Open Cirrus^{TM}

A Cloud Computing Testbed

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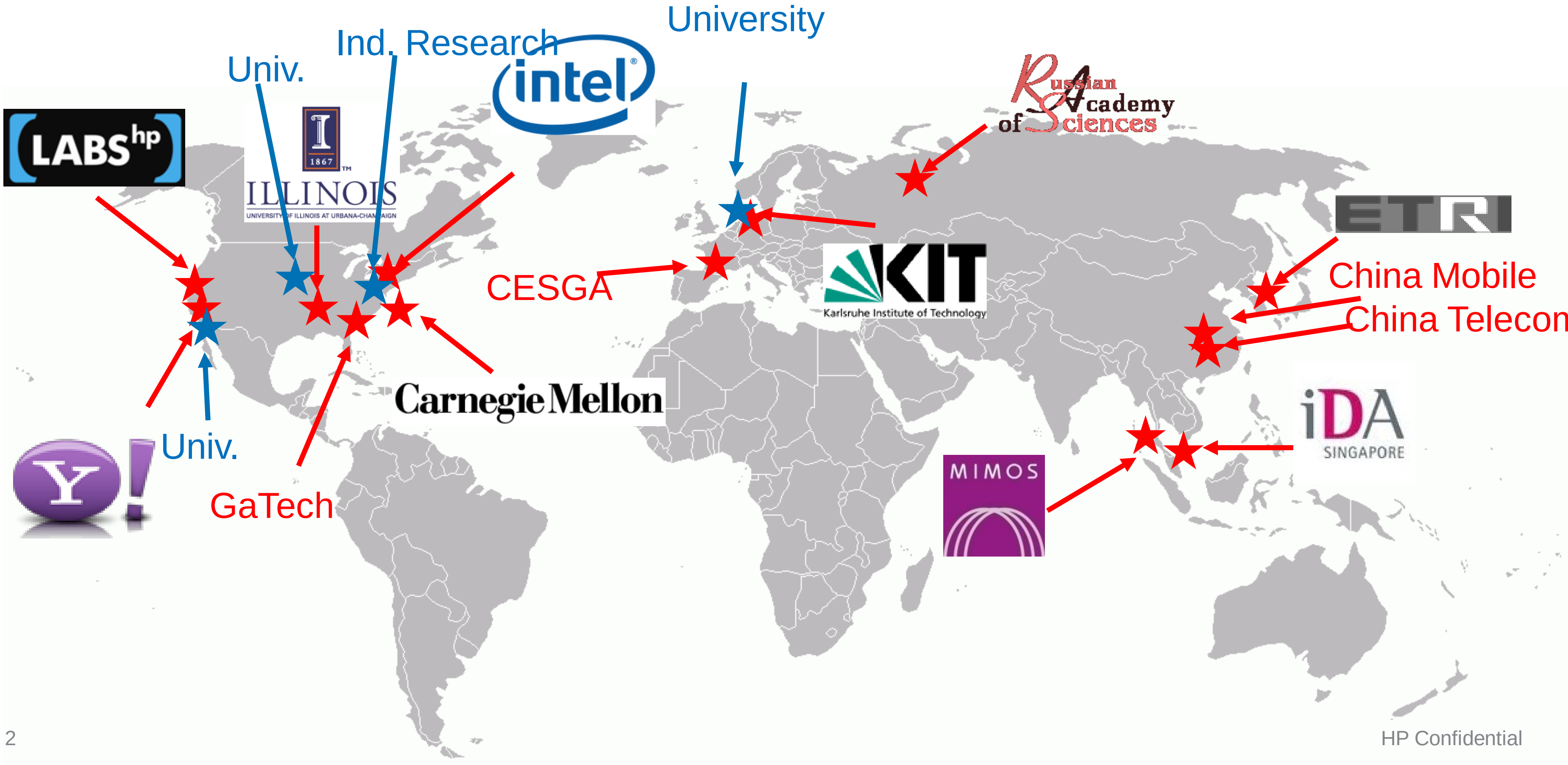
Open Cirrus™ Cloud Computing Testbed

Shared: research, **applications**, **infrastructure** (11K cores), **data sets**

Global services: sign on, monitoring, store. **Open source stack** (prs, tashi, hadoop)

Sponsored by **HP, Intel, and Yahoo!** (with additional support from **NSF**)

- 14 sites currently, target of around 20 in the next two years.



Open Cirrus

- Objectives
  - Create an ecosystem for Cloud services modeling
  - Foster systems research around cloud computing
  - Expose research community to enterprise level requirements
  - Provide realistic traces of cloud workloads
  - Vendor-neutral open-source stacks and APIs for the cloud

- How are we unique
  - Support for systems research and applications research
  - Federation of heterogeneous datacenters
  - Interesting data sets

Process

- Central Management Office, oversees Open Cirrus
- Governance model
  - Research team
  - Technical Team
  - New site additions
  - Support (legal (export, privacy), IT, etc.)
- Each site
  - Runs its own research and technical teams,
  - Contributes individual technologies
  - Operates some of the global services
- E.g. HP Site supports: Portal and PRS

Home | About Us | Resources ▾ | Services | Contact ▾ | Forums

Open Cirrus (TM)

Home

Search this site:

Search

marthalyons

- My account
- CoE Collaboration Space
- Admin Forums
- Workflow summary
- Create content
- Recent posts
- Feed aggregator
- Administer
- Log out

Request Access

View | Edit | Outline | Track

Requesting Access to OpenCirrus

The resources provided through the OpenCirrus Cloud Computing Testbed are a finite resource and are intended to be used for research purposes only.

Consequently, OpenCirrus computing resources are allocated to research projects that must be approved by one or more of the OpenCirrus Centers of Excellence. Project proposals are submitted by a *Principal Investigator* who is typically a university faculty member, senior staff member, or industrial researcher/technologist. Once a project is approved the Principal Investigator is able to identify additional team members who should be granted access as part of the project. This organization is similar to the arrangement for PlanetLab and nearly identical to the one used for Emulab.

Project Proposal Process

The process for proposing a project is relatively straightforward.

1. First, the Principal Investigator (PI) should select one of the OpenCirrus Centers of Excellence to serve as the *Home Site* for a project.
2. The PI should email a brief description of the project to the Project Coordinator at the Home Site. This description should include at least (1) the research goals of the projects, (2) a high-level description of the OpenCirrus resources that would be involved, and (3) the expected project start/end dates. See a sample here. The research coordinators for each site are listed below:
    - **HP Labs Site** - Martha Lyons, martha.lyons@hp.com
    - **Intel Pittsburgh Research Site** - Michael Kozach, email@intel.com
    - **Yahoo! Research** - Thomas Kwan, email@yahoo.com
    - **UIUC** -
    - **KIT** -
    - **Singapore IDA** -

New forum topics

- Hi Everyone
- Participating in Open Cirrus!
- Why is Open Cirrus unique and interesting to the systems community?
- Why are we building Open Cirrus?
- Welcome!!!! Some facts about Open Cirrus!

