

Nimbus: Open Source Infrastructure-as-a-Service Cloud Computing Software

Workshop on adapting applications and computing services to
multi-core and virtualization

CERN, June 2009

Kate Keahey

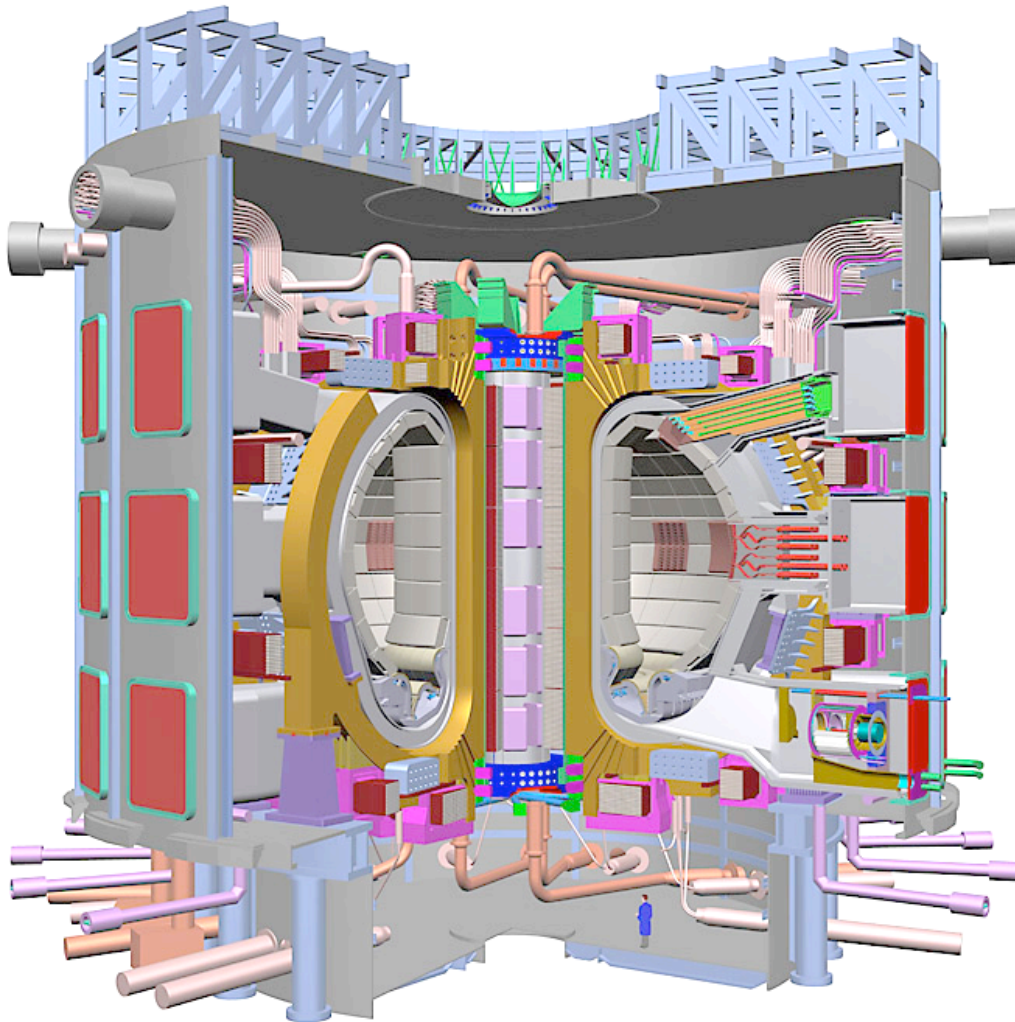
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Nimbus project lead

University of Chicago

Argonne National Laboratory

Cloud Computing for Science



- Complex environments
- Need for control

10/26/09

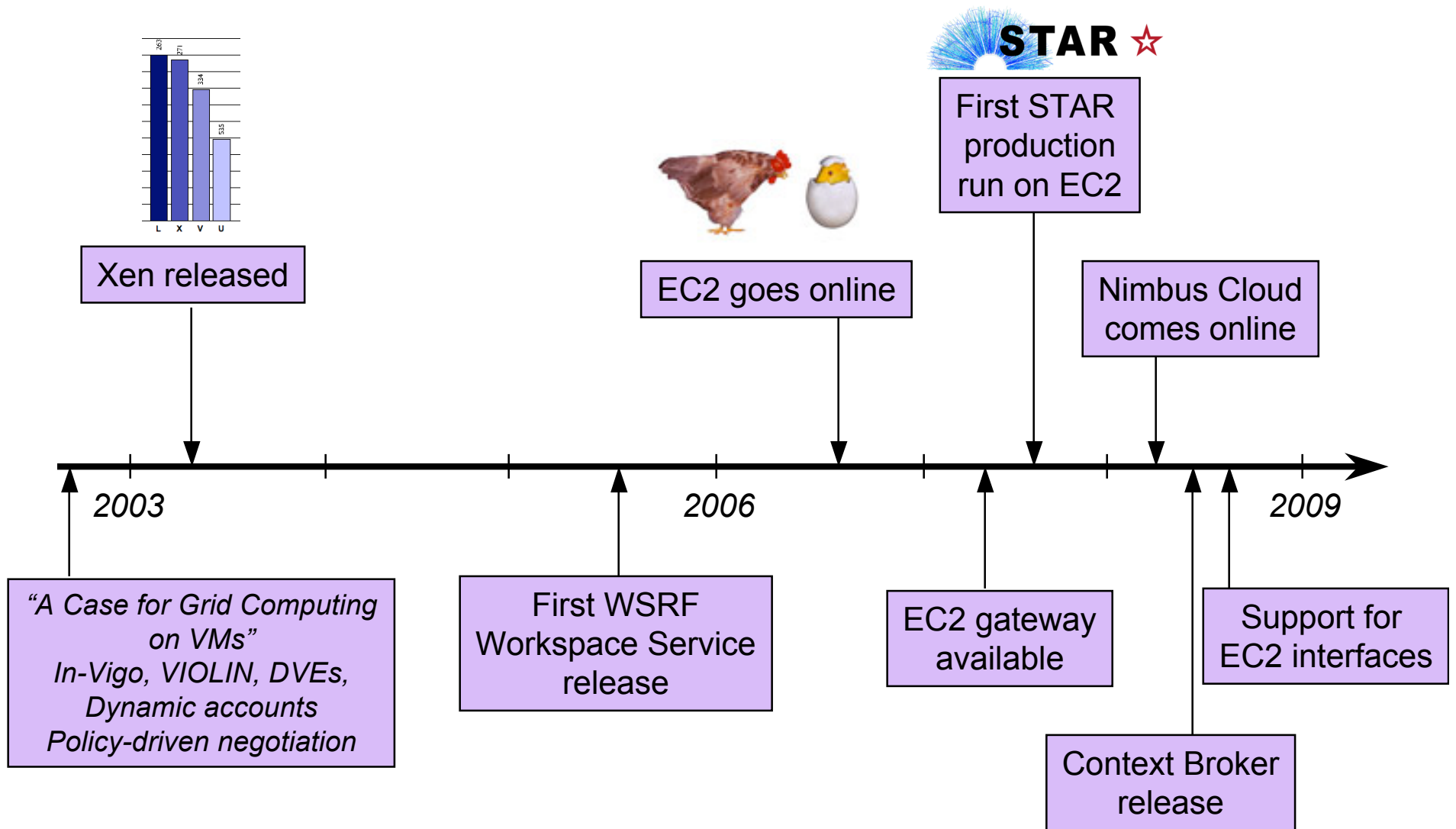
The Nimbus Toolkit: <http://workspace.globus.org>

Workspaces

- Dynamically provisioned environments
 - ◆ Environment control
 - ◆ Resource control
- Implementations
 - ◆ Via leasing processes: reimaging, configuration, account creation, dynamic
 - ◆ Via virtualization: deployment

