Extending Rocks Clusters into Amazon EC2 Using Condor

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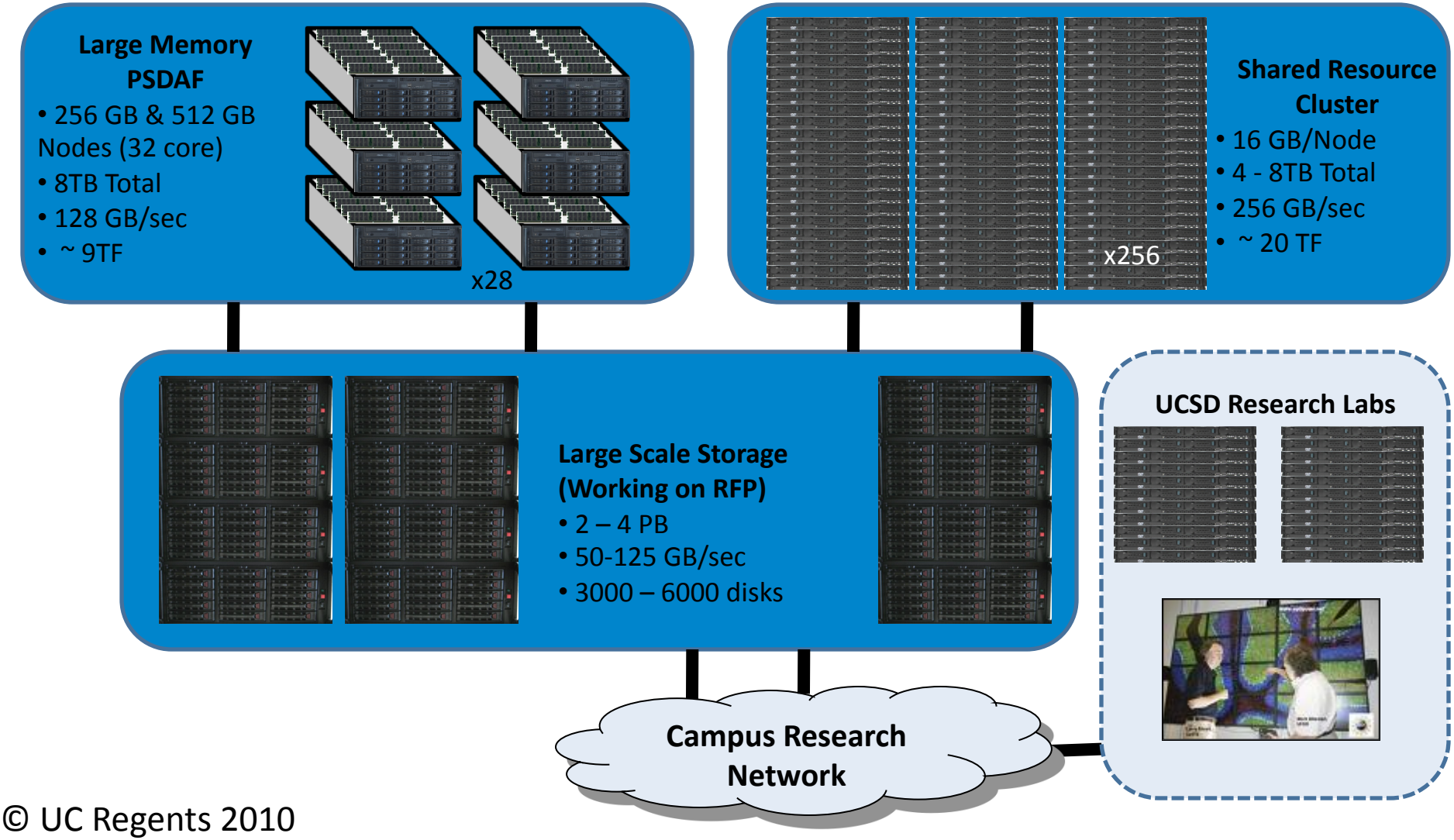
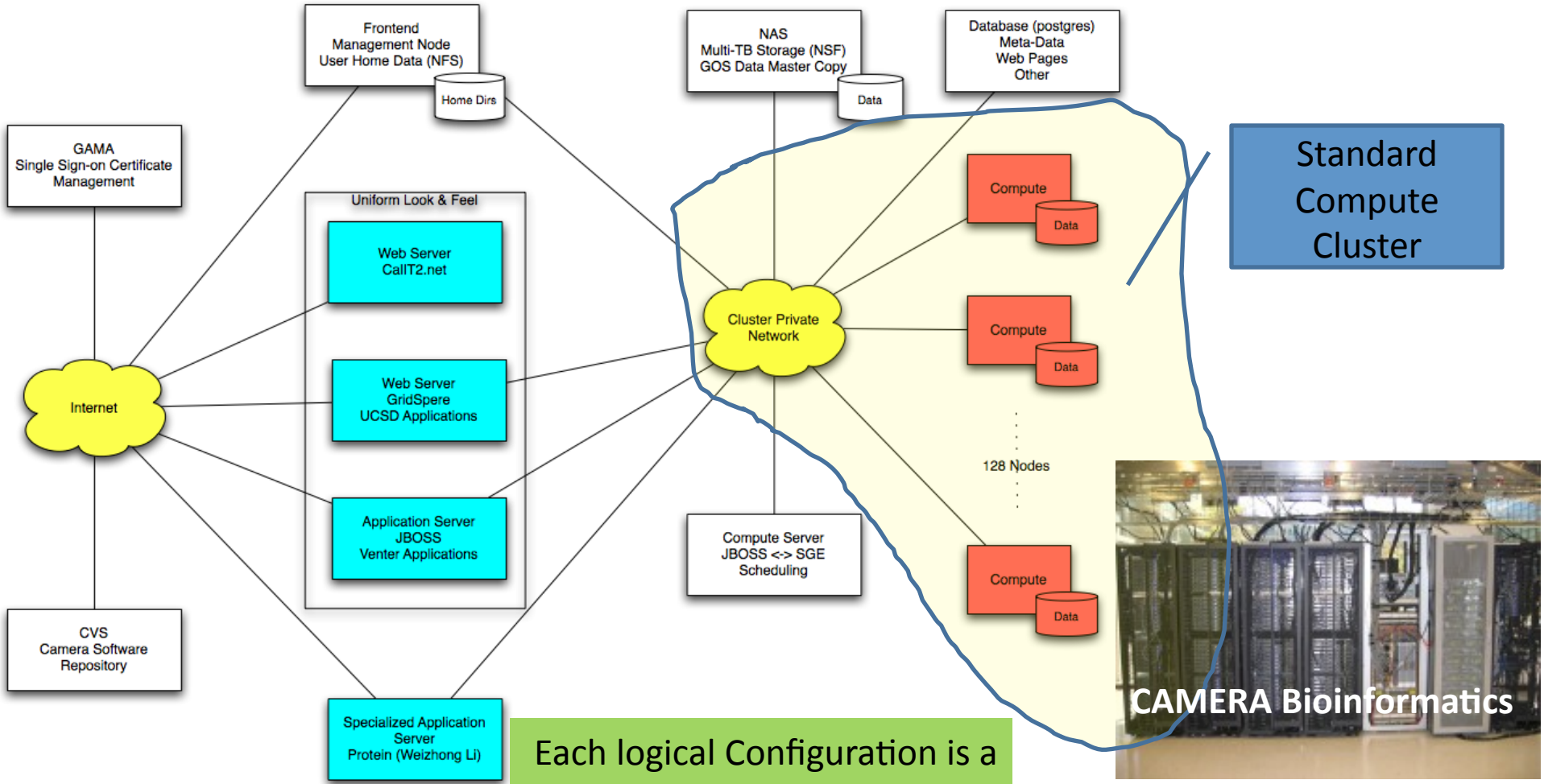
Triton Resource