more

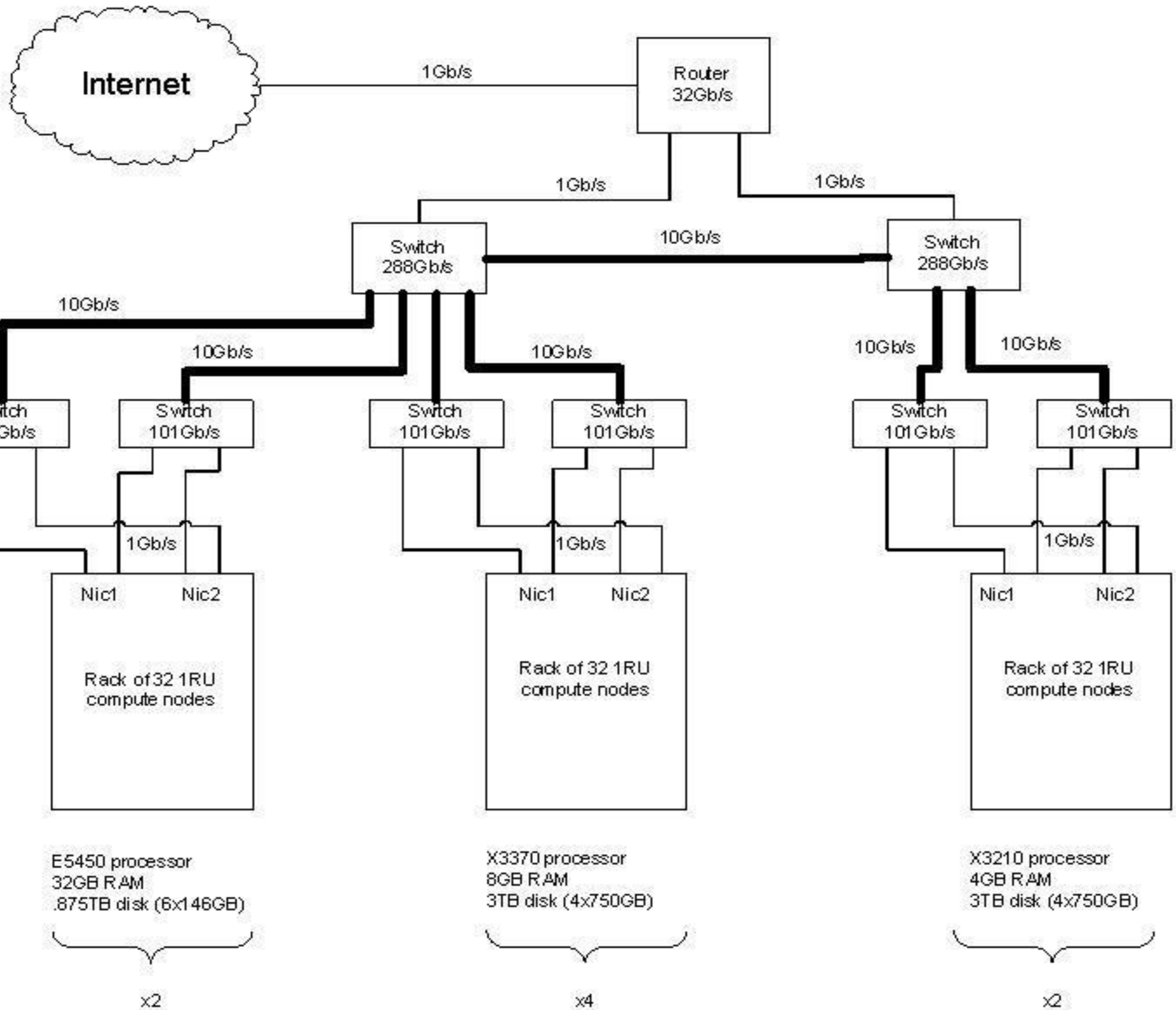
Who's online

There are currently *1 user* and *0 guests* online.

Online users

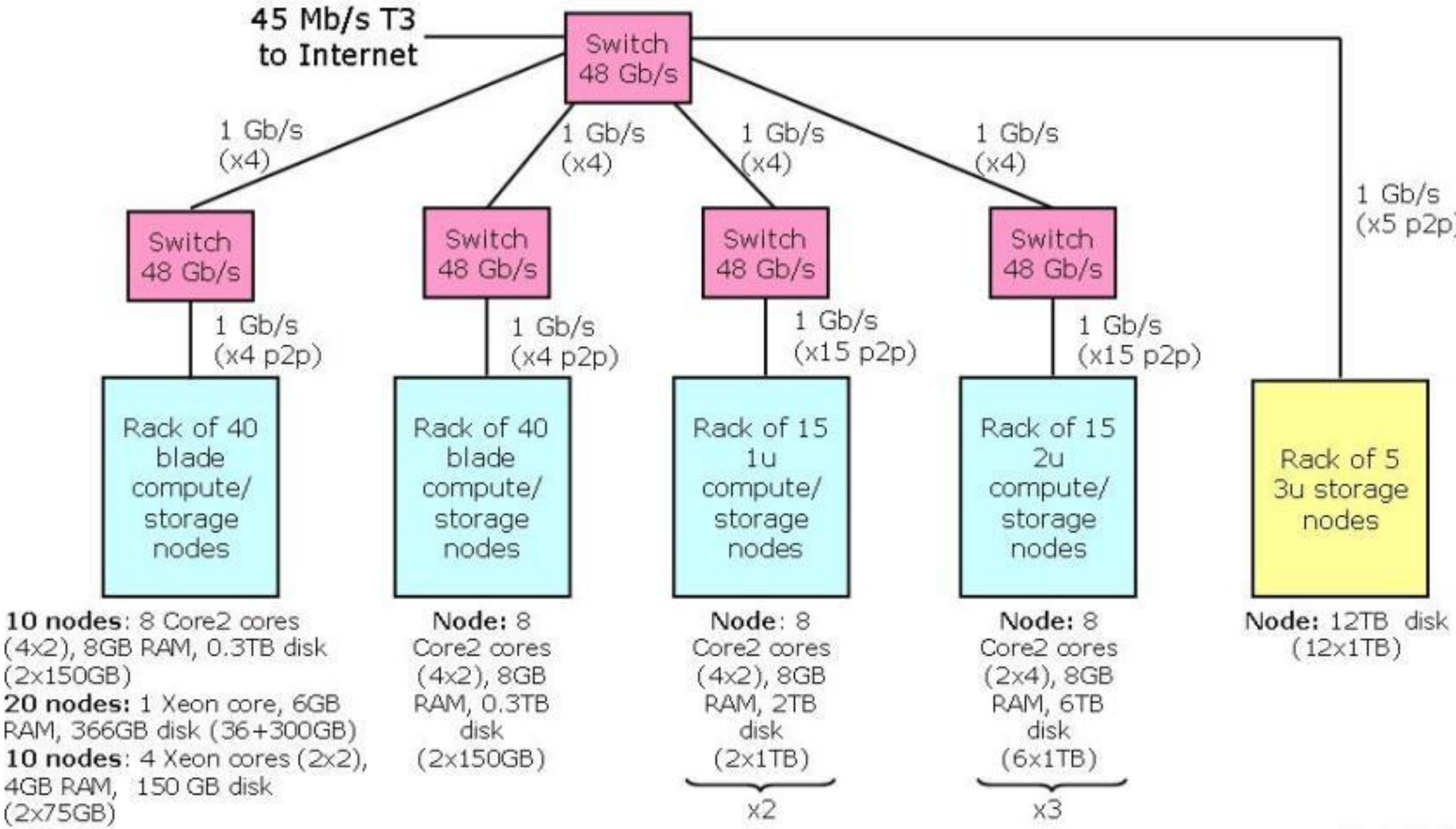
- marthalyons

HP Labs Cirrus Cluster topology



				Totals
Nodes/cores:	64/256	128/512	64/256	256/1024
RAM (GB):	2048	1024	256	3328
Storage (TB):	56	384	192	632
Spindles:	384	512	256	1152