Isolation

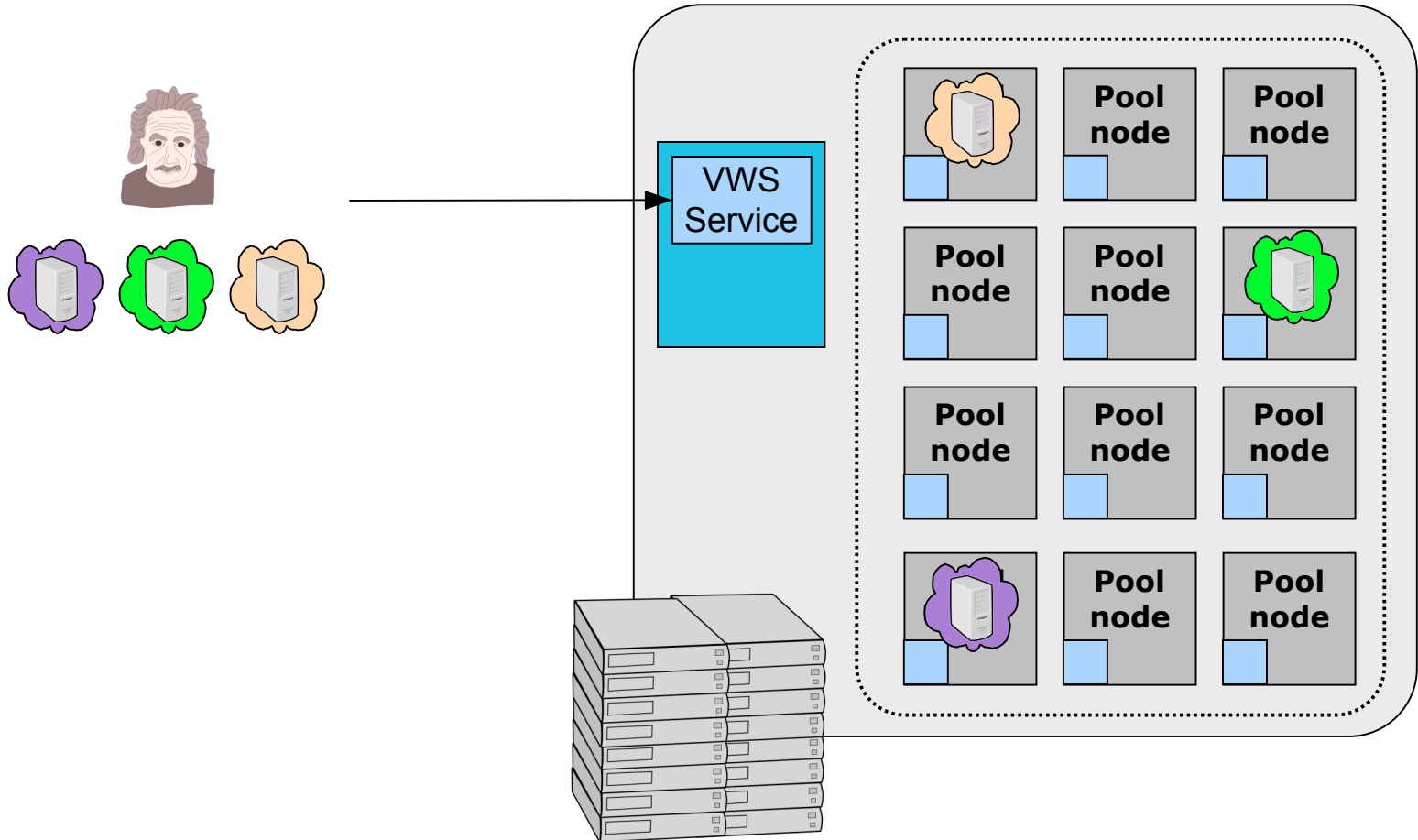
A Brief History of Nimbus



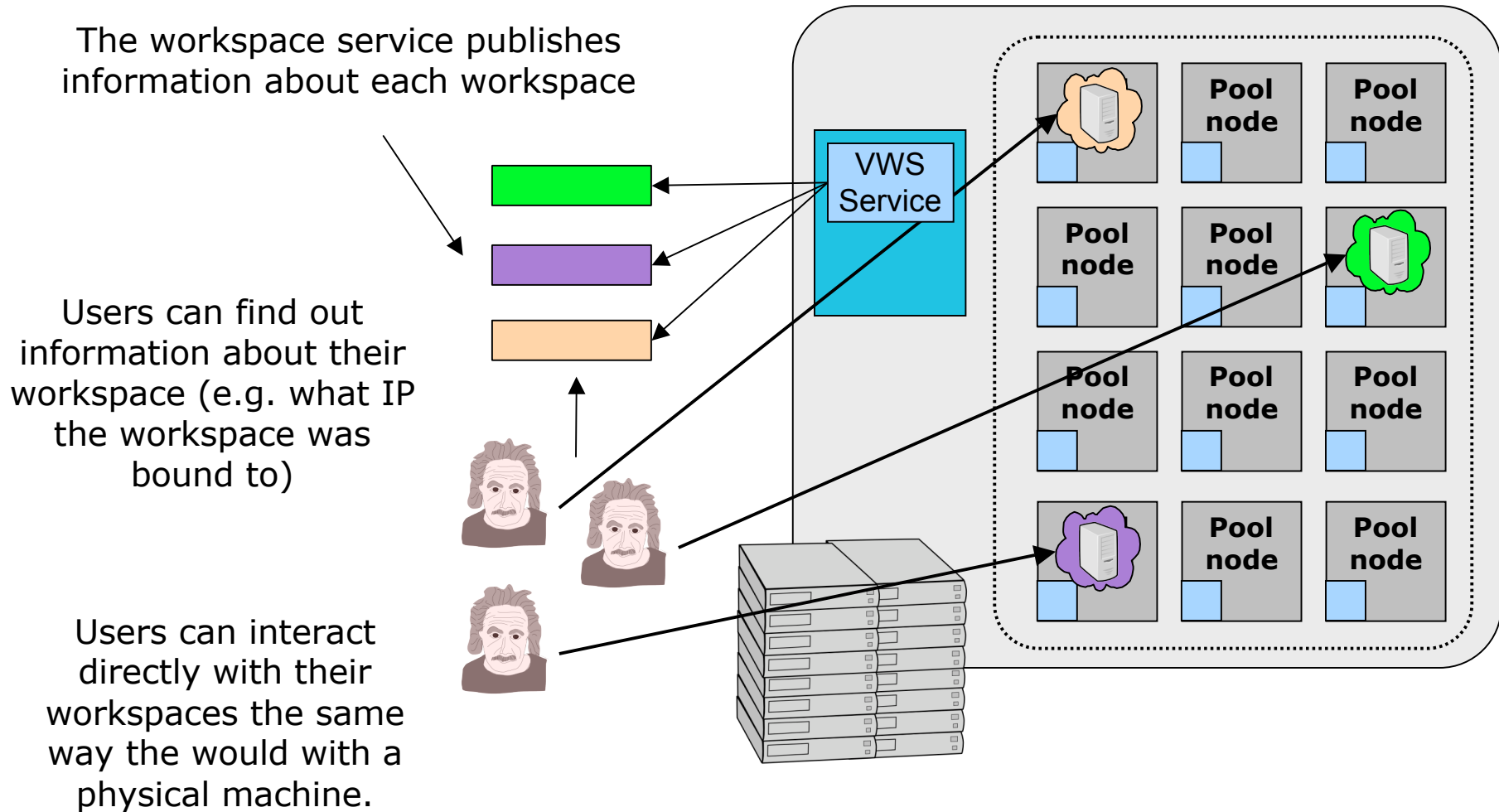
Nimbus Goals

- Allow providers to build clouds
 - ◆ Private clouds (privacy, expense considerations)
 - ◆ Workspace Service: open source EC2 implementation
- Allow users to use cloud computing
 - ◆ Do whatever it takes to enable scientists to use IaaS
 - ◆ Context Broker: turnkey virtual clusters
 - ◆ IaaS Gateway: interoperability
- Allow developers to experiment with Nimbus
 - ◆ For research or usability/performance improvements
 - ◆ Community extensions and contributions