Background:
So, You want to build a cluster?



The Modern "Cluster" Architecture is Not Just an MPI Cluster

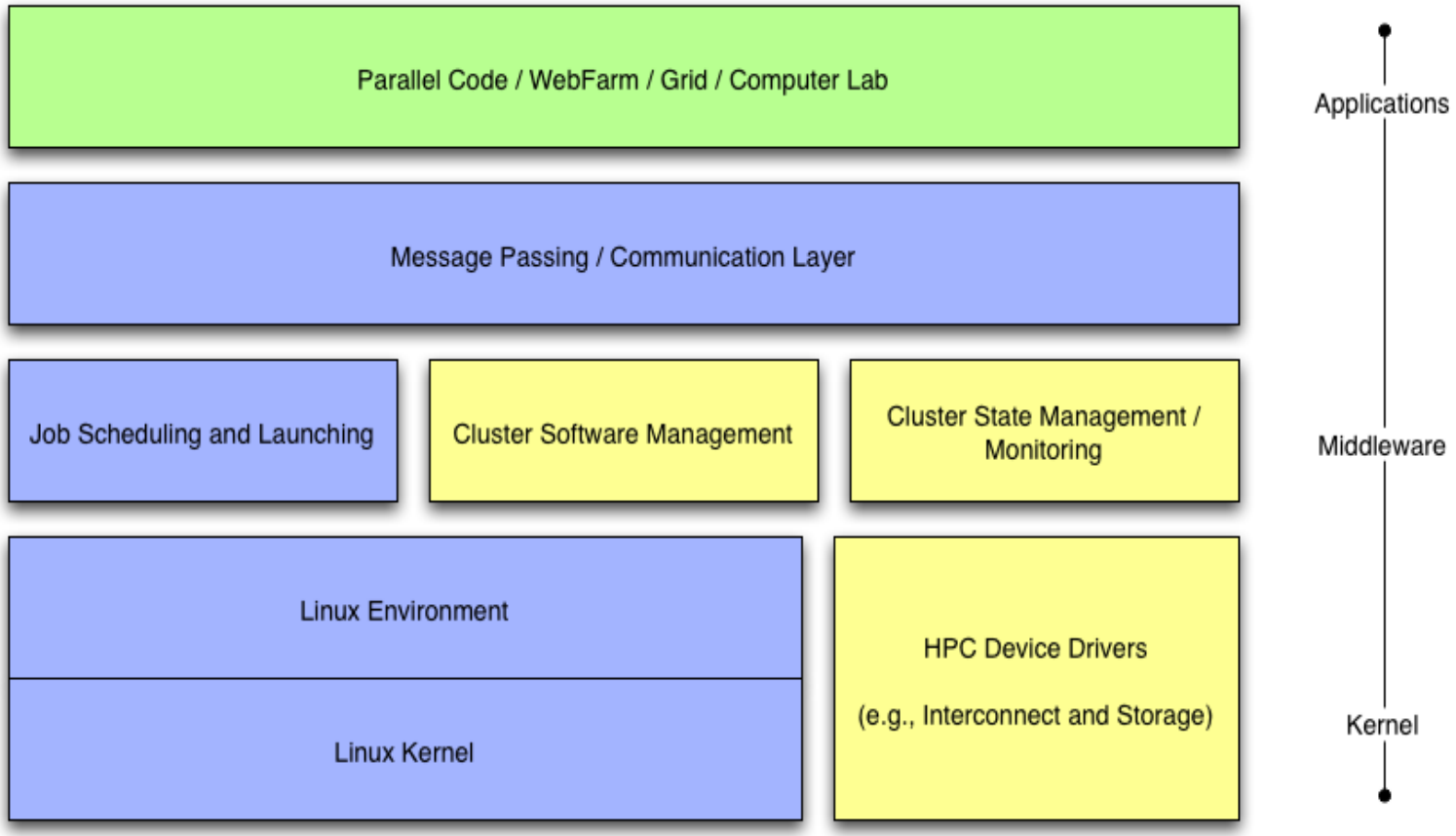


Each logical Configuration is a Rocks ***Appliance***

Rocks www.rocksclusters.org

- Technology transfer of commodity clustering to application scientists
  - "make clusters easy"
- Rocks is a cluster on a CD
  - Clustering software (PBS, SGE, Ganglia, Condor, …)
  - Highly programmatic software configuration management
  - Put CDs in Raw Hardware, Drink Coffee, Have Cluster.
- Extensible using "Rolls"
- Large user community
  - Over 1PFlop of known clusters
  - Active user / support list of 2000+ users
  - Estimate > 2000 installed cluster
- Active Development
  - 2 software releases per year
  - Code Development at SDSC
  - Other Developers (UCSD, Univ of Tromso, External Rolls
- Supports Redhat Linux, Scientific Linux, Centos and Solaris
- Can build Real, Virtual, and Hybrid Combinations

