Clouds for research computing

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Grand challenges

Why is the universe not made of equal amounts matter and antimatter?

We build instruments large detectors to record the collisions of matter and antimatter

Record billions of particle collisions
“Events”
Users build their analysis code and submit many batch jobs

**BaBar experiment** uses multiple and independent facilities

**Newer generation** experiments (LHC) use *grid* technologies to construct an integrated environment using many sites around the world
Role of clouds in research computing

Parallel applications require large, dedicated facilities (High-performance computing HPC environment)

Large-scale, data intensive, embarrassingly parallel applications well suited for the Grid (Tight integration of the application and systems)

Commercial and science clouds provide SaaS and IaaS research computing solutions

SaaS (Software-as-a-Service)
IaaS (Infrastructure-as-a-Service)
Complex research environments

How do we analyze the BaBar in the coming few years?

Data Preservation:
We need to archive the data and the software for many (>10) years

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

Third Workshop on Data Preservation and Long Term Analysis in HEP
CERN, Mon 7th-Wed 9th December 2009
**Distributed compute cloud**

**Sophisticated user communities in physical sciences**
- Non-GUI users
- Batch computing environments

**Complex software packages and demanding system requirements**
- Specific OS system
- Specific application libraries and compilers

**Medium-scale data sets (100s TBs)**
- Data accessed (on-demand) from remote or local repositories

**Distributed compute cloud**
System to boot user-customized VMs on any number of science or commercial clouds in a familiar batch computing environment

Often referred to as *Sky Computing* or *Grid of Clouds*
Components

Virtualization
- Application encapsulation
  - Image replication
    - eg Xen, KVM
- Clouds
  - WS interface
    - eg Nimbus, OpenStack, EC2

IaaS

Job Scheduler
- Dynamic resources
  - eg Condor, SGE
- Managing multiple clouds
  - eg Cloud Scheduler
The Interactive System

User saves the modified environment as a new image

```
$ ssh login.heprc.uvic.ca
$ myproxy-init
$ myproxy-login
$ vm-run
    ip 206.12.154.91
$ ssh root@206.12.154.91
$ yum install xyz
$ emacs tau11.cpp
$ make tau11
$ mv tau11 /usr/local/bin/
$ chmod 750 /usr/local/bin/tau11
$ myproxy-login
$ repoman save bbr-test1
```
User view of the system is the same as a standard batch environment

Job script contains a link to the user’s VM required for the job
CS looks at the job queue and sends a request to the next available cloud to boot the User-VM
Simulation Production

Condor Jobs - by day

Cloud Scheduler VMs by Cloud - by day

~1300 jobs
50 slots
2 time zones

~850 more jobs
20 more slots

15 more
3rd time zone

2500 more jobs
35 more slots
Astronomy applications

**CANFAR Project**  
*Canadian Advanced Network for Astronomical Research*  
*UIVC, UBC, NRC-HIA*  
*CANARIE-funded project*

Distributed cloud used to process survey data

In production for 8 months using different IaaS cloud resources

Compute Canada cloud site at UVIC

Enabling system for user analysis as well as production jobs
Summary

- We have established a distributed cloud for research applications
  - Focus is on applications in physical sciences with large high-throughput (HTC) workloads and a knowledgeable user community
  - Fault-tolerant system using multiple-IaaS (commercial or science) cloud resources
  - Based on open-source components with two new in-house elements
  - Easily scales for low-IO applications
  - We are currently studying the scaling to high-IO applications where the data located at a few repositories

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