Cloud Computing for Science

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Cloud Computing for Science

- Need for control
- Complex codes
Clouds of All Types

**Software-as-a-Service (SaaS)**

- Community-specific tools, applications and portals

**Platform-as-a-Service (PaaS)**

- Microsoft
- Google

**Infrastructure-as-a-Service (IaaS)**

- NIMBUS
- www.nimbusproject.org

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Nimbus Goals

High-quality, extensible, customizable, open source implementation

Sky Computing 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
IaaS: How it Works
IaaS: How it Works

Nimbus publishes information about each VM

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

Users can interact directly with their VM in the same way the would with a physical machine.
Sky Computing Tools: 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)
Cumulus: a Scalable Storage Cloud

- **Challenge:** a scalable storage cloud
- S3-compatible open source implementation
- Quota support for scientific users
- Pluggable back-end to various technologies such as POSIX, HDFS, Sector, BlobSeer
- Configurable to take advantage of multiple servers
- *SC10 poster today @ 5:15 pm*
LANTorrent: Fast Image Deployment

- **Challenge:** make image deployment faster
- Moving images is the main component of VM deployment
- LANTorrent: the BitTorrent principle on a LAN
- Streaming
- Minimizes congestion at the switch
- Detecting and eliminating duplicate transfers
- **Bottom line:** a thousand VMs in 10 minutes
- Nimbus release 2.6

Preliminary data using the Magellan resource
At Argonne National Laboratory
Backfill: Lower the Cost of Your Cloud

- **Challenge:** utilization, catch-22 of on-demand computing
- **Solutions:**
  - Backfill
  - Spot pricing
- **Bottom line:** up to 100% utilization
- Open Source community contribution
- Preparing for running of production workloads on FG @ U Chicago
- Nimbus release 2.7
Elastic Scaling Tools: Towards Bottomless Resources

- Early efforts:
  - 2008: The ALICE proof-of-concept
  - 2009: ElasticSite prototype
  - 2009: OOI pilot

- **Challenge**: a generic HA 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

- STAR: a nuclear physics experiment at Brookhaven National Laboratory

- Strategy:
  - Nimbus Science Clouds -> EC2 runs
  - Virtual OSG clusters with Nimbus Context Broker

- Impact
  - Production runs on EC2 since 2007
  - The Quark Matter 2009 deadline: producing just-in-time results

Work by Jerome Lauret (BNL) et al.

Priceless?

- **Compute costs:** $5,630.30
  - `Fedsl 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
• Large NSF-funded observatory with requirements for adaptive, reliable, elastic computing

• Approach:
  – Private Nimbus regional clouds -> commercial clouds
  – Highly Available services that provision resources on many clouds based on need
  – Significant OOI CI infrastructure and sensor management based on this model

• Status:
  – Scalability and reliability tests on 100s of EC2, FutureGrid and Magellan resources
  – HA elastic services release in Spring 2011
Sky Computing @ Scale

• Approach:
  – Combine resources obtained in multiple Nimbus clouds in FutureGrid and Grid’ 5000
  – Deployed a virtual cluster of over 1000 cores on Grid5000 and FutureGrid – largest ever of this type
  – Combine Context Broker, ViNe, fast image deployment

• Grid’5000 Large Scale Deployment Challenge award
• Demonstrated at OGF 29 06/10
• TeraGrid ’10 poster

iSGTW this week: www.isgtw.org
Canadian Efforts

- BarBar Experiment at SLAC in Stanford, CA
- Using clouds to simulating electron-positron collisions in their detector
- Exploring virtualization as a vehicle for data preservation
- Strategy:
  - Distributed Nimbus clouds
  - Appliance preparation and management
  - Cloud Scheduler
- Running production BaBar workloads
• Provide infrastructure for six observational astronomy survey projects
• Strategy:
  – Running on a Nimbus cloud on WestGrid
  – Dynamic Condor pool for astronomy
  – Appliance creation and management
• Status:
  – 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
• Strategy:
  – Running on Nimbus Science Clouds, Magellan and EC2
  – A platform for building appliances representing push-button pipelines
• Impact
  – From desktop to cloud
  – http://clovr.org
The Nimbus Team

Collaboration on Nimbus 2.5 release
The Nimbus Team

- Project lead: Kate Keahey, ANL & UC
- Committers:
  - 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 Marshall, Adam Bishop
- And many others
  - See http://www.nimbusproject.org/about/people/
Parting Thoughts

• Cloud computing is here to stay
• A change of paradigm -> a change of pattern
  – New technology requirements
    • Cost comparisons, scaling, data management, appliance management, etc.
  – New work patterns and new opportunities
• Open source an essential tool to effect change
Let’s make cloud computing for science happen.