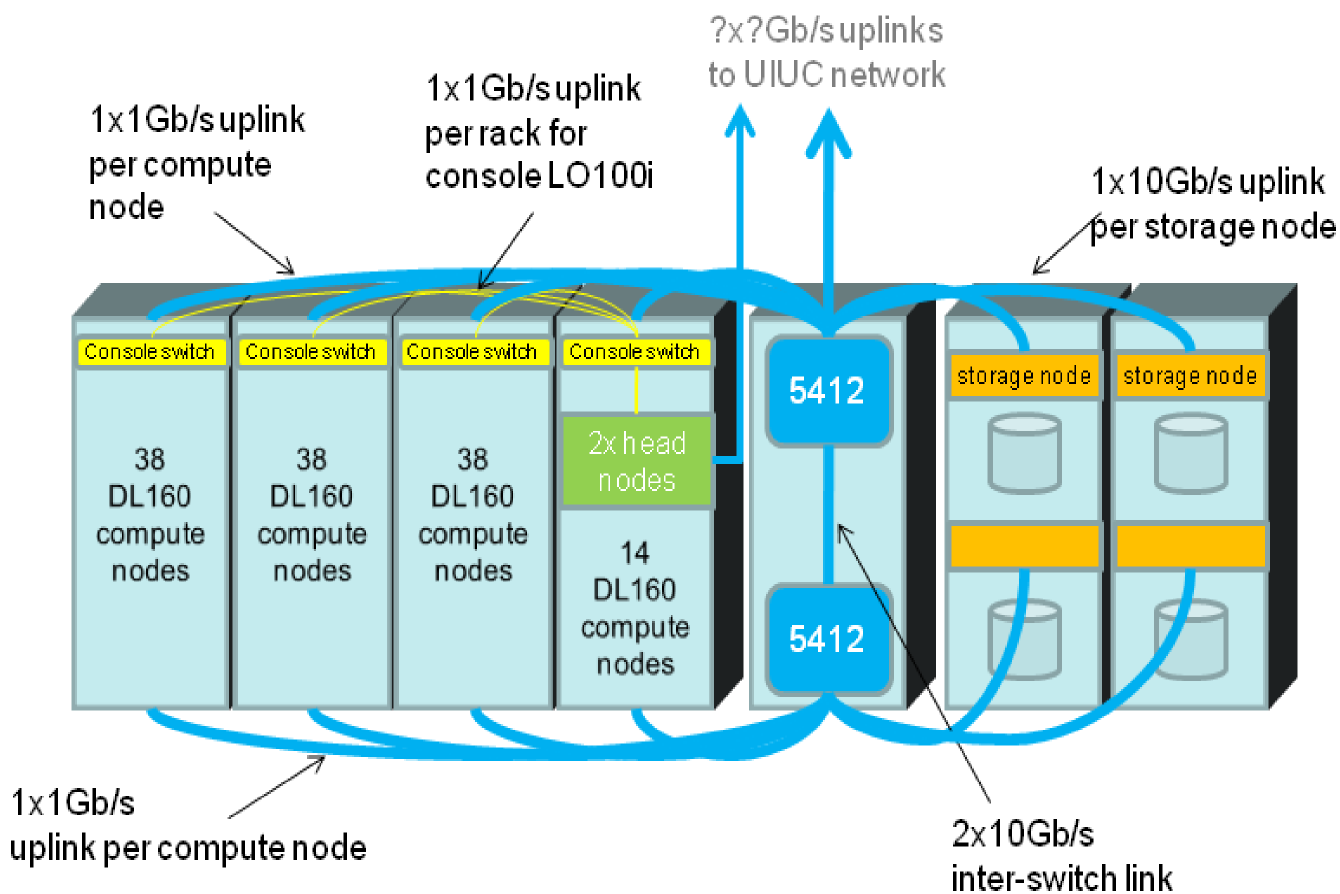
Intel Research BigData Cluster



						[totals]
Nodes/cores:	40/140	40/320	30/240	45/360		[155/1060]
RAM (GB):	240	320	240	360		[1160]
Storage (TB)	11	12	60	270	60	[413]
Spindles:	80	80	60	270	60	[550]

UIUC cluster network topology

- Console switches: connect to 1 port/head node
- Links to external UIUC network connect either to both head nodes, or to both core switches
- Each storage node has 1x10Gb/s to each core switch
- Each compute node has 1x1Gb/s link to each core switch
- Core switches have 2x10Gb/s inter-switch links between them



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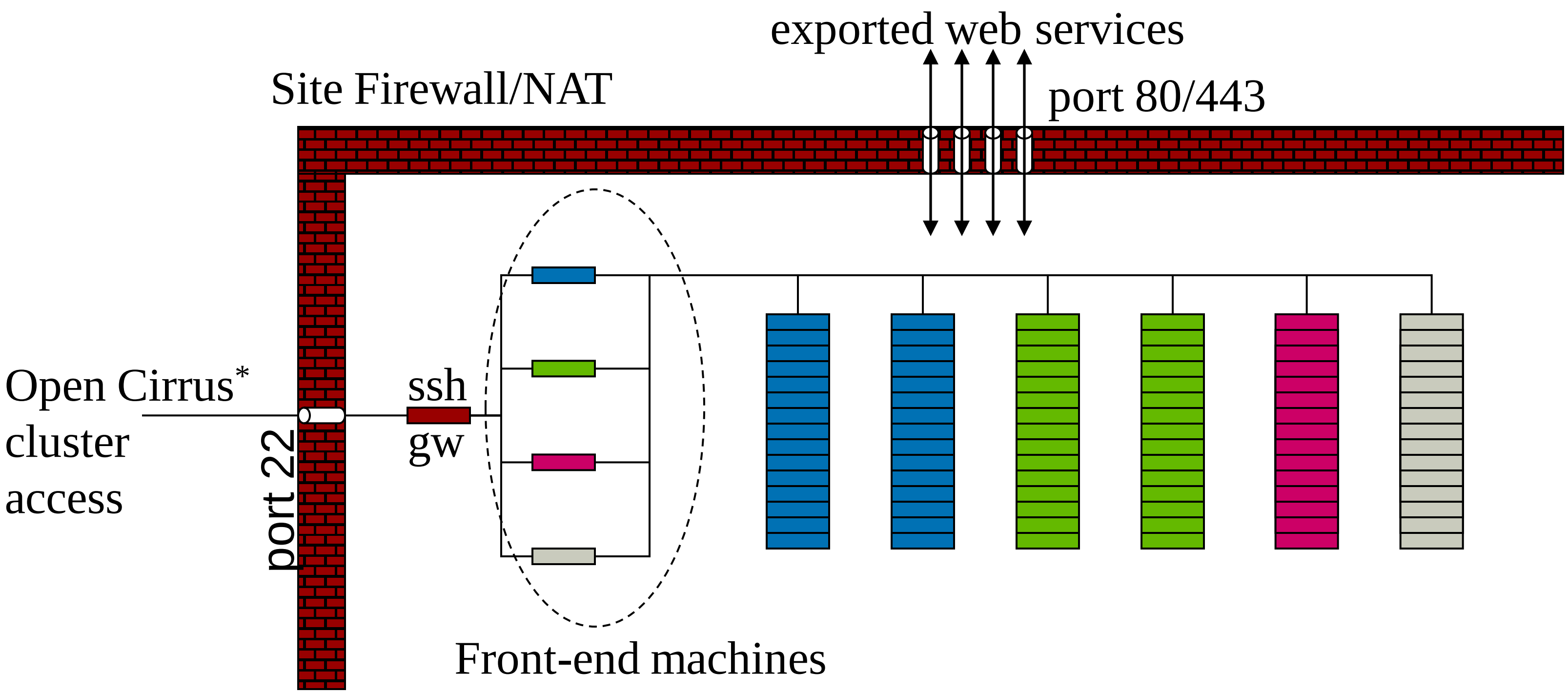
Open Cirrus Sites

