Cloud Computing for Science

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Cloud Computing for Science

- Complex codes
- Need for control
Grid Computing

Assumption: control over the manner in which resources are used stays with the site

- Site-specific environment and mode of access
- Site-driven prioritization
- But: site control -> rapid adoption
Cloud Computing

*Change of assumption: control over the resource is turned over to the user*

- Enabling factors: virtualization and isolation
- Challenges our notion of a site
- Lends itself to more explicit service level negotiation
- But: slow adoption

www.nimbusproject.org
Cloud Computing for Science: A Personal Perspective

“A Case for Grid Computing on VMs”
In-Vigo, VIOLIN, DVEs, Dynamic accounts
Policy-driven negotiation

First STAR production run on EC2

EC2 released

Science Clouds available

Xen released

2004

2006

2008

2010

First Nimbus release

Nimbus Context Broker release

OOI starts

Magellan Experimental Clouds for Science

Nimbus Context Broker release

EC2 released

First STAR production run on EC2

Xen released

“A Case for Grid Computing on VMs”
In-Vigo, VIOLIN, DVEs, Dynamic accounts
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First Nimbus release

Nimbus Context Broker release
Benefits to Consumers

Eliminate expense and headache of acquiring, managing and operating hardware

Elastic computing
Pay-as-you-go model

capital expense  operational expense
Benefits to Providers

- Economies of scale to amortize the costs of buying and operating resources
- Avoid cost and complexity of managing multiple customer-specific environments and applications

Streamline and specialize

10/19/10
Unclouding the Cloud

Community-specific applications and portals

Platform-as-a-Service (PaaS)

Infrastructure-as-a-Service (IaaS)

10/19/10

www.nimbusproject.org
Infrastructure-as-a-Service: the Nimbus Toolkit
Nimbus Goals

High-quality, extensible, customizable, open source implementation

Higher-level IaaS Tools
- Context Broker
- Elastic Scaling Tools
- Nimbus Clients

Enable users to use IaaS clouds

Infrastructure-as-a-Service Tools
- Workspace Service
- Cumulus

Enable providers to build IaaS clouds

Enable developers to extend, experiment and customize

10/19/10

www.nimbusproject.org
The workspace service publishes information about each workspace.

Users can find out information about their workspace (e.g. what IP the workspace was bound to).

Users can interact directly with their workspaces the same way they would with a physical machine.
Nimbus IaaS

Workspace Interfaces
- EC2: SOAP and Query
- WSRF

Workspace API

Workspace Service Implementation

Workspace RM options
- Default
- Default+backfill/spot
- Workspace pilot

Workspace Control Protocol

Workspace Control
- Virtualization (libvirt)
  - Xen
  - KVM
- Image Mngm
  - ssh
  - LANtorrent
- Network
- Ctx

Cumulus interfaces
- S3

Cumulus API

Cumulus Service Implementation

Cumulus Storage API

Cumulus Implementation options
- POSIX
- HDFS

10/19/10

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Nimbus Highlight: Cumulus

- S3-compatible open source storage cloud
- Quota support for scientific users
- Pluggable back-end to popular technologies such as POSIX, HDFS, potentially also Sector and BlobSeer
- Performance studies comparing to GridFTP
- SC10 poster
Nimbus Highlights: LANtorrent

• Fast delivery of images to deployment nodes
• LANtorrent: the bittorrent principle on a LAN
• Detecting and eliminating duplicate transfers
• Significantly improves image transfer times
• To be available in Nimbus release 2.6
Nimbus Highlight: Backfill and Spot Pricing

- The utilization challenge:
  - Spot pricing: auction of cloud resources
  - Using HTC as “backfill” for on-demand clouds
- Extension to Workspace default Resource Manager
- Significant utilization improvement leading to lowering cost for cloud computing
- Preparing for running of production workloads on FG @ U Chicago
- To be available in Nimbus release 2.7
Working with Hybrid Clouds

Creating Common Context

Nimbus Elastic Provisioning
interoperability  automatic scaling
HA provisioning  policies

Private clouds (e.g., FNAL)
community clouds (e.g., Science Clouds)
public clouds (e.g., EC2)
Nimbus Context Broker

- Turnkey, tightly-coupled cluster
  - Shared trust/security context
  - Shared configuration
  - Across different clouds, appliances, providers
Nimbus Elastic Scaling Tools

• Prototypes
  – The ALICE proof-of-concept
  – ElasticSite prototype
  – OOI pilot

• Service Model
  – React to sensor information
  – Queue: the workload sensor
  – Scale to demand
  – Across different cloud providers
  – Use contextualization to integrate machines into the network
  – Customizable
  – Latest tests scale to 100s of nodes on EC2