The Workspace Service



The Workspace Service



Workspace Service: Interfaces and Clients

- Web Services based
- Web Service Resource Framework (WSRF)
 - ◆ WS + state management (WS-Notification)
- Elastic Computing Cloud (EC2)
 - ◆ Compatible with EC2 clients
 - ◆ Supported: ec2-describe-images, ec2-run-instances, ec2-describe-instances, ec2-terminate-instances, ec2-reboot-instances, ec2-add-keypair, ec2-delete-keypair
 - ◆ Unsupported: availability zones, security groups, elastic IP assignment, REST
- Protocol adapter, moving towards messaging

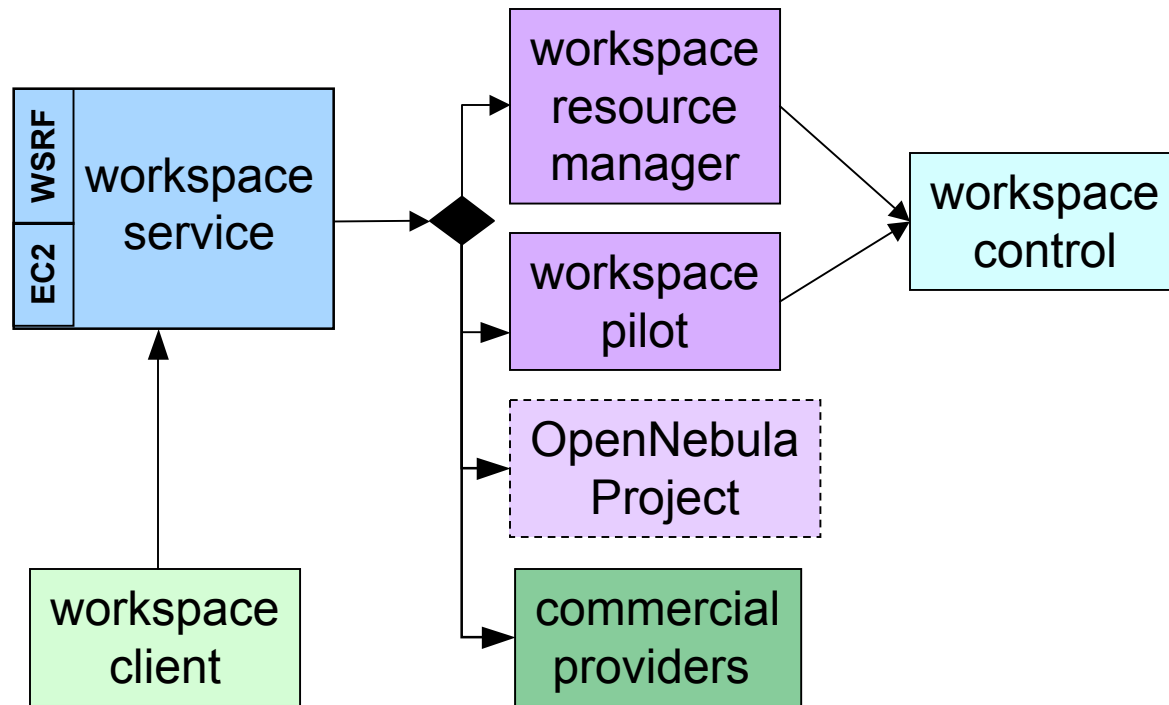
Workspace Service: Security

- GSI authentication and authorization
 - ◆ PKI-based
 - ◆ VOMS, Shibboleth (via GridShib), custom PDPs
- Secure access to VMs
 - ◆ EC2 key generation or accessed from .ssh
- Validating images and image data
 - ◆ Extensions from Vienna University of Technology
 - ◆ *Paper: Descher et al., Retaining Data Control in Infrastructure Clouds, ARES (the International Dependability Conference), 2009.*

Workspace Service: Networking

- Network configuration
 - ◆ External: public IPs or private IPs (via VPN)
 - ◆ Internal: private network via a local cluster network
- Each VM can specify multiple NICs mixing private and public networks (WSRF only)
 - ◆ E.g., cluster worker nodes on a private network, headnode on both public and private network