Site	Characteristics							
	#Cores	#Servers	Public partition	Memory Size	Storage Size	Spindles	Network	Focus
HP	1,024	256	178	3.3TB	632TB	1152	10G internal 1Gb/s x-rack	Hadoop, Cells, PRS, scheduling
IDA	2,400	300	100	4.8TB	43TB+ 16TB SAN	600	1Gb/s	Apps based on Hadoop, Pig
Intel	1060	155	145	1.16TB	353TB local 60TB attach	550	1Gb/s	Tashi, PRS, MPI, Hadoop
KIT	2048	256	128	10TB	1PB	192	1Gb/s	Apps with high throughput
UIUC	1024	128	64	2TB	~500TB	288	1Gb/s	Datasets, cloud infrastructure
Yahoo	3200	480	400	2.4TB	1.2PB	1600	1Gb/s	Hadoop on demand

Access Model

- At a minimum, sites must expose a ssh gateway
- Sites may also provide additional external connections
  - Some provision for web services is highly recommended
- Sites may also be divided into resource pools by service
  - Some services may require a front-end machine (e.g. hadoop)



Open Cirrus* Software Components

Single Sign-On

Global Monitoring

Global User Directories

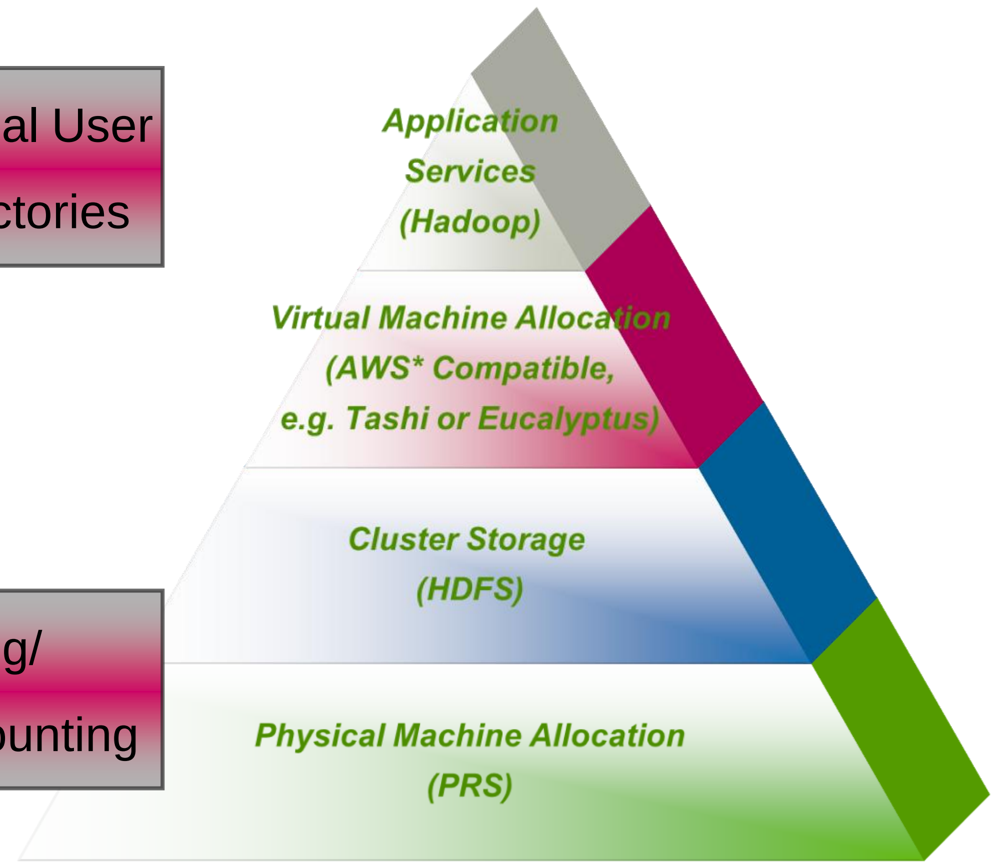
Global Services

Data Location

Resource Telemetry

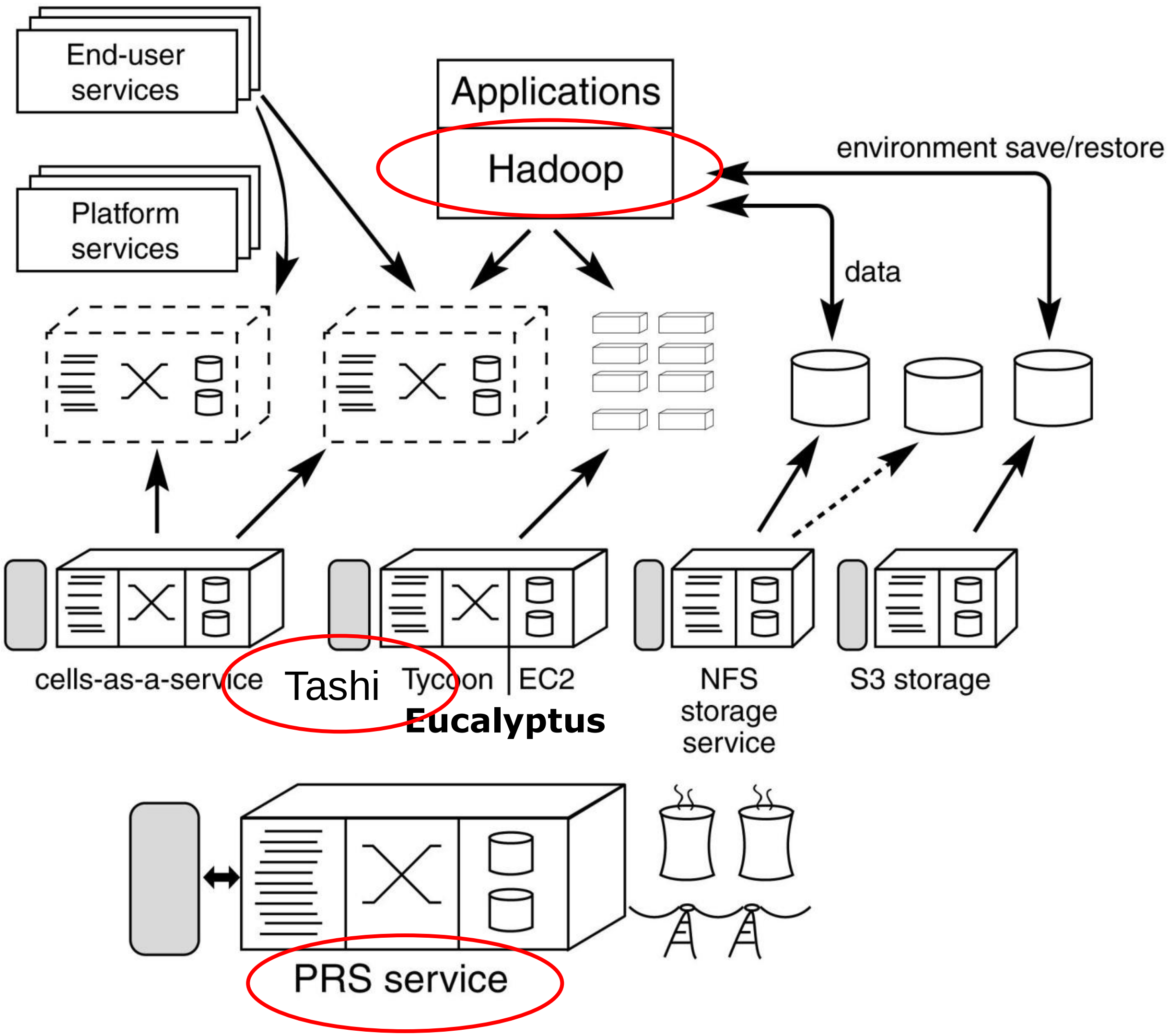
Billing/ Accounting

Site Services



Compute Node Services

