Grid as a Service and Cloud Systems Research

Marcel Kunze, Steinbuch Centre for Computing
The Cloud is just a new Computing Platform

- 70’s: Mainframe
- 80’s: PC
- 90’s: Workstation
- 00’s: Grid
- 10’s: Cloud
“Building on compute and storage virtualization, and leveraging the modern Web, **Cloud Computing** provides scalable, network-centric, abstracted IT infrastructure, platforms, and applications as on-demand services that are billed by consumption.”

Part I: Grid as a Service
Conventional Grid Architecture
Build Clouds on Grids?

VDE: Virtual Distributed Environment

VDE

Grid Infrastructure
Build Grids on Clouds (Grid as a Service)?
Grid as a Service looks promising

Cloud Fabric

- Cloud resources >> Grid resources
- Instantiate Grids on Cloud resources
- Each VO could generate its own Grid on demand
New Job Flow Scenarios: Grid vs. Cloud

- Grid example: Run 1000 Jobs to generate 1 million MC events
- The Grid is a complex system
A Cloud Job Flow looks smarter

- Works the same like on a local computer
  - Develop and debug the program locally

- Bundle an image with the following characteristics
  - Automated program start after machine launch (e.g. EC2)
  - Do the data processing (e.g. generate 1000 MC events)
  - Write output to persistent cloud storage (e.g. S3)
  - Automated shut down once finished to stop accounting

- Just instantiate the suiting number of machines in the cloud
  - Simply launch 1000 machines to produce 1 million events
  - Cost is the same:
    - Run 1 machine 1000 hours
    - Run 1000 machines 1 hour

- No need for batch queues and scheduling (“unlimited resources”)
Part II: Cloud Systems Research

WHERE THE HECK IS MY DATA?

ITS THERE, UP IN THE CLOUDS.

Brainstruck.com
The Role of Open Source

- Cloud computing is primarily a commercial endeavor
- What are the options for open source to stay competitive with cloud computing?
- Cooperation
  - Create open source infrastructure for clouds
  - Return innovation and best practices to the community
  - Apply open business models to all components
  - Everybody can participate as resource provider and consumer
  - Possibly evolving into the largest single cloud ecosystem in the world
- Federation
  - Take advantage of standards
  - Interoperability between similar data centers
  - Enterprise virtual private clouds
  - Open source drives standardization and interoperability
  - Overcome vendor lock-in and create a market
Hybrid Clouds: Cloud Bursting

- Transfer workloads and data transparently between clouds
- Example: Amazon Virtual Private Cloud
Cloud Systems Research

- Simple, transparent, controllable cloud computing infrastructure
  - What types of interfaces are appropriate for clouds?
  - How should cloud networks be constructed/managed?
  - How are security concerns addressed in “the cloud”?
  - How are various workloads most efficiently transferred?
  - What types of applications can run in clouds?
  - What types of service level agreements are appropriate/possible?

- Research requirements
  - Perform experiments also on a low system level
  - Flexible cloud computing framework
  - Compare different methodologies and implementations
OpenCirrus Cloud Computing Research Testbed
http://opencirrus.org

- An open, internet-scale global testbed for cloud computing research
  - a tool for collaborative research
  - focus: data center management & cloud services

- Resources
  - Multi-continent, multi-datacenter, cloud computing system
  - Federated “Centers of Excellence” around the globe
    - each with 100–400+ nodes and up to ~2PB storage
    - and running a suite of cloud services

- Structure
  - Sponsors: HP Labs, Intel Research, Yahoo!
  - Partners: UIUC, Singapore IDA, KIT, NSF
  - New partners: ETRI, MIMOS, RAS
  - Members: System and application development

- Great opportunity for Cloud R&D
  - Accepts proposals for cloud systems research
  - Apply through website
Proprietary Cloud Computing Stacks

GOOGLE

Applications

Application Frameworks
MapReduce, Sawzall, Google App Engine, Protocol Buffers

Software Infrastructure
VM Management
Job Scheduling
Storage Management
GFS, BigTable
Monitoring
Borg

Hardware Infrastructure
Borg

AMAZON

Applications

Application Frameworks
EMR – Hadoop

Software Infrastructure
VM Management
EC2
Job Scheduling
Storage Management
S3, EBS
Monitoring
Borg

Hardware Infrastructure
Borg

MICROSOFT

Applications

Application Frameworks
.NET Services

Software Infrastructure
VM Management
Fabric Controller
Job Scheduling
Fabric Controller
Storage Management
SQL Services, blobs, tables, queues
Monitoring
Fabric Controller

Hardware Infrastructure
Fabric Controller

Publicly accessible layer
Open Source Cloud Stack

Applications

Application Frameworks
Hadoop, Pig, MPI, Sprout, Mahout

Software Infrastructure
VM Management
Tashi
Job Scheduling
Maui/Torque/HOD
Storage Management
HDFS, NFS
Monitoring
Ganglia

Hardware Infrastructure
PRS (dynamic h/w allocation)

OpenCirrus™ researchers have complete access to the hardware and software platform
Open Cirrus™ Blueprint

Cloud Application Services

Virtual Resource Sets

Cloud Infrastructure Services

IT-Infrastructure Layer (Physical Resource Sets)
Eucalyptus: A potential VRS

http://eucalyptus.cs.ucsb.edu

Collects resource information from the CC. Operates like a meta-scheduler in the Cloud.

Schedules the distribution of virtual machines to the NC. Collects (free) resource information.

Runs on every node in the Cloud. Xen-Hypervisor running. Provides Information about free resources to the CC.

Source: R. Wolski
Programming the Cloud: Hadoop

- An open-source Apache software foundation project sponsored by Yahoo!
  - Reproduce the proprietary software infrastructure developed by Google
  - [http://wiki.apache.org/hadoop/ProjectDescription](http://wiki.apache.org/hadoop/ProjectDescription)

- Provides a parallel programming model (MapReduce), a distributed file system, and a parallel database
Tashi
http://wiki.apache.org/incubator/TashiProposal

- Co-Scheduling of CPU and data
How do users get access to OpenCirrus™ sites?

- Project PIs apply to each site separately

- Contact names, email addresses, and web links for applications to each site will be available on the OpenCirrus™ Web site
  - [http://opencirrus.org](http://opencirrus.org)

- Each OpenCirrus™ site decides which users and projects get access to its site

- Planning to have a *global sign on* for all sites
  - Users will be able to login to each OpenCirrus™ site for which they are authorized using the same login and password.
What kinds of research projects are OpenCirrus™ sites looking for?

- Open Cirrus™ is seeking research in the following areas:
  - Datacenter federation
  - Datacenter management
  - Web services
  - Data-intensive applications and systems
  - Hadoop map-reduce applications

- The following kinds of projects are not of primary interest:
  - Traditional HPC application development.
  - Production applications that just need lots of cycles.
  - Closed source system development.
Summary

- Promising to implement Grid services on cloud infrastructures
  - Fully automated operations (Centralized management)
  - Economy of scale
  - Business models lead to efficient use of resources
- **OpenCirrus™ offers interesting R&D opportunities**
  - Cloud systems development
  - Cloud application development
  - Accepting research proposals
- **Open Source cloud stack**
  - Federation of clouds (Cloud bursting)
  - De-facto standards are around (e.g. S3)
  - Standards evolving (OCCI)