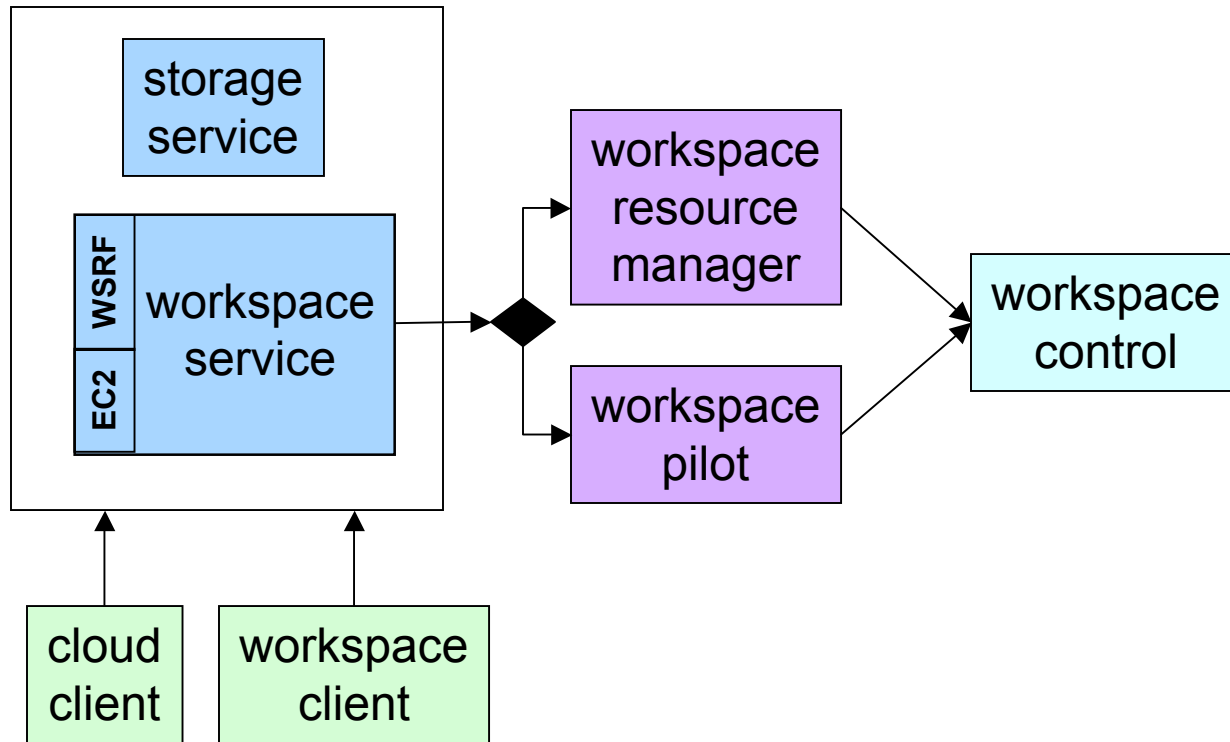
Workspace Components



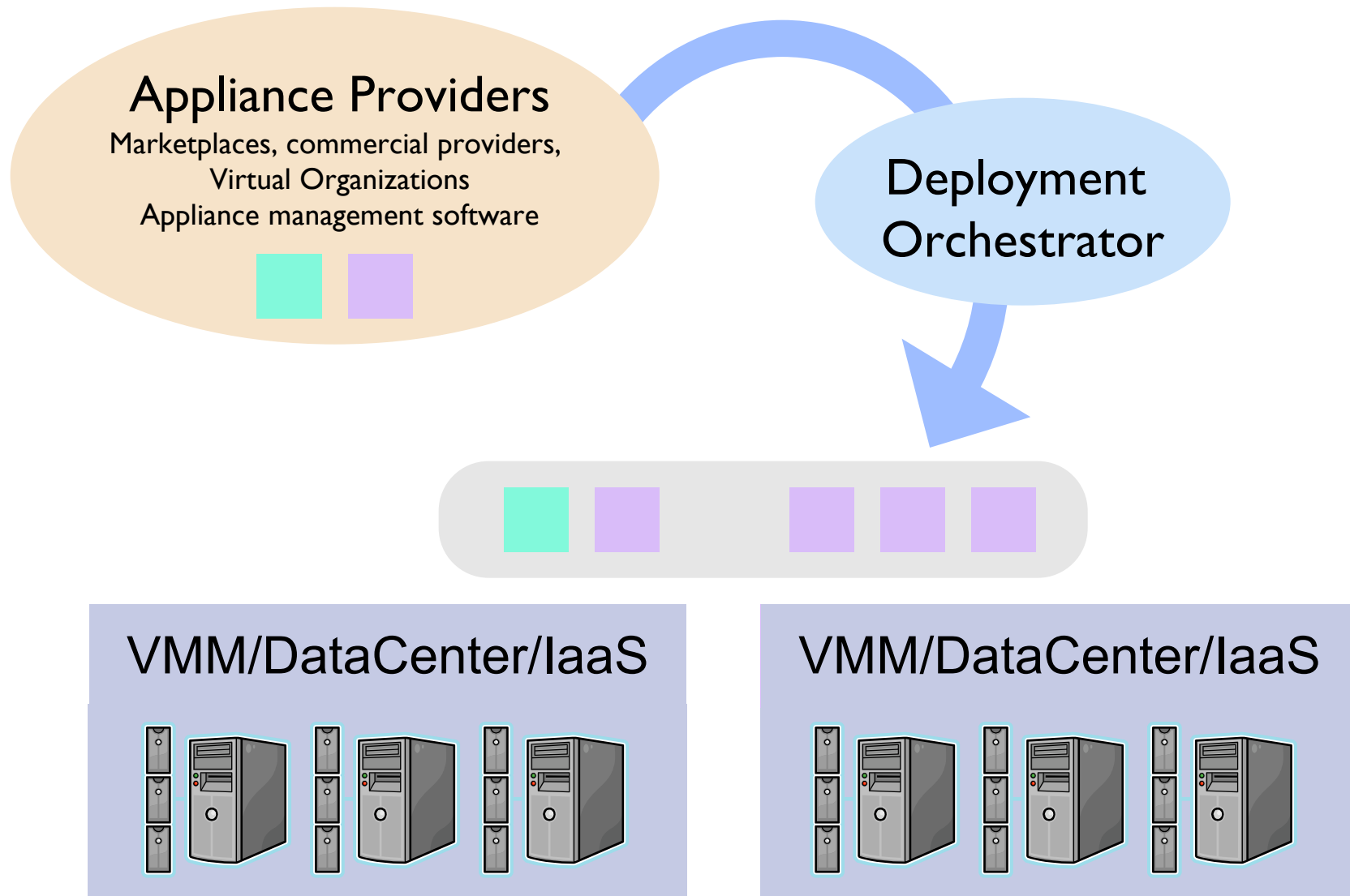
See papers at: <http://workspace.globus.org/papers/index.html>

- "Simple Leases with Workspace Pilot" (EuroPar08)
- "Combining Batch Execution and Leasing Using Virtual Machines" (HPDC08),