Open Cirrus Software Stack



Cloud application services

Virtual Resource Sets

Cloud infrastructure services

IT infrastructure layer

(Zoni, Physical Resource Sets)

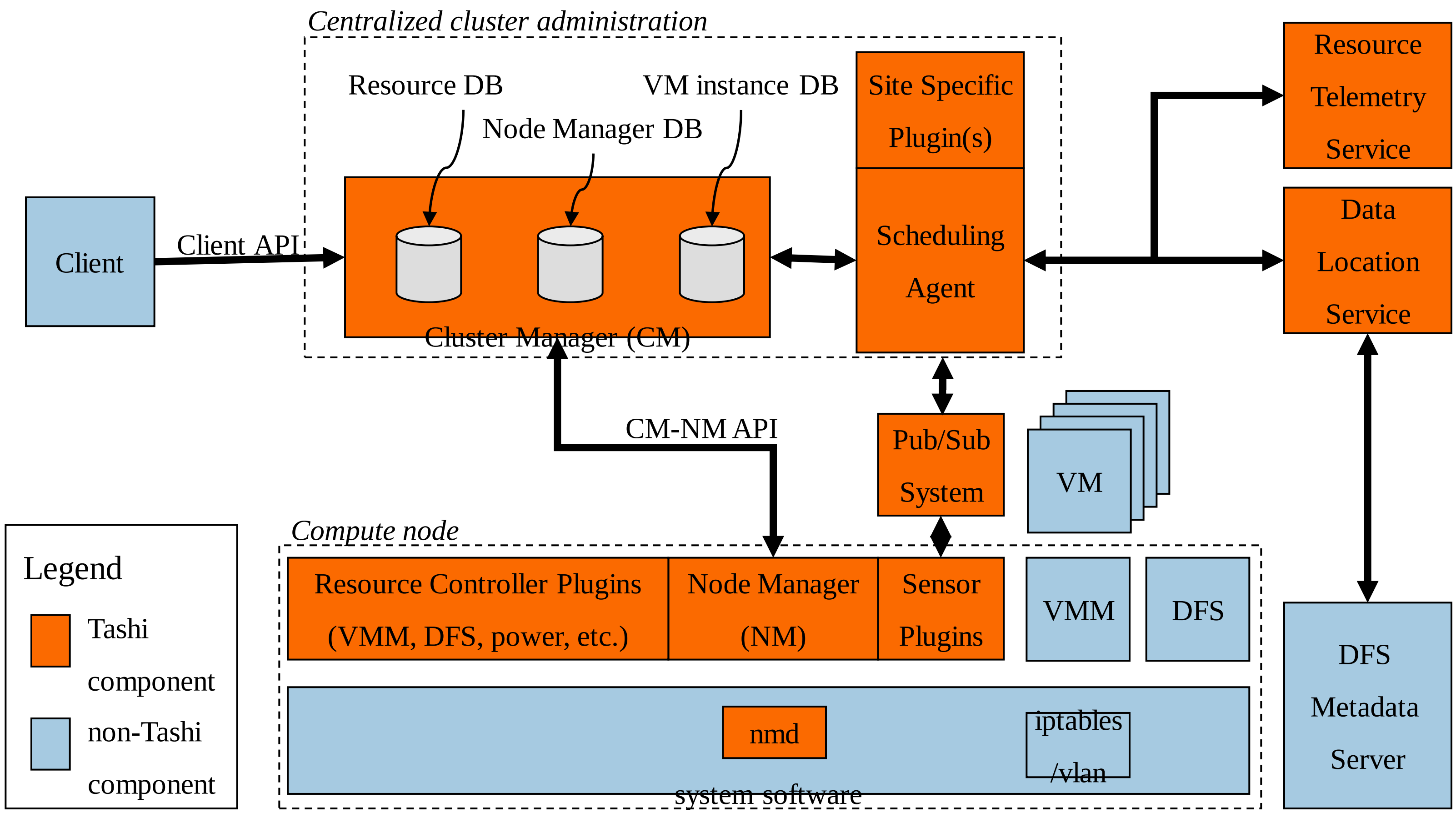
Zoni, Physical Resource Sets (PRS)

- Zoni service goals
  - Provide mini-datacenters to researchers
  - Isolate experiments from each other
  - Stable base for other research

- Zoni service approach
  - Allocate sets of physical co-located nodes, isolated inside VLANs
  - Start simple, add features as we go
  - Base to implement virtual resource sets

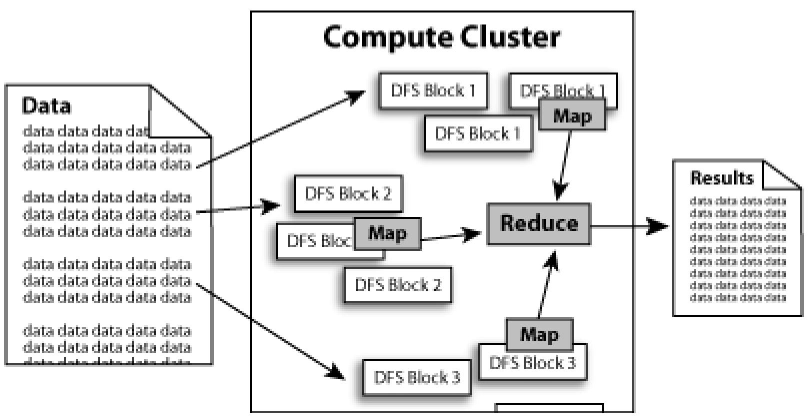
- Hardware as a Service (HaaS)

Tashi Software Architecture



Programming the Cloud: Hadoop

- An open-source Apache software foundation project sponsored by Yahoo!
  - http://wiki.apache.org/hadoop/ProjectDescription
  - reproduce the proprietary software infrastructure developed by Google
- Provides a parallel programming model (MapReduce), a distributed file system, and a parallel database
  - http://en.wikipedia.org/wiki/Hadoop
  - http://code.google.com/edu/parallel/mapreduce-tutorial.html



How do users get access to Open Cirrus sites?

