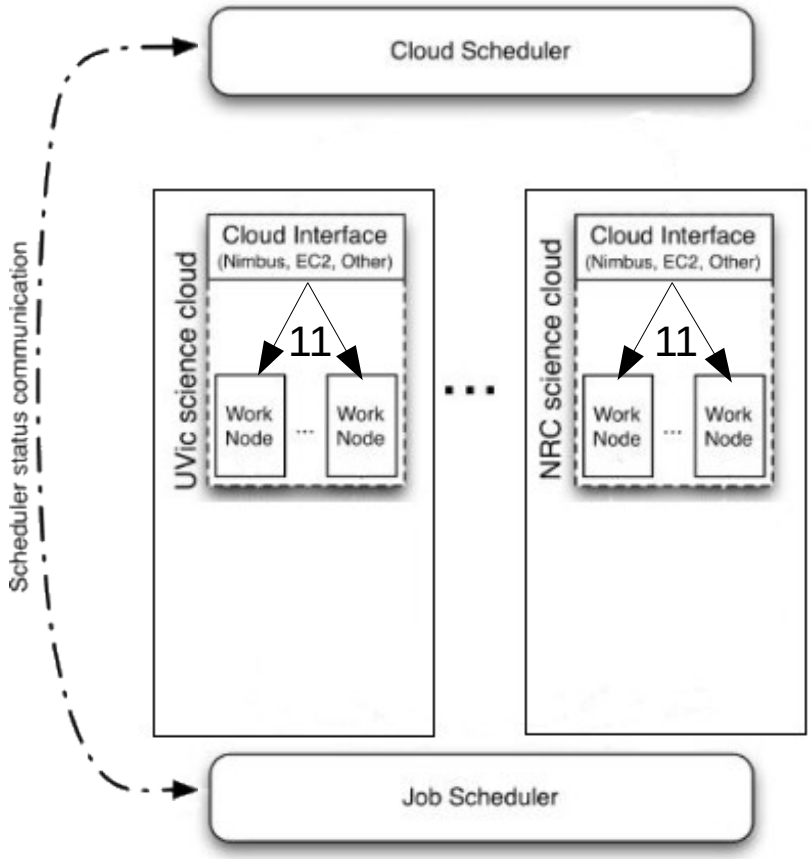
How does it work?

10. Cloud Scheduler requests shutdown and destruction of VMs



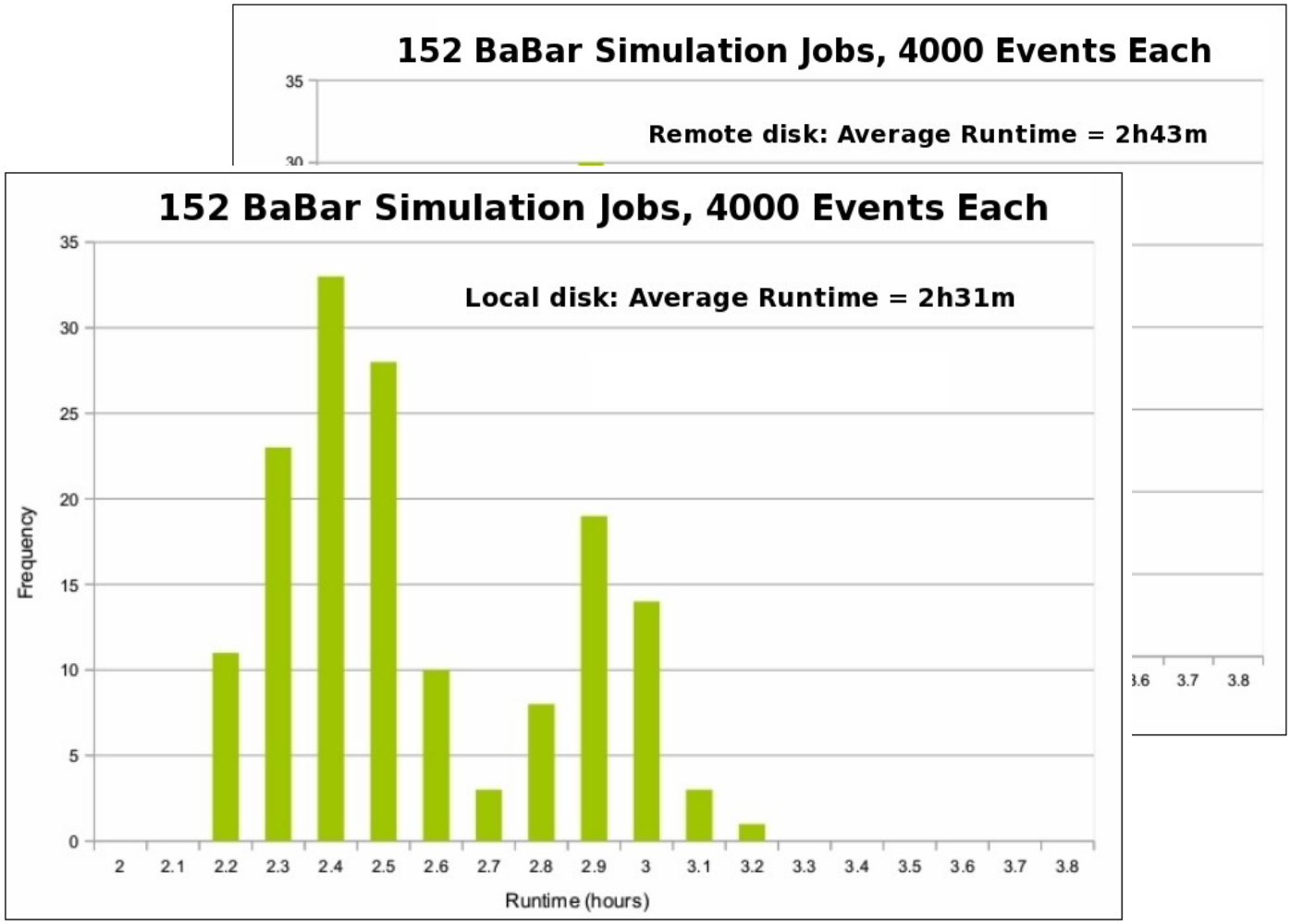
How does it work?