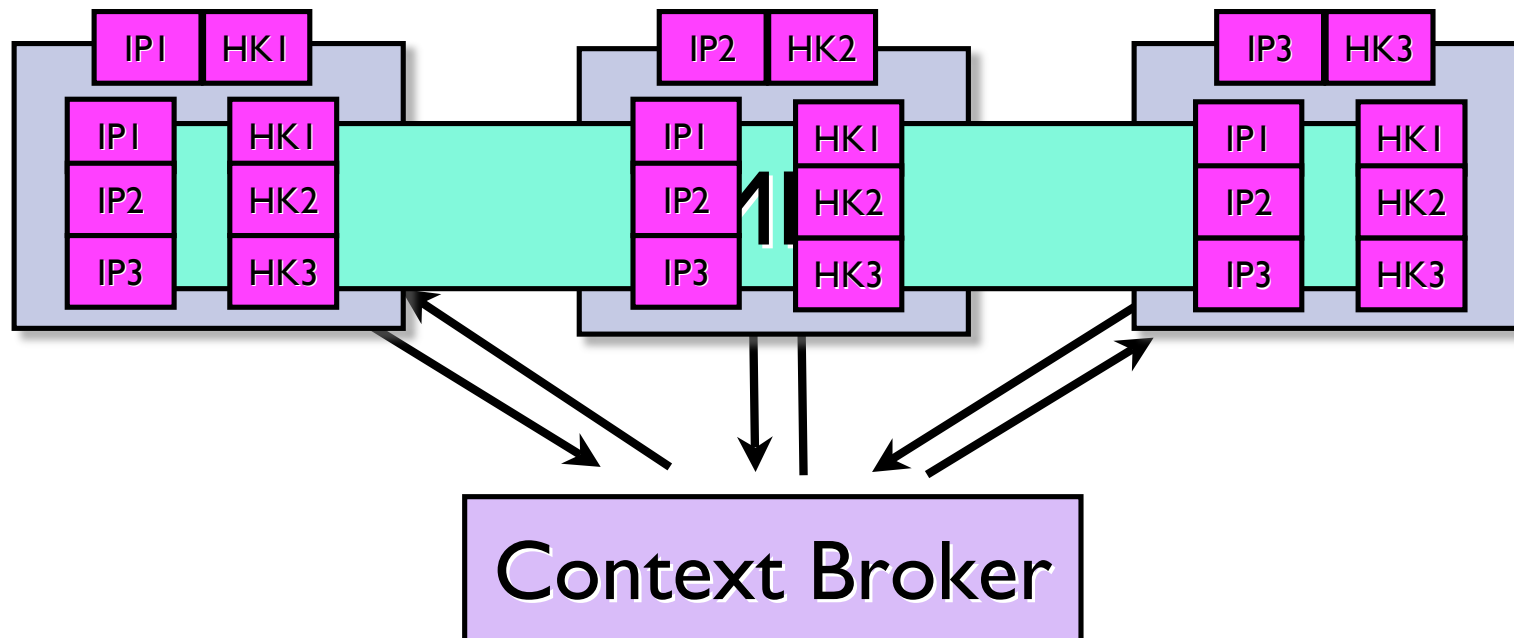
Cloud Capabilities



Cloud Computing Ecosystem



Turnkey Virtual Clusters



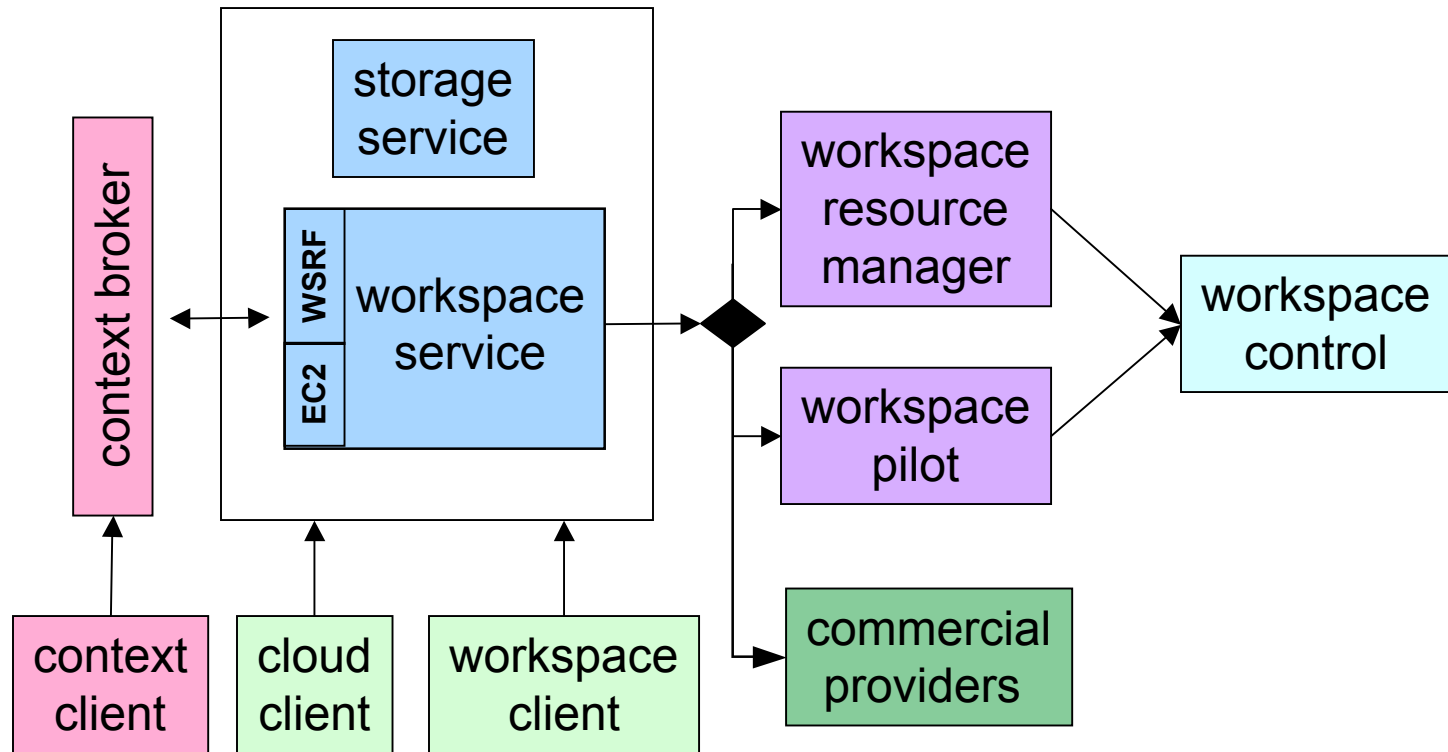
- Turnkey, tightly-coupled cluster
 - ◆ Shared trust/security context
 - ◆ Shared configuration/context information

Context Broker Status

- Releases
 - ◆ In alpha since 08/07, first release 06/08, update 01/09
- Used to contextualize cluster composed of 100s of virtual nodes for multiple production apps
- Contextualized images on workspace marketplace
- Working with rPath to make contextualization easier for the user

Paper: Keahey&Freeman, Contextualization: Providing One-Click Virtual Clusters, eScience 2008

End of Nimbus Tour



Nimbus: Extensions and Collaborations

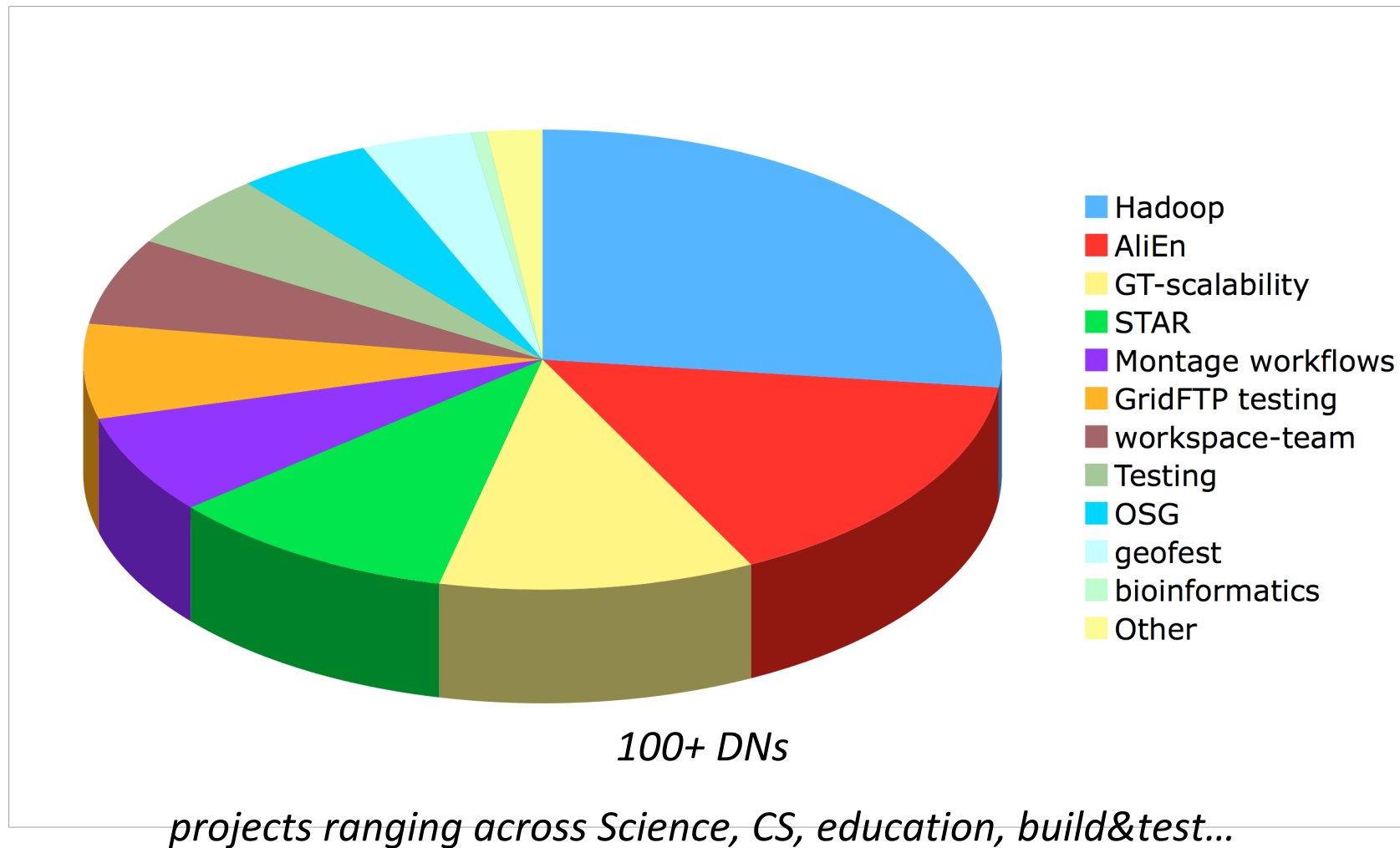
- Nimbus core team:
 - ◆ UC/ANL: Kate Keahey, Tim Freeman, David LaBissoniere
 - ◆ UVIC: Ian Gable & team (Nimbus monitoring)
- Cumulus: Raj Kettimuthu and John Bresnahan (ANL/UC)
- EBS: Marlon Pierce, Xiaoming Gao, Mike Lowe (IU)
- ViNe: Mauricio Tsugawa, Jose Fortes (UFL)
- Others:
 - ◆ OpenNebula project (University of Madrid)
 - ◆ Descher et al (Technical U of Vienna): privacy extensions

Congratulations to the EBS team for winning best poster award at TG09!