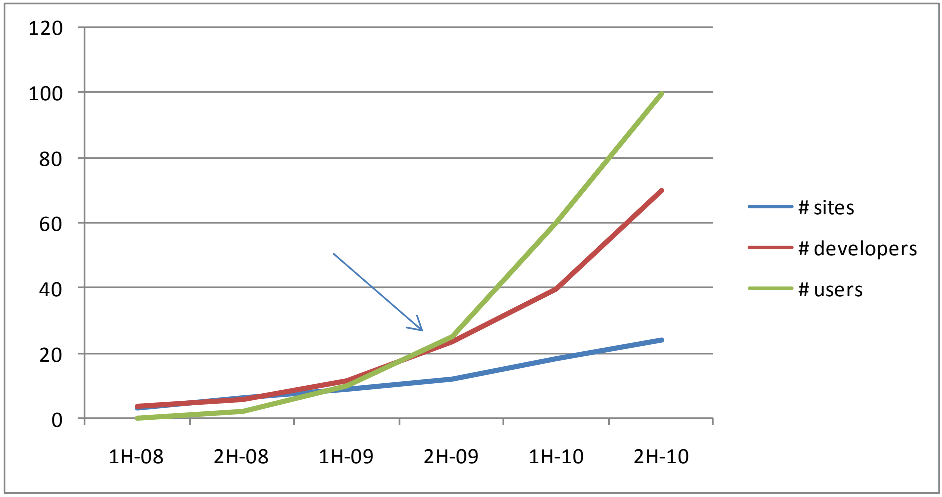
- Project PIs apply to each site separately
- Contact email addresses on the Open Cirrus portal
  - http://opencirrus.org
- Each Open Cirrus site decides which users and projects get access to its site
- A *global sign on* for all sites
  - Users are able to login to each OpenCirrus site for which they are authorized using the same login and password.

What kinds of research projects are Open Cirrus sites looking for?

- Open Cirrus™ is seeking research in the following areas (different centers will weight these differently)
  - Datacenter federation
  - Datacenter management
  - Web services
  - Data-intensive applications and systems
  - Hadoop map-reduce applications

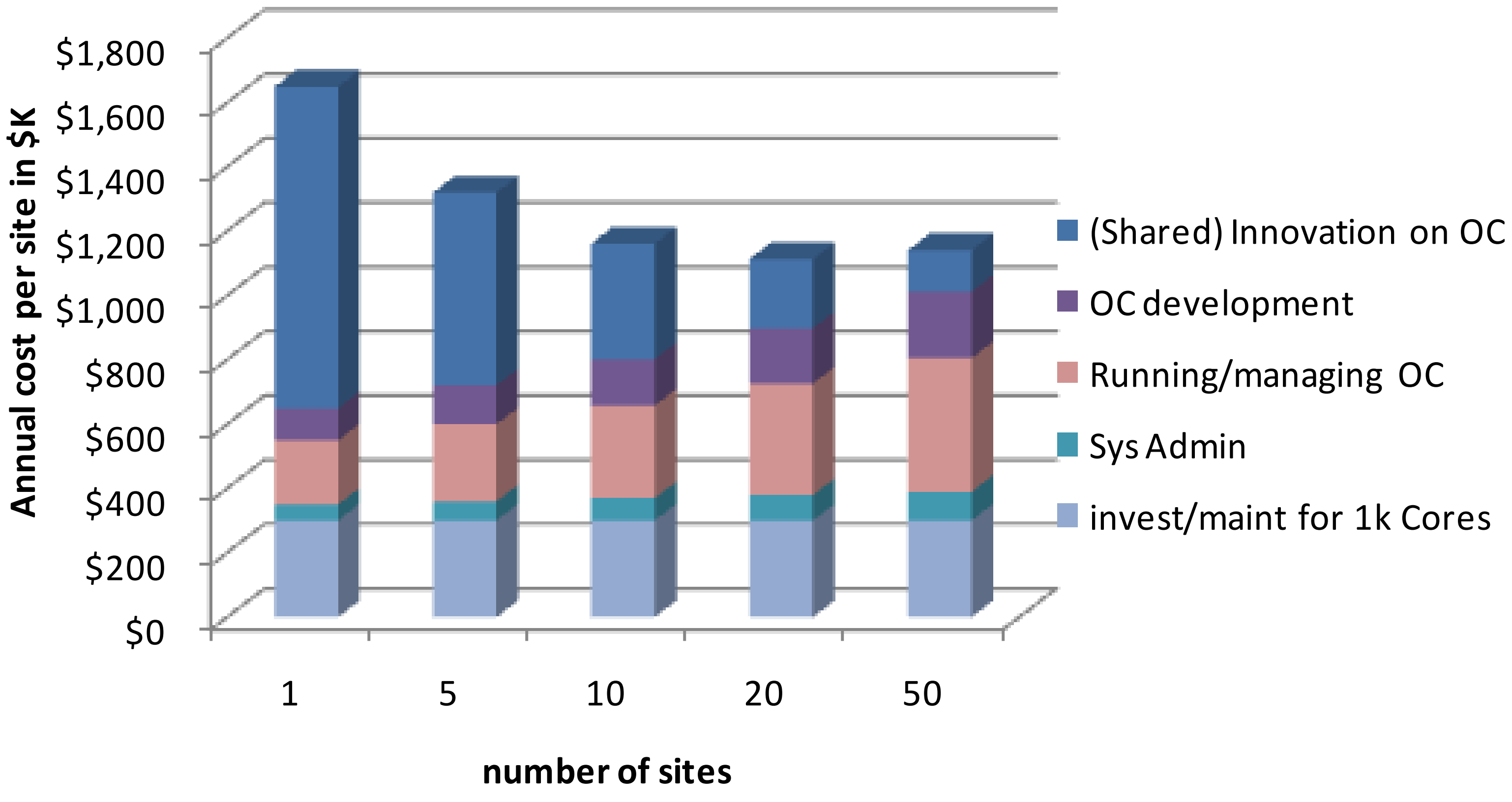
- The following kinds of projects are of less interest
  - Traditional HPC application development
  - Production applications that just need lots of cycles
  - Closed source system development

Metrics of Success



- Community
  - Technology used
  - # Sites, Projects, (Vibrant) Users
  - Research Productivity (Shared Cost of Research), # papers published
  - Cross-collaboration (Portal traffic)
  - # New open source components
  - Global presence
- Technical
  - Utilization of Open Cirrus, TCO
  - Ease of use (e.g. provision 50% of OC nodes in < 30sec)
  - Federation transparency/adoption
  - Reliability