Rocks Breaks Apart the Software Stack into **Rolls**



Rolls on a Simple Cluster

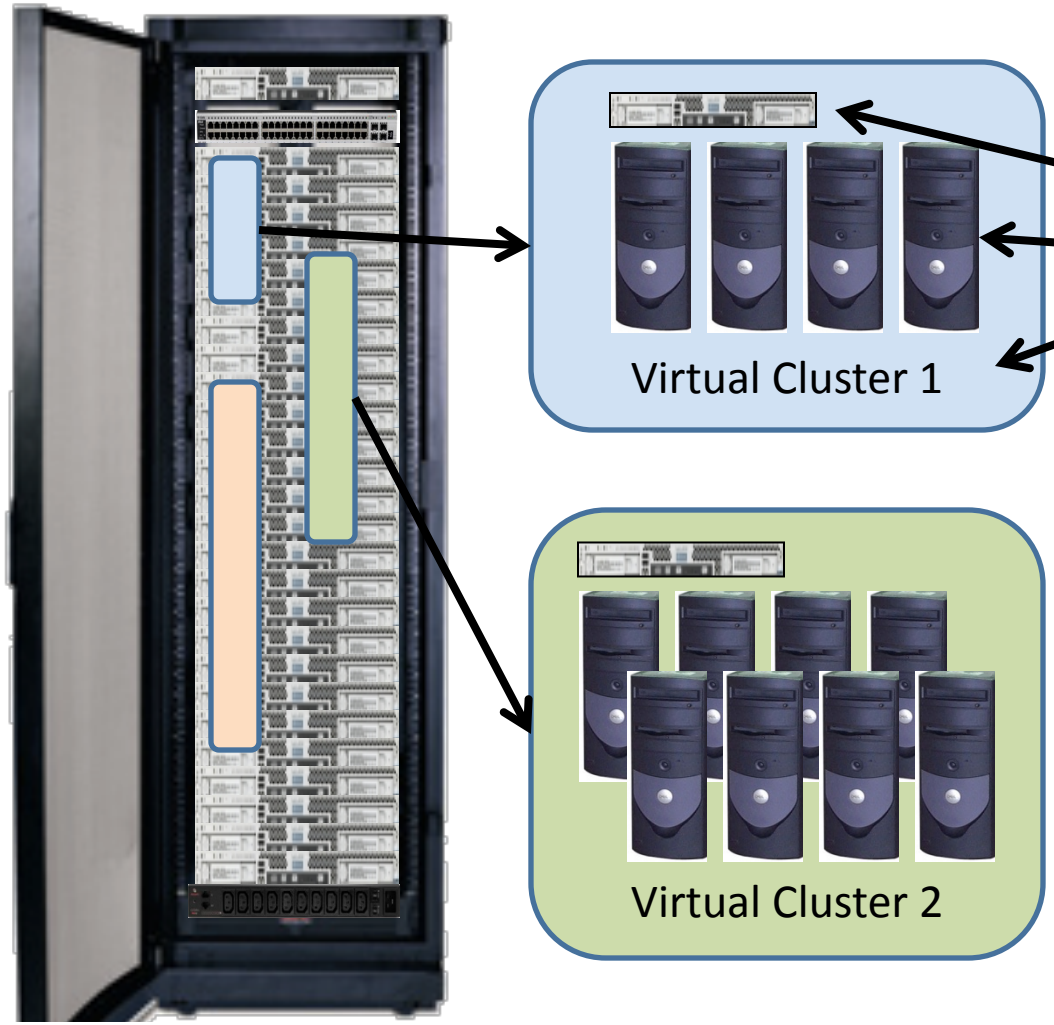
root@landphil:~

```
Connection to ec2-75-101-204-74.compute-1.amazonaws.com closed.
[root@landphil ~]# rocks list roll
NAME            VERSION        ARCH   ENABLED
sge:            5.2            x86_64 yes
ganglia:        5.2            x86_64 yes
kernel:         5.2            x86_64 yes
base:           5.2            x86_64 yes
java:           5.2            x86_64 yes
service-pack:   5.2.2          x86_64 yes
bio:            5.2            x86_64 no
area51:         5.2            x86_64 yes
xen:            5.2            x86_64 yes
hpc:            5.2            x86_64 yes
web-server:     5.2            x86_64 yes
CentOS:         5.3            x86_64 yes
CentOS-Updates: 5.3-2009-09-02 x86_64 yes
green:          5.2            x86_64 yes
condor:         5.2            x86_64 yes
ec2:            5.2            x86_64 yes
apbs:           5.3            x86_64 no
[root@landphil ~]#
```

Condor Roll

- Condor 7.4.1 (updating to 7.4.2)
- Integration with Rocks command line to do basic Condor configuration customization
- To build a Condor Cluster with Rocks
  - Base, OS, Kernel, Condor Roll
  - Gives you local collector, scheduler
- Basic, Working Configuration that can be customized as required.

Virtual Clusters in Rocks Today



Physical Hosting Cluster
"Cloud Provider"

Require:
1. Virtual Frontend
2. Nodes w/disk
3. Private Network
4. Power

Virtual Clusters:
- May overlap one another on physical HW
- Need network isolation
- May be larger or smaller than physical hosting cluster

How Rocks Treats Virtual Hardware

- **It's just another piece of HW**.
  - If RedHat supports it, so does Rocks
- Allows mixture of real and virtual hardware in the same cluster
  - Because Rocks supports heterogeneous HW clusters
- Re-use of all of the software configuration mechanics
  - E.g., a compute appliance is compute appliance

Virtual HW must meet minimum HW Specs

- 1GB memory
- 36GB Disk space*
- Private-network Ethernet
- + Public Network on Frontend