Science Clouds

- Goals
 - ◆ Enable experimentation with IaaS
 - ◆ Evolve software in response to user needs
 - ◆ Exploration of cloud interoperability issues
- Participants
 - ◆ University of Chicago (since 03/08, 16 nodes), University of Florida (05/08, 16-32 nodes, access via VPN), Masaryk University, Brno, Czech Republic (08/08), Wispy @ Purdue (09/08)
 - ◆ In progress: Grid5K, IU, Vrije
 - ◆ Using EC2 for large runs
- Science Clouds Marketplace: OSG cluster, Hadoop, etc.
- Come and run: <http://workspace.globus.org/clouds>

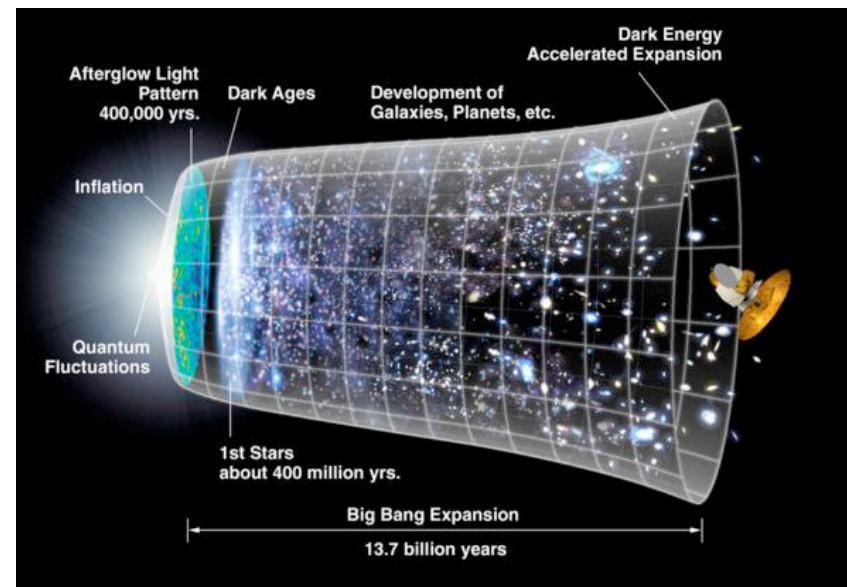
Who Runs on Nimbus?



STAR experiment



- STAR: a nuclear physics experiment at Brookhaven National Laboratory
- Studies fundamental properties of nuclear matter
- Problem: computations require complex and consistently configured environments that are hard to find in existing grids



STAR Virtual Clusters

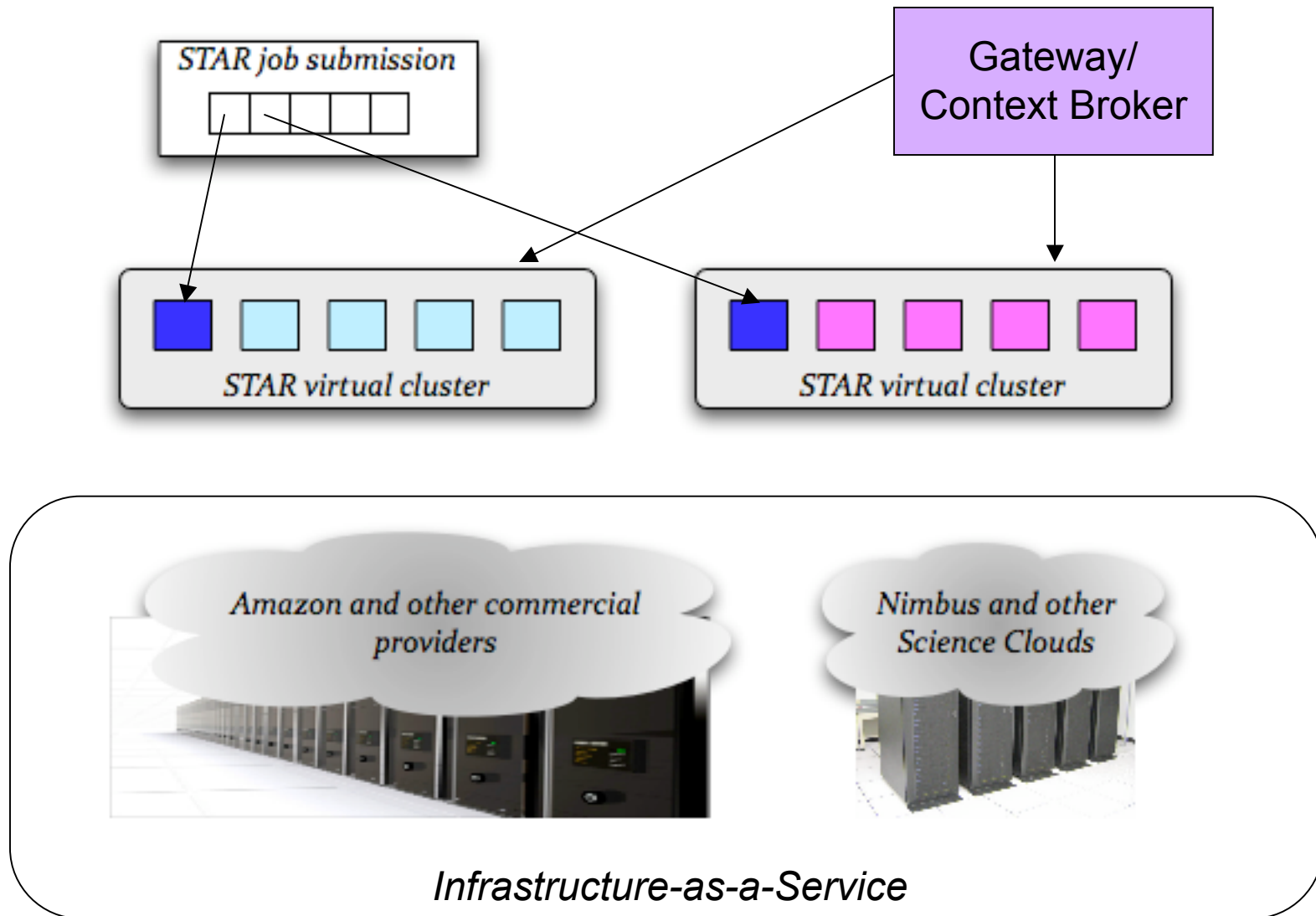
- Virtual resources
 - ◆ A virtual OSG STAR cluster: OSG headnode (gridmapfiles, host certificates, NFS, Torque), worker nodes: SL4 + STAR
 - ◆ One-click virtual cluster deployment via Nimbus Context Broker
- From Science Clouds to EC2 runs
- Running production codes since 2007
- Work by Jerome Lauret, Leve Hajdu, Lidia Didenko (BNL), Doug Olson (LBNL)
- The Quark Matter run: producing just-in-time results for a conference: <http://www.isgtw.org/?pid=1001735>



TECHTONIC SHIFTS

Number Crunching Made Easy

STAR Quark Matter Run



STAR Quark Matter Run (2)

- Application stats:
 - ◆ Processed 1.2 M events
 - ◆ Moved ~1TB of data over duration (small I/O needs)
- Run facts:
 - ◆ 300+ nodes, total of ~36,000 hours
 - ◆ Instances, 32-bit, 1.7 GB memory:
 - EC2 default: 1 EC2 CPU unit
 - High-CPU Medium Instances: 5 EC2 CPU units (2 cores)
 - ◆ Cost:
 - Comp: ~ \$6,000: ~ \$1,7 K (default) + ~ \$3,9K (medium)
 - Data: ~ \$150