11. IaaS destroys the requested VMs



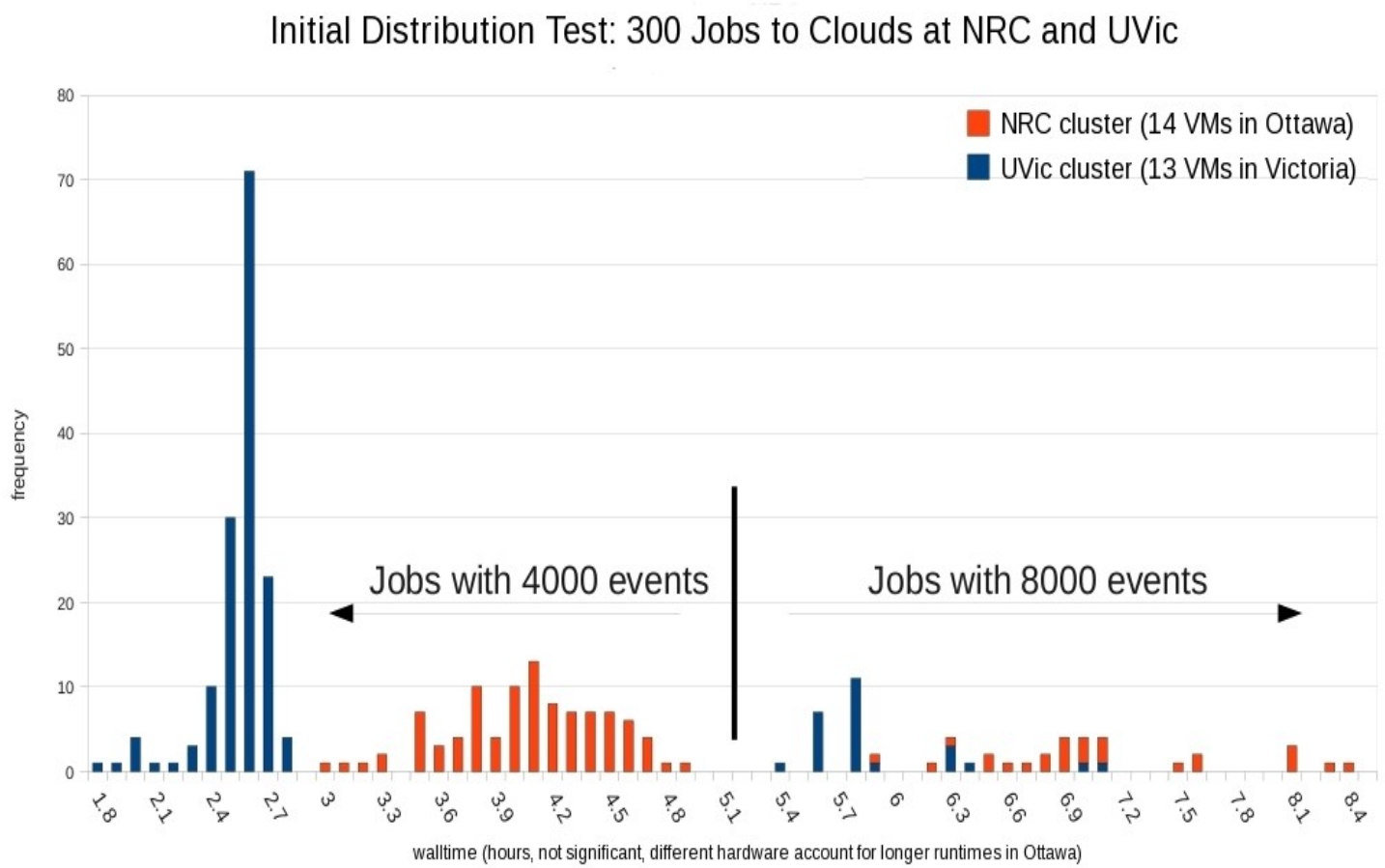
Does it work?