* Not strict – EC2 images are 10GB

Rocks Hybrid: Linux/Solaris/ Physical/Virtual

File Edit View Terminal Help

```
[root@vstorage ~]# uname -a
Linux vstorage.rocksclusters.org 2.6.18-128.1.6.el5xen #1 SMP Wed Apr 1 09:53:14
 EDT 2009 x86_64 x86_64 x86_64 GNU/Linux
[root@vstorage ~]# rocks list host
HOST              MEMBERSHIP    CPUS RACK RANK RUNACTION INSTALLACTION
vstorage:         Frontend      1    0    0    os        install
v20nas-sdsc-0-0: NAS Appliance 1    0    0    os        install_sol
v20nas-sdsc-0-1: NAS Appliance 1    0    1    os        install_sol
[root@vstorage ~]# ssh v20nas-sdsc-0-0
Last login: Fri Oct  2 07:51:02 2009 from vstorage.local
Sun Microsystems Inc.   SunOS 5.10      Generic January 2005
Rocks 5.2 (Chimichanga)
Profile built 15:24 27-May-2009

Jumpstarted 15:30 27-May-2009
# uname -a
SunOS v20nas-sdsc-0-0.local 5.10 Generic_137138-09 i86pc i386 i86pc
# zfs list | grep datapool
datapool1                  39.1M  8.89T  43.2K  /datapool1
datapool1/arajendr         43.2K  8.89T  43.2K  /datapool1/arajendr
datapool1/gbruno           47.3K  8.89T  47.3K  /datapool1/gbruno
datapool1/mjkatz           47.3K  8.89T  47.3K  /datapool1/mjkatz
datapool1/ppapadop         38.7M  8.89T  38.7M  /datapool1/ppapadop
datapool1/pragma           29.9K  8.89T  29.9K  /datapool1/pragma
```

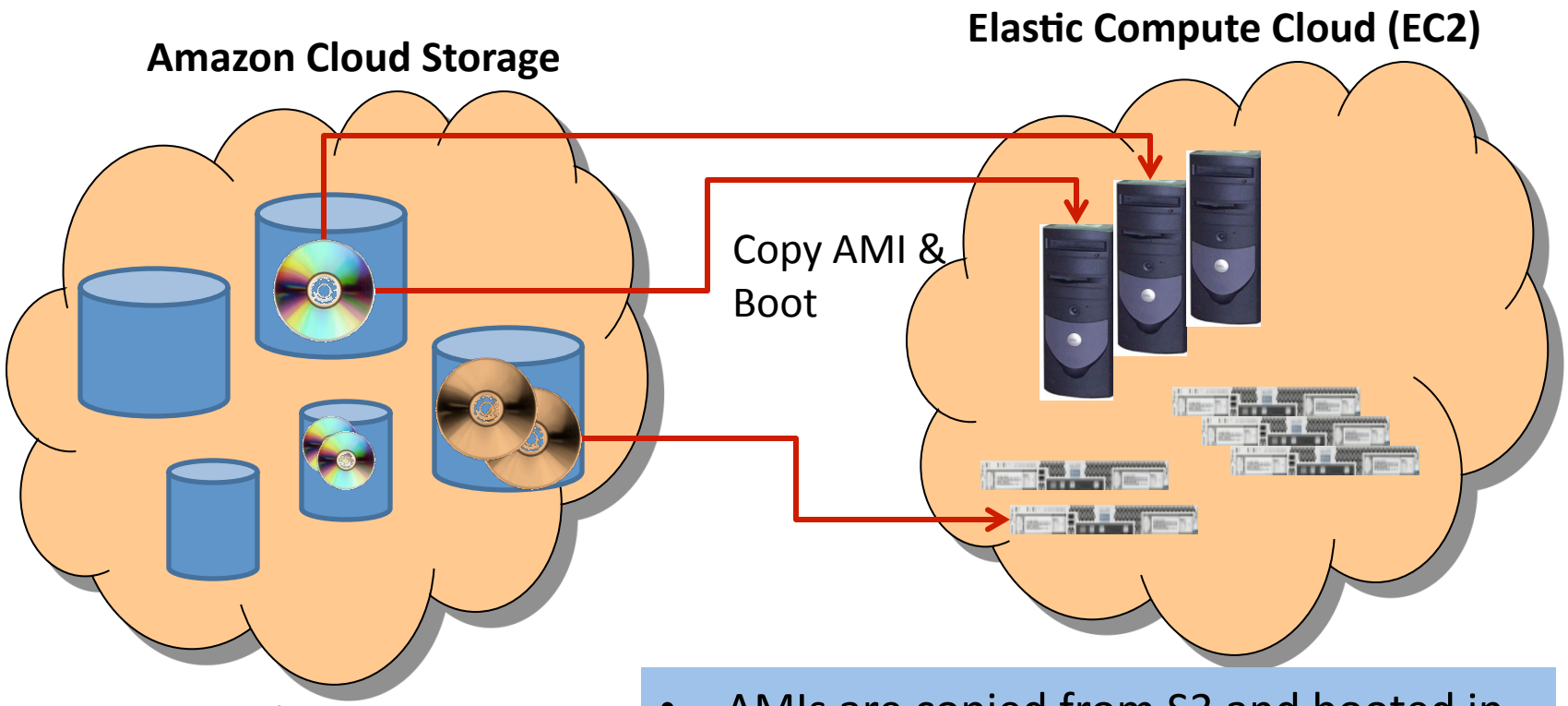
Linux → Linux vstorage.rocksclusters.org 2.6.18-128.1.6.el5xen #1 SMP Wed Apr 1 09:53:14 EDT 2009 x86_64 x86_64 x86_64 GNU/Linux