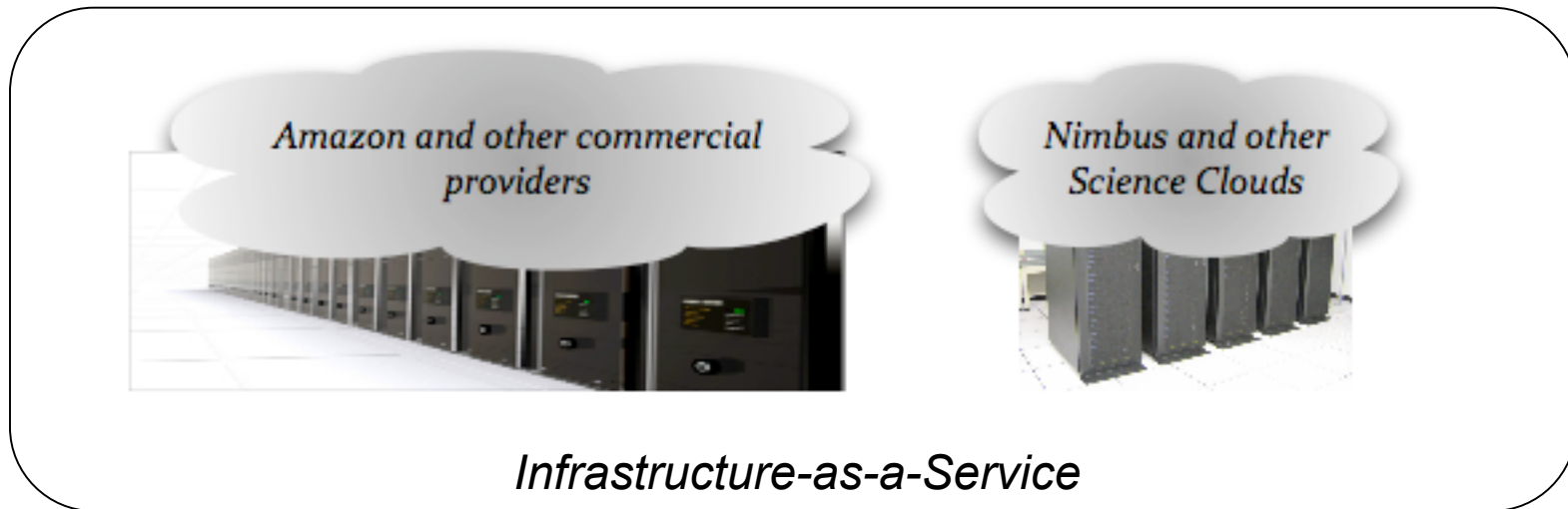
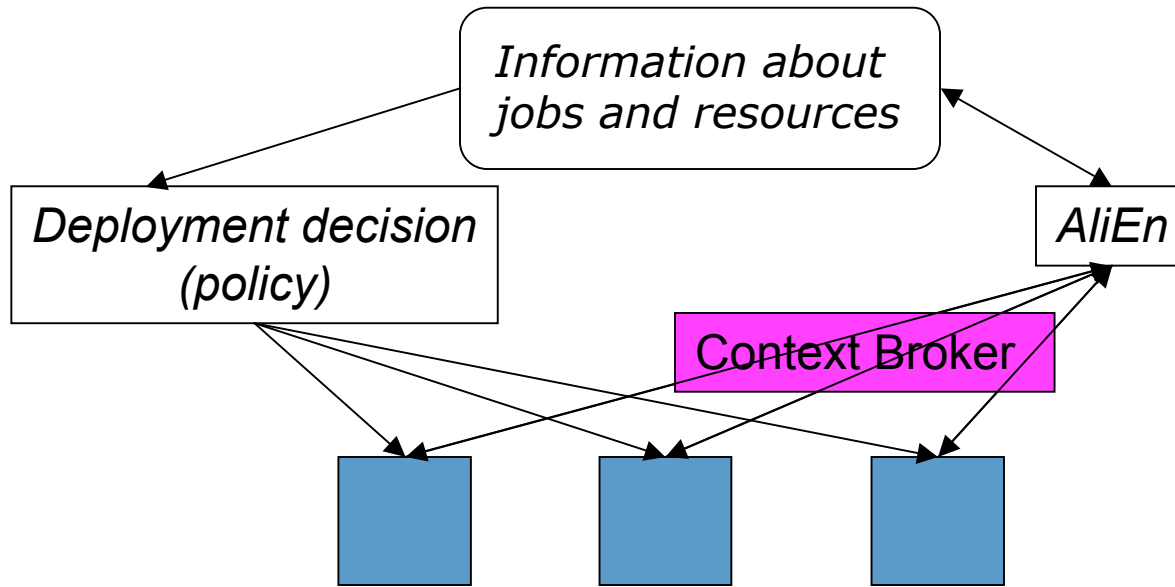
Elastic Provisioning for AliEn



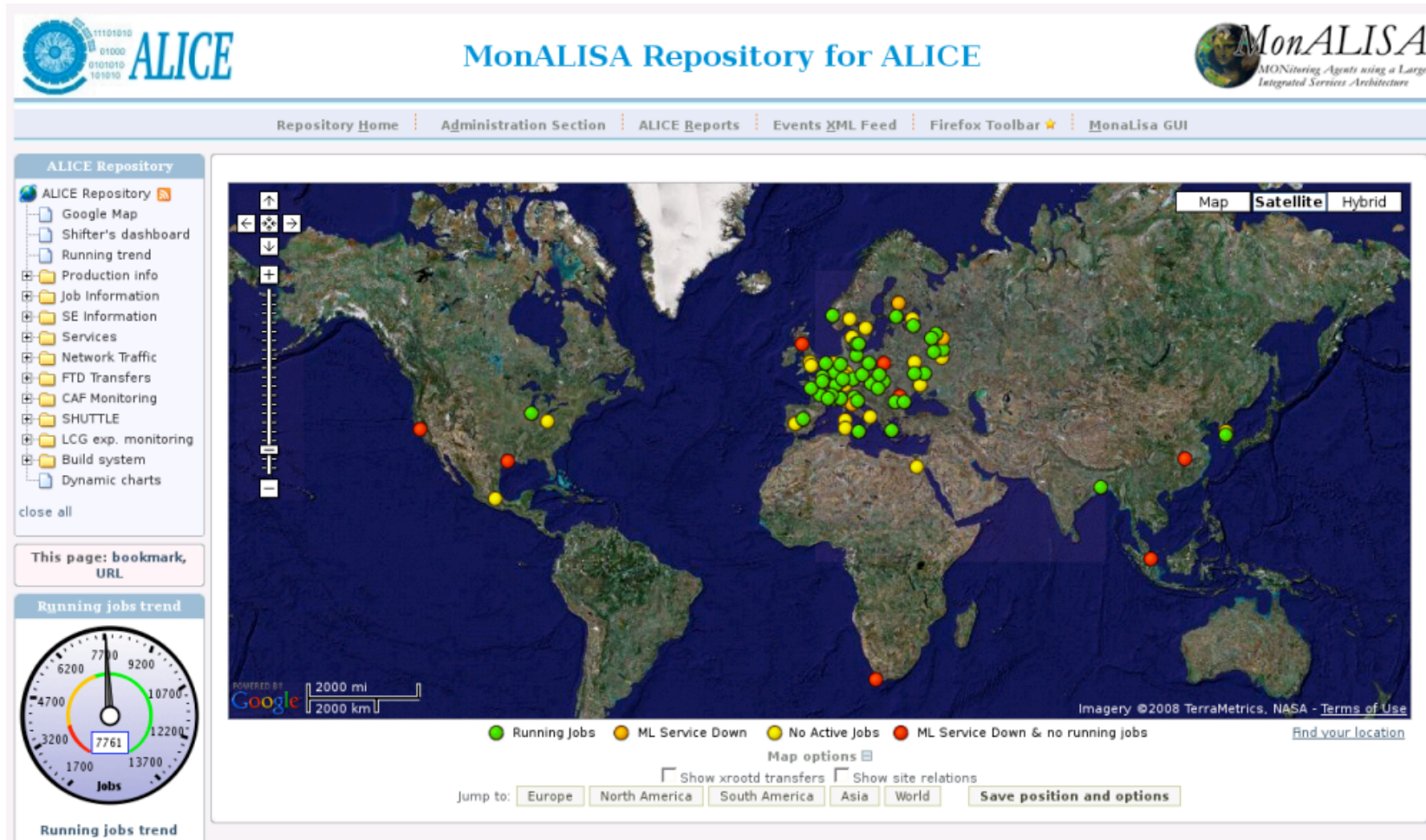
- Challenge: integrate elastic computing into existing infrastructure for the ALICE experiment
- Collaboration with CernVM project
- Work by Artem Harutyunyan