• Release in 2011

Paper: “Elastic Site”, CCGrid 2010
Resources, Applications and Ecosystem
Scientific Cloud Resources

• Science Clouds
  – UC, UFL, Wispy@Purdue
  – ~300 cores
• Magellan
  – DOE cloud @ ANL&LBNL
  – ~4000 cores@ANL
• FutureGrid
  – ~6000 cores
• DIAG =
  – Data Intensive Academic Grid
  – U of Maryland School of Medicine in Baltimore
  – ~1200-1500 cores
• Outside of US:
  – WestGrid, Grid5000
STAR: a nuclear physics experiment at Brookhaven National Laboratory
Studies fundamental properties of nuclear matter
A virtual OSG STAR cluster
Science Clouds -> EC2 runs
Production runs since 2007
The Quark Matter run: producing just-in-time results for a conference:
http://www.isgtw.org/?pid=1001735

Work by Jerome Lauret, Leve Hajdu, Lidia Didenko (BNL), Doug Olson (LBNL)
Priceless?

• **Compute costs: $ 5,630.30**
  - Fdsf 300+ nodes over ~10 days,
  - Instances, 32-bit, 1.7 GB memory:
    - EC2 default: 1 EC2 CPU unit
    - High-CPU Medium Instances: 5 EC2 CPU units (2 cores)
  - ~36,000 compute hours total

• **Data transfer costs: $ 136.38**
  - Small I/O needs: moved <1TB of data over duration

• **Storage costs: $ 4.69**
  - Images only, all data transferred at run-time

• Producing the result before the deadline…

...$ 5,771.37
Modeling the Spread of Epidemics

Work by Ron Price and others, University of Utah

- Can we use clouds to acquire on-demand resources for modeling the progression of epidemics?
  - Monte Carlo simulations

- Cloud computing found to be 90% efficient on Science Clouds
• A Large Ion Collider Experiment (ALICE)
• Heavy ion simulations at CERN
• Problem: integrate elastic computing into current infrastructure
• Collaboration with CernVM project
Elastically Provisioned Resources

- CHEP09 paper, Harutyunyan et al.
• Large NSF-funded observatory
• Cloud computing a vital part of resource strategy
• HA services that provision resources on clouds in response to need
• First release due out in Spring 2011
• Scalability and reliability tests on EC2, FutureGrid and Magellan resources
• Work in progress
Sky Computing

Work by Pierre Riteau et al, University of Rennes 1

- What happens when you are working with many clouds?
- Sky Computing = a Federation of Clouds
- Nimbus clouds in FutureGrid and Grid 5000
- Combine resources obtained in multiple clouds
- Deployed a virtual cluster of over 1000 cores on Grid5000 and FutureGrid and used it for bioinformatics comps
- Demonstrated at OGF 29 06/10
- TeraGrid ’10 poster
• BarBar Experiment at SLAC in Stanford, CA
• Using clouds to simulating electron-positron collisions in their detector
• Features:
  – Distributed clouds
  – Appliance preparation and management
  – Cloud Scheduler
• Provide infrastructure for six observational astronomy survey projects
• Running on 200 core Nimbus cloud on WestGrid
• Dynamic Condor pool for astronomy
• Appliance creation and management
• MACHO experiment Dark Matter search
• In production operation since July 2010
The emergent need for processing

A virtual appliance for automated and portable sequence analysis
- A platform for building appliances representing push-button pipelines
- From desktop to cloud
- Running on EC2, Magellan and Science Clouds

http://clovr.org
Emerging Patterns

• Community appliance management
• Cloud bursting for elasticity and reliability
• Differentiated instance offerings
• Mix and match: using multiple clouds and multiple instances
The Nimbus Team
The Nimbus Team

• Project lead: Kate Keahey, ANL&UC

• Comitters:
  – Tim Freeman - University of Chicago
  – Ian Gable - University of Victoria
  – David LaBissoniere - University of Chicago
  – John Bresnahan - Argonne National Laboratory
  – Patrick Armstrong - University of Victoria
  – Pierre Riteau - University of Rennes 1, IRISA

• Github Contributors:
  – Tim Freeman, David LaBissoniere, John Bresnahan, Pierre Riteau, Alex Clemesha, Paulo Gomez, Patrick Armstrong, Matt Vliet, Ian Gable, Paul Marshal, Adam Bishop

• And many others
  – See http://www.nimbusproject.org/about/people/
Parting Thoughts

• Cloud computing is here to stay
• We showed that it is important to a set of applications – how can we make that set larger?
• A change of paradigm -> a change of pattern
  – New exciting modes of usage
  – New exciting opportunities and needs
• The importance of open source collaboration