Xen VM → vstorage:

Phys → v20nas-sdsc-0-0: NAS Appliance 1 0 0 os install_sol; v20nas-sdsc-0-1: NAS Appliance 1 0 1 os install_sol

Solaris → SunOS v20nas-sdsc-0-0.local 5.10 Generic_137138-09 i86pc i386 i86pc

Basic EC2



S3 – Simple Storage Service
EBS – Elastic Block Store

Amazon
Machine
Images (AMIs)

- AMIs are copied from S3 and booted in EC2 to create a "running instance"
- When instance is shutdown, all changes are lost
  - Can save as a new AMI

Basic EC2

- AMI (Amazon Machine Image) is copied from S3 to EC2 for booting
  - Can boot multiple copies of an AMI as a "group"
  - Not a cluster, all running instances are independent
- If you make changes to your AMI while running and want them saved
  - Must repack to make a new AMI
    - Or use Elastic Block Store (EBS) on a per-instance basis

Some Challenges in EC2

1. Defining the contents of <u>your</u> Virtual Machine (Software Stack)
2. Understanding limitations and execution model
3. Debugging when something goes wrong
4. Remembering to turn off your VM
   - Smallest 64-bit VM is ~$250/month running 7x24

What's in the AMI?

- Tar file of a / file system
  - Cryptographically signed so that Amazon can open it, but other users cannot
  - Split into 10MB chunks, stored in S3
- Amazon boasts more than 2000 public machine images
  - What's in a particular image?
  - How much work is it to get your software part of an existing image?
- There are tools for booting and monitoring instances.
- Defining the software contents is "an exercise left to the reader"