Metrics of Success: Shared Innovation

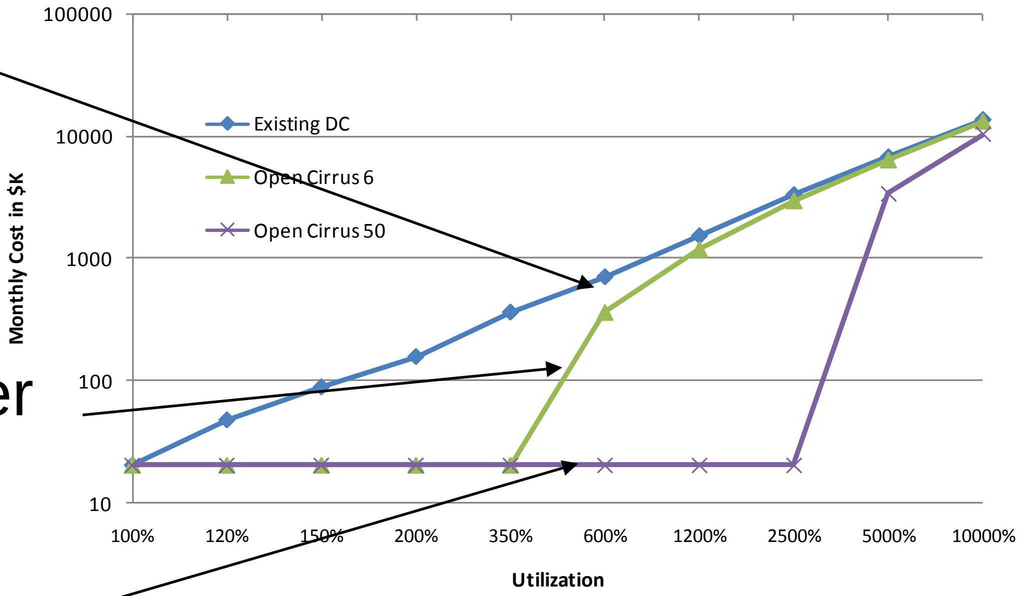


Single site Cloud: to Outsource or Own?

- Medium-sized organization: wishes to run a service for *M* months
  - Service requires 128 servers (1024 cores) and 524 TB
  - Same as UIUC cloud site
- Outsource (e.g., via AWS): monthly cost
  - Storage ~ $62 K
  - Total ~ $136 K (using 0.45:0.0.4:0.15 split for hardware:power:network)
- Own: monthly cost
  - Storage ~ $349 K / *M*
  - $ 1555 K / *M* + 7.5 K (includes 1 sysadmin / 100 nodes)
- Breakeven analysis: **more preferable to own if**:
  - *M* > 5.55 months (storage)
    - Not surprising: Cloud providers benefit monetarily most from storage
  - *M* > 12 months (overall)
- With underutilization of x%, still more preferable to own if:
  - x > 33.3%
  - Even with CPU util of 20%, storage > 47% makes owning preferable

Federation Economics

- Federation can help contain demand overflow within itself
- Cost of outsourcing overflow to AWS is higher than to federation of 6 sites
- Cost reduces with size of federation increasing to 50



Open Cirrus v. Other Testbeds

	Testbeds							
	Open Cirrus	**IBM/Google**	**TeraGrid**	**PlanetLab**	**EmuLab**	**Open Cloud Consortium**	**Amazon EC2**	**LANL/NSF cluster**
Type of research	Systems & applications	Data-intensive applications research	Scientific applications	Systems and services	Systems	interoperab. across clouds using open APIs	Commer. use	Systems
Approach	Federation of heterog. data centers	A cluster supported by Google and IBM	Multi-site hetero clusters super comp.	A few 100 nodes hosted by research instit.	A single-site cluster with flexible control	Multi-site heterogeneous clusters	Raw access to virtual machines	Re-use of LANL's retiring clusters
Participants	HP, Intel, IDA, KIT, UIUC, Yahoo!	IBM, Google, Stanford, U.Washington, MIT	Many univ. & orgs	Many univ & organizations	University of Utah	4 centers –	Amazon	CMU, LANL, NSF
Distribution	6 sites	1 site	11 partners in US	> 700 nodes world-wide	>300 nodes univ@Utah	480 cores, distributed in four locations		1000s of older, still useful nodes at 1 site

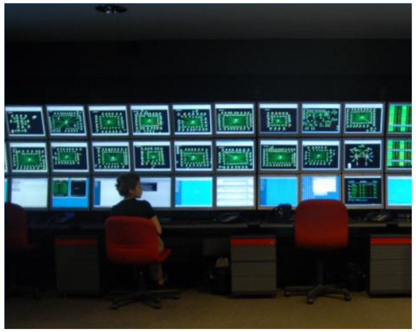
Clouds vs. Grids

	Cloud Computing	**Grid Computing**
Objective	Provide desired computing platform via network enabled services	Resource sharing Job execution
Infrastructure	One or few data centers, heterogeneous/homogeneous resource under central control, Industry and Business	Geographically distributed, heterogeneous resource, no central control, VO Research and academic organization
Middleware	Proprietary, several reference implementations exist (e.g. Amazon)	Well developed, maintained and documented
Application	Suited for generic applications	Special application domains like High Energy Physics
User interface	Easy to use/deploy, no complex user interface required	Difficult use and deployment Need new user interface, e.g., commands, APIs, SDKs, services …
Business Model	**Commercial: Pay-as-you-go**	**Publicly funded: Use for free**
Operational Model	**Industrialization of IT** **Fully automated Services**	**Mostly Manufacture** **Handcrafted Services**
QoS	Possible	Little support
On-demand provisioning	Yes	No

Open Cirrus Research Summary

HP	Intel	
• Mercado • Policy Aware Data Mgmt • Wikipedia Mining & tagging • SPARQL Query over Hadoop (UTD) • N-tier App Benchmark (GaTech)	• Everyday Sensing and Perception • SLIPstream/Sprout • Parallel Machine Learning • NeuroSys • Computational Health • FastBeat (w/France Telecom)	*Cloud application frameworks and services*
• Economic Cloud Stack • Parallel Data Series	• Tashi (with CMU, Yahoo)	*Cloud infrastructure services*
• OpenNet • Exascale Data Center	• PRS (with HP)	*IT infrastructure layer*

Exascale Data Center



Scalable Monitoring

- Data computation overlay for aggregation and analysis services
- Anomaly detection with minimal a priori knowledge
- Scale to exascale level

Resource Matchmaking

- Determine resource requirements without a priori knowledge
- VM placement in a virtual IaaS platform
- Reduce performance variability

Cloud Benchmarks: support this research and build community

PIs: Niraj Tolia, Vanish Talwar

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OpenNet on OpenCirrus

- OpenNet
  - Programmable, open layer-2 network
  - Features for
    - Robust, adaptive routing over redundant layer-2 networks
    - VM machine migration *without* dropping connections
    - In-situ network monitoring
    - Quality-of-Service guarantees
  - Installed on OpenCirrus cluster at HP Fall 2009
- OpenNet on OpenCirrus
  - Full bisection bandwidth
  - Virtual machine migration
  - Platform for high energy efficiency in the Data Center
  - Based on SPAIN (HP Labs), PortLand (UC San Diego)
  - Joint project between HP Labs, UC San Diego (funded by HP Open Innovation Program)

