Using VCL to Power “Clouds”

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Outline

• Architecture
• VCL and Clouds
• Workflows Support
• Economics of Cloud Computing
http://vcl.ncsu.edu

Architecture

Virtual Computing Laboratory is Open Source
http://incubator.apache.org/projects/vcl.html
NC State Computational "Cloud" is powered by VCL

VCL Database

Authentication Service

VCL Manager & Scheduler

Internet

Node Manager #1
- Storage
- Image Repository
- University Labs

Node Manager #2
- Image Repository
- Tera-Grid
- z-Series

Node Manager #n
- Image Repository
- Storage

Virtual or Real Differentiated Resources

Virtual or Real Undifferentiated Resources
VCL “Seats”

- VCL (actual sole-use server based, or virtual platforms)
- Undifferentiated Resources
  - Single Seat (VCL-Desktop)
  - Multiple Synced Seats (VCL-Class)
  - Servers (VCL-Server)
  - Research Clusters (VCL-Research)
  - HPC Clusters (VCL-HPC)
- Differentiated Resources
  - VCL Agent
    - Other …
    - System Z (mainframes)
    - Supercomputers
  - Storage
Dynamic Re-Configuration

- Single Seat (VCL-Desktop)
- Multiple Synced Seats (VCL-Class)
- Servers (VCL-Serve)
- Aggregates (VCL-Environment)
- HPC Clusters (VCL-HPC)

non-HPC

HPC
**Differentiator:** User to Image to Resource Mapping, Management & Provenance

Images & Environments

"Application" Image Stack

Hardware
Blades, servers, desktops, storage ...

Undifferentiated Local or distributed

Reliability, Component-Based, Scalability, Economy
Virtual Computing Initiatives

- OC12 (622 Mbps Circuit)
- OC48 (2.4 Gbps Circuit)
- DWDM (10 Gbps Ethernet)

NC Community College System
NC K-12

U. South Carolina, Clemson

India
Amrita U.
U. Hyderabad
HBTI-UPTU

UMBC
Toronto
Queens
Waterloo
Carleton

VTech
ODU
CCV
MSU
GM

Trade PoP
Centennial
Campus

Research
Production/
Pilots/Users
Interest/Plans

OGF25/V2/March-09
HPC and Cloud
Typical HPC Use of VCL

![Diagram showing the typical HPC use of VCL. The diagram includes a login node, HPC scheduler, HPC storage, and compute nodes connected through the internet.]

OGF25/V2/March-09
Typical “Cloud” Use of VCL

On-demand construction and reservation of clusters of homogenous or non-homogenous resources, operating systems and apps.
Workflows and Integration
Heterogeneous Resources
Workflow Framework

VCL Computing Resources

Orchestration

Kepler

Meta-Data about:
Processes,
Data,
Workflows,
System &
Environment

Storage

Auth

Rec API

DB

Disp API

Dash

Custom Web

php myAdmin

Computing + Analytics

VCL Computing Resources

Kepler

Rec API

DB

Disp API

Dash

Custom Web

php myAdmin

Meta-Data about:
Processes,
Data,
Workflows,
System &
Environment
Business Model

Current VCL (only NC State University):
1. cca 2,000 blades
2. open to 30,000+ students and faculty
3. cca 500 to 600 in non-HPC mode, the rest in HPC mode
VCL Usage 2004-2008

Non-HPC:
Total Reservations: 352,488
"Now" Reservations: 338,245
"Later" Reservations: 24,876
Unavailable or failed: 10,633
Failed: 5,080
Reliability: 0.969 – 0.985

Non-HPC Reservations:
0 - 30 Min: 132,052
30 Min - 1 Hour: 77,023
1 Hour - 2 Hours: 75,809
2 Hours - 4 Hours: 54,922
> 4 Hours: 23,315
Non-HPC:
Total Reservations: 130,800
Total Hours Used: 198,583
"Now" Reservations: 125,278
"Later" Reservations: 11,436
Unavailable + Failed: 5,914
Failed: 1,611
Reliability: 0.955 – 0.988
Load times < 2 minutes: 109,223
Load times >= 2 minutes: 21,577

Non-HPC: VCL Usage
1-Jul-07 to 30-Jun-08
0 - 30 Min: 48,614
30 Min - 1 Hour: 31,014
1 Hour - 2 Hours: 27,421
2 Hours - 4 Hours: 22,222
> 4 Hours: 7,443

HPC
Linux Cluster CPU-Hrs Used by Month
November 2008
Non-HPC

- 0 - 30 Min: 5959
- 30 Min - 1 Hour: 5069
- 1 Hour - 2 Hours: 5604
- 2 Hours - 4 Hours: 3224
- > 4 Hours: 1847

Total Reservations: 20,686
Total Hours Used: 31,853
"Now" Reservations: 19,770
"Later" Reservations: 1,933
Unavailable + Failed: 1,017
Failed: 429
Reliability: 0.950 - 0.979
Load times < 2 minutes: 17,013
Load times >= 2 minutes: 3,673
Total Unique Users: 4,095

cca 500 blades

OGF25/V2/March-09
Case-Study: Wake Tech Community College

- 60,000 students
- Pilot project with cca 800 students
  - Some introductory class laboratories.
  - Using VCL with about 60 blades, no bare-metal loads (virtualization using VMware)
- Lab cost savings: cca 50%
Cost Factors

- Utilization (70-80%) – HPC + non-HPC mix
- Lab spaces (25:1) – in 2008/09 cca 160,000 non-HPC reservations, cca 7 million HPC CPU hrs
- Refresh cycle (yearly), resource lifetime (cca 5 years) – yearly down-migration of resources
- Power savings (Blades)
- Architectural savings (e.g., NCCCS)
- Reduced administration and maintenance costs (2-3 FTEs for about 2,000 blades)
- One stop shopping (augmentation)
- Distributed burden of image creation (600+ images)
- “Green”
- Other …
Economics

• In 2008, about 7,200,000 CPU hours (about 6.9 million on HPC and about 300,000 on non-HPC) on about 1,500 blades (cca 3000 processors) – about 1000 in HPC mode.

• About 70-80% utilization on the average, but in reality low on non-HPC side (over provisioned to handle peak loads), high on the HPC side.

• About $2 million annually (refresh, management and maintenance, improvements, personnel, …).

• About 27 cents per CPU hour (3 cents HPC, 24 cents non-HPC).

• This can come down to 10 to 15 cents per CPU hour with scale-up, large-scale virtualization, and new hardware (moving to quad-core processors).
The **Economics** of Cloud Computing

Surface Graph of Cost per unit of Service

*(NC State University Using VCL and HPC Data)*
Shades of Things to Come
Plans

• Virtualization variety (VMware, XEN, KVM, …)
• Pro-active and speculative scheduling
• Automated image construction
• Government and military-level security options
• UNC build-out
• Community Colleges and K-12
• Increased performance
• Seamless resource sharing
• Modularization
• Other …