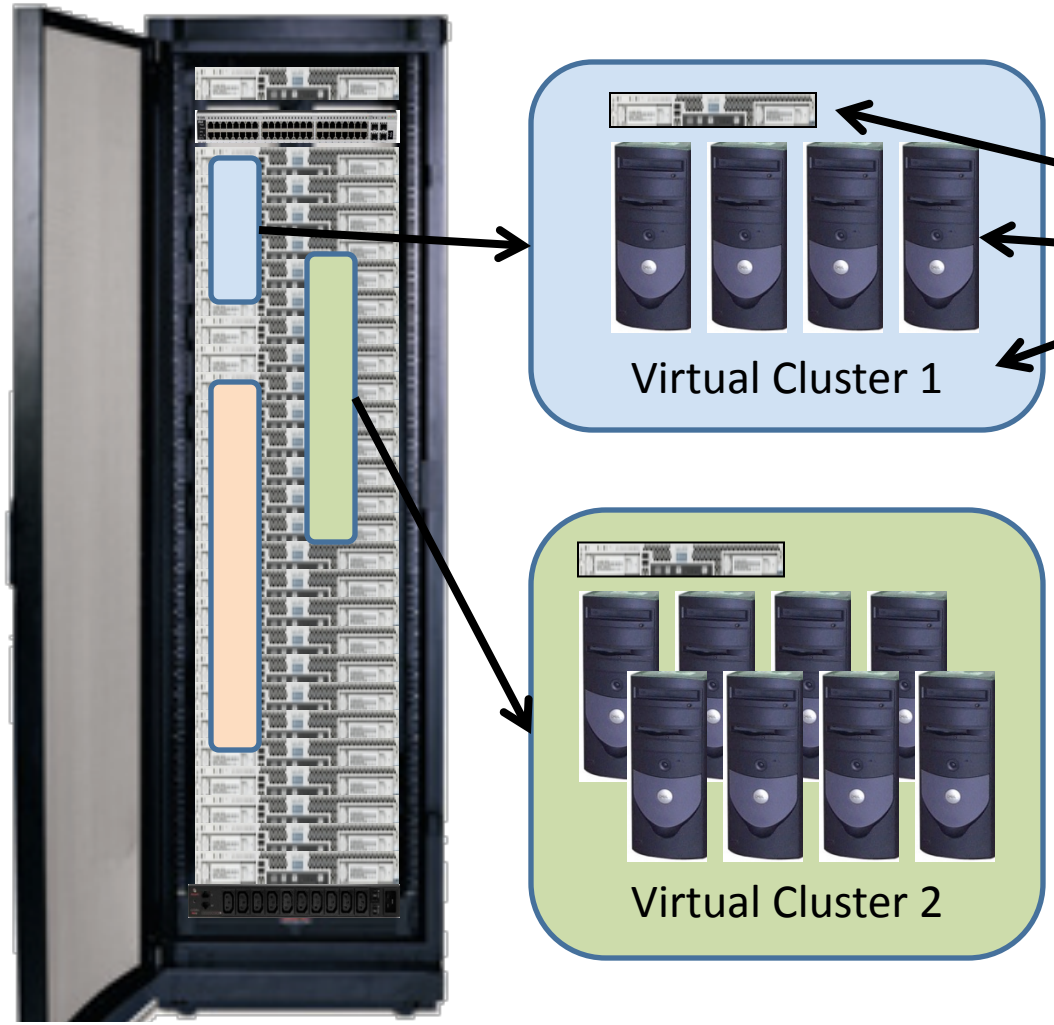
The EC2 Roll

- Take a Rocks appliance and make it compatible with EC2:
  - 10GB disk partition (single)
  - DHCP for network
  - ssh key management
  - Other small adjustments
- Create an AMI bundle on local cluster
  - `rocks create ec2 bundle`
- Upload a bundled image into EC2
  - `rocks upload ec2 bundle`