1. Single site test in Ottawa



Does it work?

2. Using multiple clouds



Next Steps

- Incorporate Amazon EC2 within our distributed cloud environment
  - Awarded research grant of US $3500 of time on Amazon EC2
- Commence BaBar simulation production; minimum 3 clouds
- Augment/improve image and data management; functionality and performance
  - Awarded US $5000 Google summer of code
- Greater emphasis on BaBar analysis
- Reliability and scalability improvements
- Work with WestGrid to incorporate cloud capabilities on their UVIC installation.

Wider Application

CANFAR
Canadian Advanced Network for Astronomical Research

- Jobs are embarrassingly parallel much like HEP.
- Six different surveys, each require a different processing environment, which require:
  - A specific version of a Linux distribution
  - A specific compiler version
  - Specific libraries

More Information:

- http://cloudscheduler.org
- Code on GitHub:
  - http://github.com/hep-gc/cloud-scheduler
  - http://wiki.github.com/hep-gc/cloud-scheduler/cloud-scheduler-test-drive
- http://heprc.phys.uvic.ca/

And Twitter:

- http://twitter.com/cloudscheduler

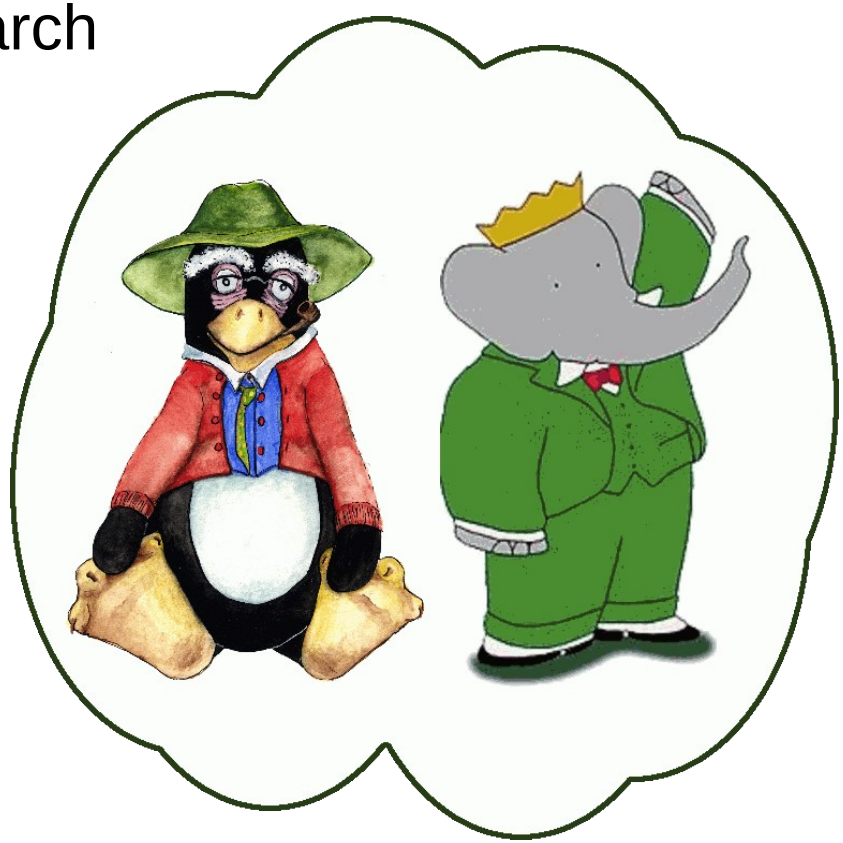
Test Drive Cloud Scheduler

Publicly available pre-configured EC2 AMI ready to go:

```
#create a security group
$ ec2addgrp cloudscheduler -d "Used for Cloud Scheduler"
$ ec2auth cloudscheduler -P icmp -t "-1:-1"
$ ec2auth cloudscheduler -P tcp -p 22
$ ec2auth cloudscheduler -P tcp -p 40000-40050
$ ec2auth cloudscheduler -P udp -p 40000-40050
$ ec2auth cloudscheduler -P tcp -p 9618
$ ec2auth cloudscheduler -P udp -p 9618

#boot the cloud scheduler/condor VM
$ ec2run ami-f9ff1190 -k ec2-keypair -g cloudscheduler

$ ssh -i ~/.ec2/id_rsa-ec2-keypair \
  root@ec2-75-101-197-134.compute-1.amazonaws.com
[root@ec2-75-101-197-134 ~]# cat README
```

Summary:

- Babar and Clouds are very good friends
- We are creating a unique system to utilize clouds for research computing
- Wider applicability: Others starting to make use of this solution