Elastic Provisioning for AliEn



Elastic Provisioning for AliEn

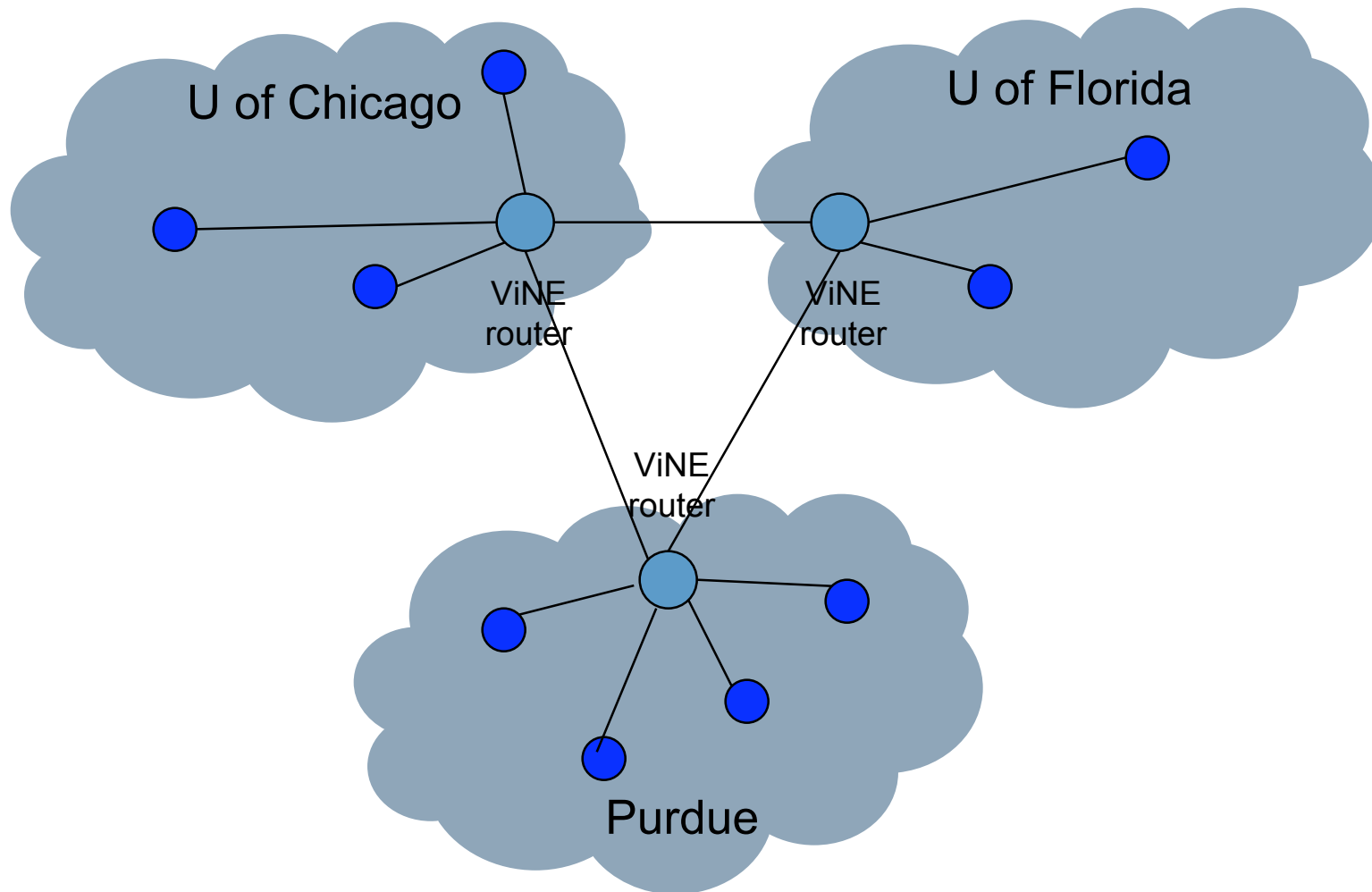


- *CHEP09 paper, Harutyunyan et al.*
- *Similar ongoing work on extensions to GANGA (ATLAS) and extensions to local schedulers*

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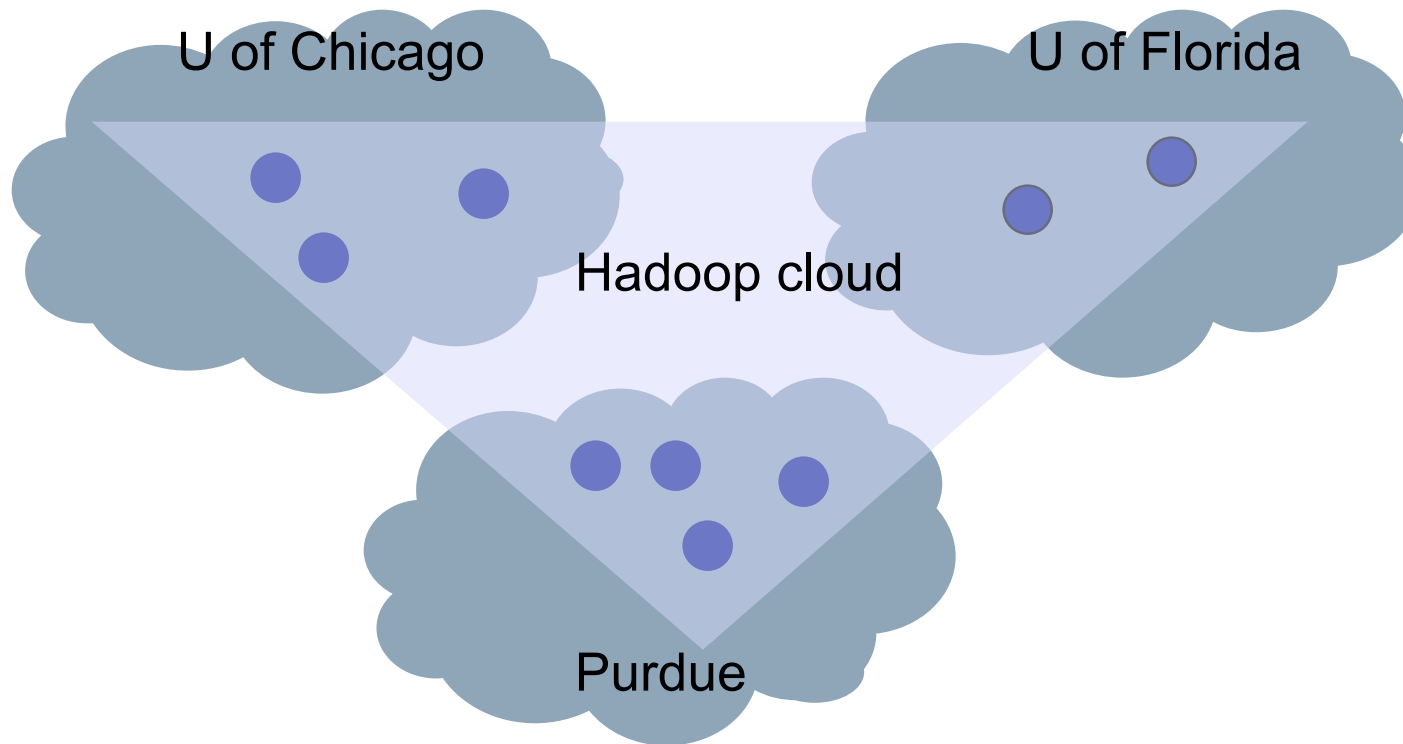
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Sky Computing Environment



Work by A. Matsunaga, M. Tsugawa, University of Florida

Hadoop in the Science Clouds



- *Papers:*

- ◆ *"Sky Computing", by K. Keahey, A. Matsunaga, M. Tsugawa, J. Fortes. Submitted to IEEE Internet Computing.*
- ◆ *"CloudBLAST: Combining MapReduce and Virtualization on Distributed Resources for Bioinformatics Applications" by A. Matsunaga, M. Tsugawa and J. Fortes. eScience 2008.*

Parting Thoughts

- IaaS cloud computing is science-driven
- Scientific applications are successfully using the existing infrastructure for production runs
- Many more could be using it, but challenges exist...
- Project for the next few years: solve them!