What Happens When Cloud Computing Meets HPC

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Outline

- Intro to Cloud Computing and Concepts
- Cloud Computing’s Impact on HPC
- A Brief Look at Grid, Globus, and Clouds
  - Globus Incubator Program
  - Open Source EC2-like Capability
- Impact and Opportunity for Supercomputing Centers
- Dan’s Head in the Clouds
“Cloud” Computing is ~1 yr old

http://linux.sys-con.com/node/587717
Sorting out the Pieces

SaaS = Software as a Service
One can categorize each component

Utility Computing

SaaS = Software as a Service

SaaS

Usage Model

Cloud

Cluster

Grid

Globus

BUT...

Infrastructure
Clouds can have any/all of these

Utility Computing  Cluster
SaaS  Grid
Globus

And the descriptions often overlap!
What makes a Cloud?

- Virtual Machines
- VM Manager (Amazon EC2, ...)
  - Scalability
- File system Infrastructure
- Remote access (portal)
- Cost?
  - One reason the EC2 is successful is because of the low cost for cpu/data movement.
- Security?
Where is the value?

- Much of the value is in the Virtual Machines
- What are VMs used for?
  - Server Consolidation (Fermilab)
  - Disaster recovery (commercial)
  - Component Isolation (sandboxing)
  - Hardware Independence (any OS on any Box)
  - Cluster Computing
    - E.g. Deploy a classroom environment
    - E.g. Deploy a multi-use cluster with ROCKS
- Adding VM Management takes this to the “clouds”
  - Access resources on-demand
  - Isolate Users from each other
  - Schedule VM usage
Where is the HPC value?

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What is a Grid?

Enable “coordinated resource sharing & problem solving in dynamic, multi-institutional virtual organizations.”
(Source: “The Anatomy of the Grid”)

Edited by Ian Foster and Carl Kesselman
THE GRID 2
Blueprint for a New Computing Infrastructure
What does Globus do?

- **Globus provides a**
  - Secure...
  - Uniform Remote Job Submission Interface...
  - Plus numerous capabilities that make the environment “useful.”
    - Data movement, Job monitoring, Service discovery, Security credential mgmt, Uniform data interfaces, ...

- **Many Globus components can be used as stand-alone software products**
  - GridFTP, RLS, Index service, MyProxy
Creating a Useful Environment

Uniform interfaces, security mechanisms, Web service transport, monitoring

- Tool
- User Application
- Workflow
- Registry
- User Svc
- Host Env
- Credent.
- GRAM
- User Svc
- Host Env
- GridFTP
- DAIS
- Database
- Computers
- Specialized resource
- Storage
Cancer Biomedical Informatics Grid

Functions:
- Grid Communication Protocol
- Workflow
- Service Description
- Service Registry
- Transport
- Resource Management
- ID Resolution
- Metadata Management
- Security

Management:
- Functions
- Security
- Resource Management
- myProxy
- GSI
- CAS
- Globus

Mobius
GCORE
Globus
OGSA-DAI
BPEL
GRAM
Globus

Spans 60 NIH cancer centers across the U.S.

Slide credit: Peter Covitz, National Institutes of Health
Incubator Projects

- Contributed from teams around the world
  - Must utilize a “Globus” open source License
  - Code can be sold, used by others, adapted...
- Each project has its own “Committers”
  - Committers govern the project
- Globus Provides Infrastructure & Oversight
  - Project site, e-mail lists, some publicity
  - Overall project approval, & follow-up
- You can add your Incubator:
  - http://dev.globus.org/
Globus & Cloud Computing

- Virtual Workspaces is a Globus Incubator

- An Open Source EC2-like Management System
  - You can run on the cloud
  - You can even build your own cloud
Science Clouds

- Powered by workspace tools
- EC2-like interfaces (PKI credential vs credit card)
- More clouds on the way
- http://workspace.globus.org/clouds
Who Runs on the Science Clouds?

- Nimbus utilization breakdown since March 4th
- ~30 Communities

http://workspace.globus.org
Interacting With Workspaces

(1) The workspace service allows users to deploy and manage workspaces on a pool of nodes through a WSRF interface.

(2) Each pool node requires a VMM and a lightweight management script.

(3) Information on each workspace is published as WSRF Resource Properties so that users can find out information about their workspace (e.g. what IP the workspace was bound to) or subscribe to notifications on changes.

http://workspace.globus.org
● Motivation for STAR
  ◆ Resources **with the right configuration** are hard to find
    ● Complex environments: correct versions of operating systems, libraries, tools, etc all have to be installed.
    ● Require validation

● Virtual Workspace: an OSG STAR cluster
  ◆ OSG cluster
    ● OSG CE (headnode), gridmapfiles, host certificates, NSF, PBS
  ◆ STAR worker nodes: SL4 + STAR conf

● Requirements
  ◆ One-click virtual clusters
  ◆ Migration: nimbus/scientific resources -> EC2

http://workspace.globus.org
From proof-of-concept to production runs
  - ~2 years ago: proof-of-concept
  - Last September: EC2 runs of up to 100 nodes (production scale)
  - Testing for full production deployment

Performance
  - Within 10% of expected performance for applications

Work by Jerome Lauret, Doug Olson, Leve Hajdu, Lidia Didenko

Long-lived community of many

Similar work for other HEP communities (Alice and Atlas), bioinformatics, geofest, and others

http://workspace.globus.org
The Supercomputing Center “Threat”

- Grid computing provides uniform access to computational resources
  - Computational resources become commodities
  - Supercomputing Centers offer a variety of applications, libraries, and support
- Cloud Computing Makes Use of Virtual Machines where applications, libraries and dependencies can be hidden
  - Supercomputing Centers can become commodities in themselves
- Ok so “threat” may be a bit overstated
  - Problems don’t go away quite so easily (shell game)
  - But shake-outs can/do happen along the way...
The Opportunity

- Be the Supercomputing Center that enables cloud computing!
  - (Gradually) turn the center into a big cloud
    - Today’s clouds have only ~16 VMs
  - Conduct Research in VMs, VM Management, and VM Maintenance
  - Develop Tools to make Cloud Computing accessible to the scientists
  - Become the center of HPC Cloud expertise
So what happens when HPC meets Cloud computing?

We don’t really know because the possibilities are just now emerging!
What if... scientists could:

- Download and use a VM that would make it easy to parallelize their application;
- And test it in parallel right on their laptop.

What if... scientists could:

- Run a converter to change one VM type to another;
- Or enable a VM created at one center to automatically run other places even though the infrastructure may be different (VMWare, Xen, RPATH, ...)

What if... scientists could:

- Select applications and components from a list;
- Select some of their own applications;
- Push a button to create a cluster-ready VM image;
- Then push another button to automatically deploy them.

And the list goes on ...
Conclusion

- HPC cloud computing is an emerging technology
- There are big opportunities for leadership to develop in this space.
- Using VMs is only the beginning. There must also be collections of tools for managing and maintaining VMs ...