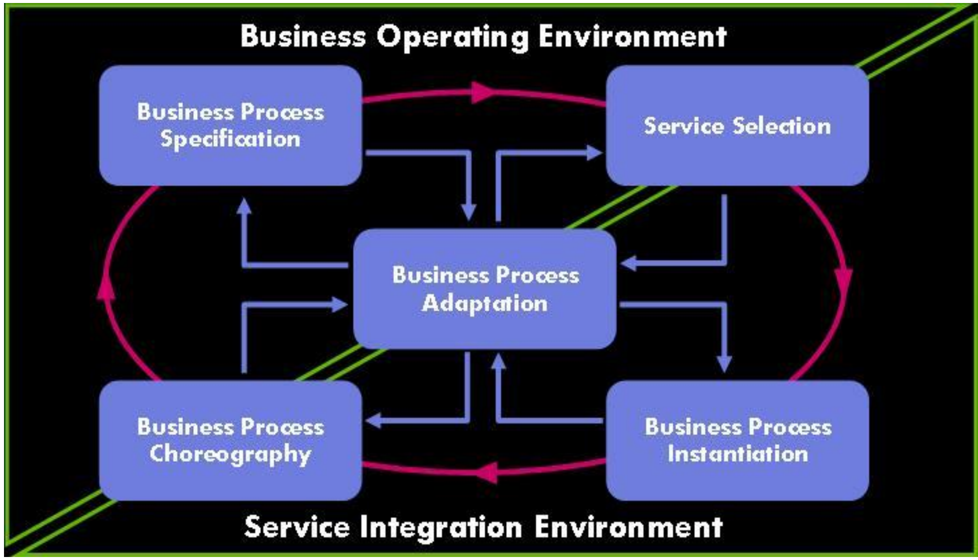
OpenCirrus on GENI

- GENI: Global Environment for Network Innovations
  - Major National Science Foundation program to provide a national-scale experimental facility for computer science researchers
  - Currently entering Spiral Two prototyping phase
- OpenCirrus on GENI
  - Give access to GENI researchers to the OpenCirrus platform (PlanetLab Control Framework for OpenCirrus)
  - Give OpenCirrus users access to GENI resources
- Key technological challenges
  - Mutual authentication between PlanetLab Control and OpenCirrus
  - Exchange of authorization and access functions
  - Resource allocation
- Status
  - Joint proposal to GENI Project Office by HP Labs (Kevin Lai, Rick McGeer) and UC San Diego (Alex Snoeren, Amin Vahdat)
  - Accepted by GENI Project Office (GPO) for Spiral Two Funding
  - Part of GPO proposal to NSF for Spiral Two (decision early Sept)

Mercado

Cloud-enabled services marketplaces

- Business process specification, service selection, instantiation, choreography & adaptation over independently created service components
- Service-oriented and model-based architectures, combined with Web 2.0, social networking, and semantic web mechanisms



PI: Sharad Singhal

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SPARQL Query over Hadoop for Very Large RDF Datasets

- Provide a semantic web framework using Hadoop which scales for large RDF data sets.
  - Use the Lehigh University Benchmark (LUBM) data (provides 14 queries) to measure SPARQL queries implemented over Map/Reduce framework provided by Hadoop.
  - Goal: to find the best possible way to query the data (SPARQL) by Map/Reduce programming.

N-tier Application Benchmark & Evaluation over Open Cirrus

- Generate, deploy, and run N-tier application benchmarks (including non-stationary workloads)
  - Collect data on standard and custom N-tier application benchmarks such as RUBiS (e-commerce) and RUBBoS (bulletin board) over a wide range of settings and configurations (both hardware and software)
  - Collect, analyze, and evaluate performance data using statistical software tools.
  - Apply the experimental evaluation results to cloud management applications such as configuration planning and adaptive reconfiguration

Cloud Sustainability Dashboard

Open Cirrus Site	Economical ($)					Ecological				Social		
	IT	cooling	ntwk	support	econo. overall	CO_2 (tonnes-eq)	water (mill. Gal)	Resource Use (GJ-eq)	ecolog. overall	State of devt.	Risk of instability	social overall
Site 1	$0.72	$0.35	$0.16	$0.43		6.0	2.6	83		High	Low	
Site 2	$1.27	$0.59	$0.21	$1.11		6.8	3.3	96		High	Very Low	
Site 3	$1.05	$0.47	$0.12	$1.07		5.9	2.3	81		High	Low	
Site 4	$0.75	$0.35	$0.12	$0.61		6.1	2.7	85		High	Very Low	
Site 5	$0.27	$0.13	$0.05	$0.09		4.3	2.4	59		Low	High	
Site 6	$1.82	$0.77	$0.11	$1.17		10.2	4.3	142		High	Low	
Site 7	$1.23	$0.54	$0.11	$0.98		15.0	4.4	192		High	Low	
Site 8	$0.55	$0.26	$0.10	$0.16		6.9	2.6	95		Med.	Low	
Site 9	$1.01	$0.44	$0.10	$0.83		5.3	2.5	74		High	Very Low	
Bricks-and-Mortar (US)	$0.58	$0.70	$0.12	$0.83		9.0	2.1	127		High	Very Low	

Summary

- Cloud is creating a new paradigm in computing
  - Flexible and elastic resource provisioning
  - Economy of scale makes it attractive
  - Move from manufacture towards industrialization of IT (Everything as a Service)
- OpenCirrus offers interesting R&D opportunities
  - Cloud systems and applications research and development
  - Interesting data sets and federation of heterogeneous data centers
- OpenCirrus workshop at HP Palo Alto on June 8/9 has links to a lot of materials

LABS hp

Financial Applications

- Key applications going forward
  - Risk management (driven by the demand to remedy past failures)
  - Trading systems (driven by fluctuating resource demand)

- Key benefits
  - Flexibility of dynamic resource allocation (eg Monte Carlo simulation)
  - Enables some of the smaller financial firms (eg hedge funds)

- State of adoption
  - Evolution of Grids already deployed by many banks
  - Perceived security risks, but experiments underway (ML, BA)
  - Grid software vendors also moving to Cloud (Platform, Data Synapse)
  - North and Latin America leading in IT spending

Risks and Opportunities in Financial Clouds

- Security (confidentiality, integrity, availability)
  - No access to physical resources, multitenancy, different security models
  - Data in Cloud reduces exposure, homogeneity simplifies auditing, automated security management, etc.
- Regulatory compliance
  - Export rules, privacy rules, global coverage (across region)
  - Automation already in place (single control point), awareness raised
- Ilities: performance, availability, business continuity
  - Lack of QoS, SLA standards/enforcement, will providers go away
  - Marketplace of service providers, competition, geographical distribution
- Data lock-in
  - Network performance lacking, proprietary I/F, semantic models
  - Promising optical networking research, standardization in progress

Financial Services Predictions and Cloud Implications

- Banks will focus on delivering information to user
  - Analytics, data warehousing in the Cloud for processing & storage
- Risk compliance and regulations will be important
  - Huge consumer of processing
- New business models seeking profitability
  - Long tail of services: prepaid cards for teens; interbank protocols; unstructured data community; mobile banking platforms, etc.
- Lower tier capital firms will rise
  - Startup equivalent, ideal for the use of Cloud
- Driving efficiency out of IT
  - Ultimate consolidation through the use of Cloud

Summary

- Cloud is creating a new paradigm in computing
  - Flexible and elastic resource provisioning
  - Economy of scale makes it attractive
  - From manufacture towards industrialization of IT: Everything as a Service
- Financial
  - Cloud very well suited to Financial institutions' needs
  - Challenges continue to be addressed, historical, and new ones
  - Entrants adoption parallel to legacy conversion roadmap
- OpenCirrus offers interesting R&D opportunities
  - Cloud systems and applications research and development
  - Interesting data sets and federation of heterogeneous data centers
  - OpenCirrus summits links to a lot of materials http://opencirrus.org