- Mini-tutorial on getting started with EC2 and Rocks

Putting all together: Virtual Cluster Experiment

Nimrod – Monash University
Rocks® – UC San Diego
Condor – U. Wisconsin
Amazon EC2 – Brought to you by Visa®

Virtual Clusters in Rocks Today



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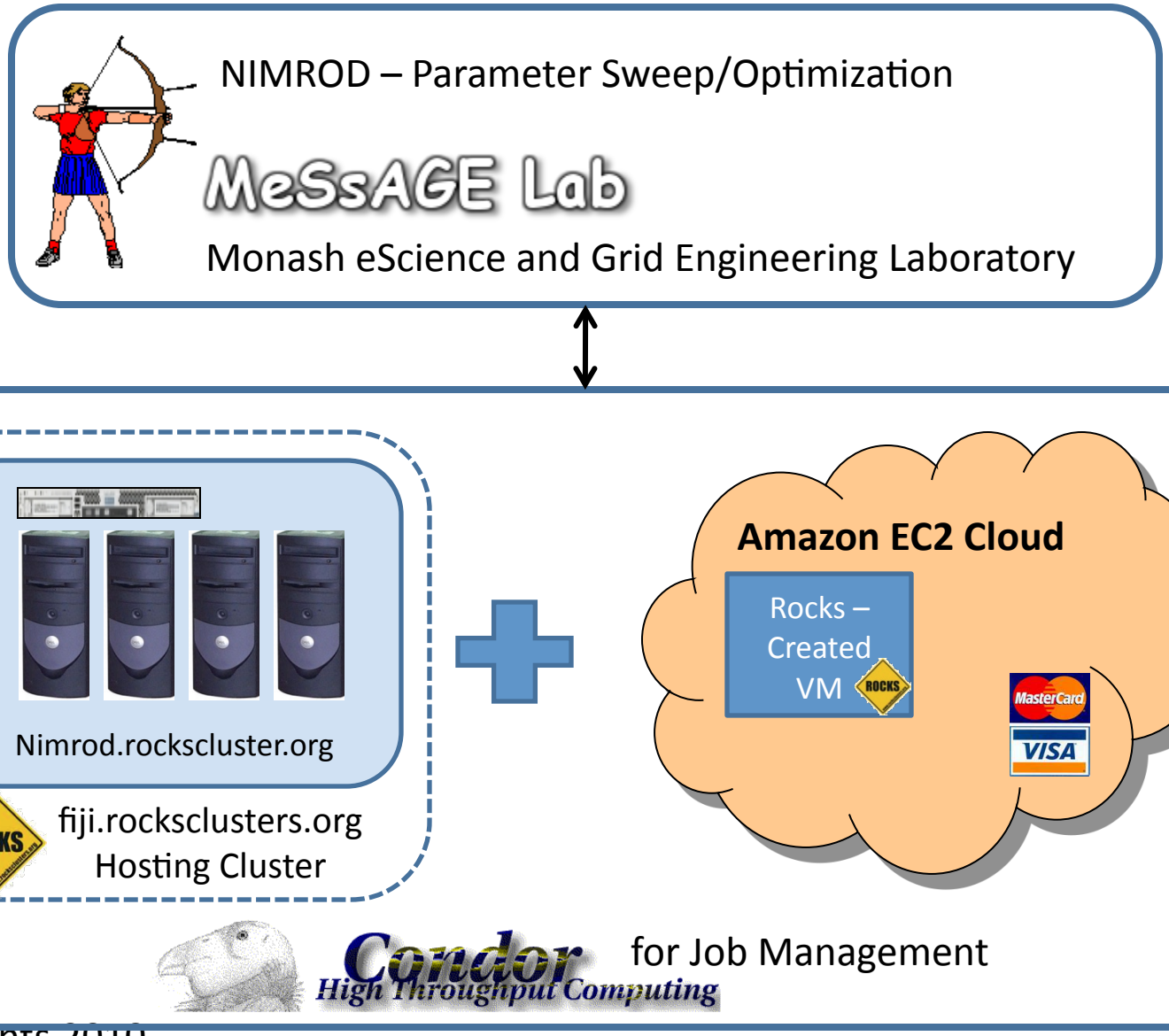
Extended Cluster Experiment in PRAGMA



Extended Cluster Using Condor

ppapadop@landphil:~

```
[ppapadop@landphil ~]$ rm *err *log *out
[ppapadop@landphil ~]$ condor_submit hello.sub
Submitting job(s)........
Logging submit event(s)........
8 job(s) submitted to cluster 11.
[ppapadop@landphil ~]$ condor_status

Name               OpSys      Arch   State     Activity LoadAv Mem   ActvtyTime

compute-0-0-0.loca LINUX      X86_64 Unclaimed Idle     0.000  1024  0+01:30:04
devel-server-0-1-0 LINUX      X86_64 Unclaimed Idle     0.000  1024  0+00:00:04
slot1@ec2-75-101-2 LINUX      X86_64 Claimed   Busy     0.000  2560  0+00:00:02
slot1@landphil-0-0 LINUX      X86_64 Unclaimed Idle     0.000   658  0+00:00:04
slot2@ec2-75-101-2 LINUX      X86_64 Claimed   Busy     0.000  2560  0+00:00:03
slot2@landphil-0-0 LINUX      X86_64 Unclaimed Idle     0.000   658  0+00:00:05
slot3@ec2-75-101-2 LINUX      X86_64 Claimed   Busy     0.000  2560  0+00:00:03
slot3@landphil-0-0 LINUX      X86_64 Claimed   Busy     0.000   658  0+00:00:06
slot4@landphil-0-0 LINUX      X86_64 Claimed   Busy     0.000   658  0+00:00:07
                     Total Owner Claimed Unclaimed Matched Preempting Backfill

        X86_64/LINUX     9     0       5         4       0          0        0

               Total     9     0       5         4       0          0        0
[ppapadop@landphil ~]$
```

Can Log into the Running VM

root@ec2-75-101-204-74:~

```
[root@landphil ~]# ssh ec2-75-101-204-74.compute-1.amazonaws.com
Last login: Thu Apr 15 07:45:08 2010 from rocks-154.sdsc.edu
Rocks 5.2 (Chimichanga)
Profile built 11:23 03-Mar-2010

Kickstarted 11:43 03-Mar-2010
EC2-enabled Client
Rocks 5.2 Development Server
[root@ec2-75-101-204-74 ~]# date
Thu Apr 15 07:46:10 PDT 2010
[root@ec2-75-101-204-74 ~]# condor_status

Name               OpSys      Arch   State     Activity LoadAv Mem   ActvtyTime

compute-0-0-0.loca LINUX      X86_64 Unclaimed Idle     0.000  1024  0+01:40:04
devel-server-0-1-0 LINUX      X86_64 Unclaimed Idle     0.000  1024  0+00:11:08
slot1@ec2-75-101-2 LINUX      X86_64 Unclaimed Idle     0.000  2560  0+00:09:28
slot1@landphil-0-0 LINUX      X86_64 Unclaimed Idle     0.000   658  0+00:11:06
slot2@ec2-75-101-2 LINUX      X86_64 Unclaimed Idle     0.000  2560  0+00:09:29
slot2@landphil-0-0 LINUX      X86_64 Unclaimed Idle     0.000   658  0+00:11:07
slot3@ec2-75-101-2 LINUX      X86_64 Unclaimed Idle     0.000  2560  0+00:09:30
slot3@landphil-0-0 LINUX      X86_64 Unclaimed Idle     0.000   658  0+00:11:08
slot4@landphil-0-0 LINUX      X86_64 Unclaimed Idle     0.000   658  0+00:11:09
                     Total Owner Claimed Unclaimed Matched Preempting Backfill
```

Steps to Make this Work

PREPARATION

- Build Local Cluster with appropriate rolls
  - Rocks + Xen Roll + EC2 Roll + Condor Roll (+ NIMROD + …)
- Create local appliance as VM using standard Rocks tools
  - Set ec2_enable attribute to build it as an EC2-Compatible VM
  - Build and test locally
- Bundle, Upload, Register as an EC2 AMI
  - Rocks command line tools

RUN

- Boot with appropriate meta data to register automatically with your local collector.
  - `ec2-run-instances -t m1.large ami-219d7248 -d "condor:landphil.rocksclusters.org:40000:40050"`
  - Requires one-time EC2 firewall settings
- Use your extended Condor Pool

Summary

- Easily Extend your Condor pool into EC2
  - Others can do this as well
  - Condor supports the public/private network duality of EC2
- Have <u>your</u> software on <u>both</u> local cluster and remote VM in EC2
- Mix and match
  - Local Physical, Local Virtual, Remote Virtual
- If you use Rocks, does not take extra effort