

Cloud Computing and Grid Computing 360-Degree Compared

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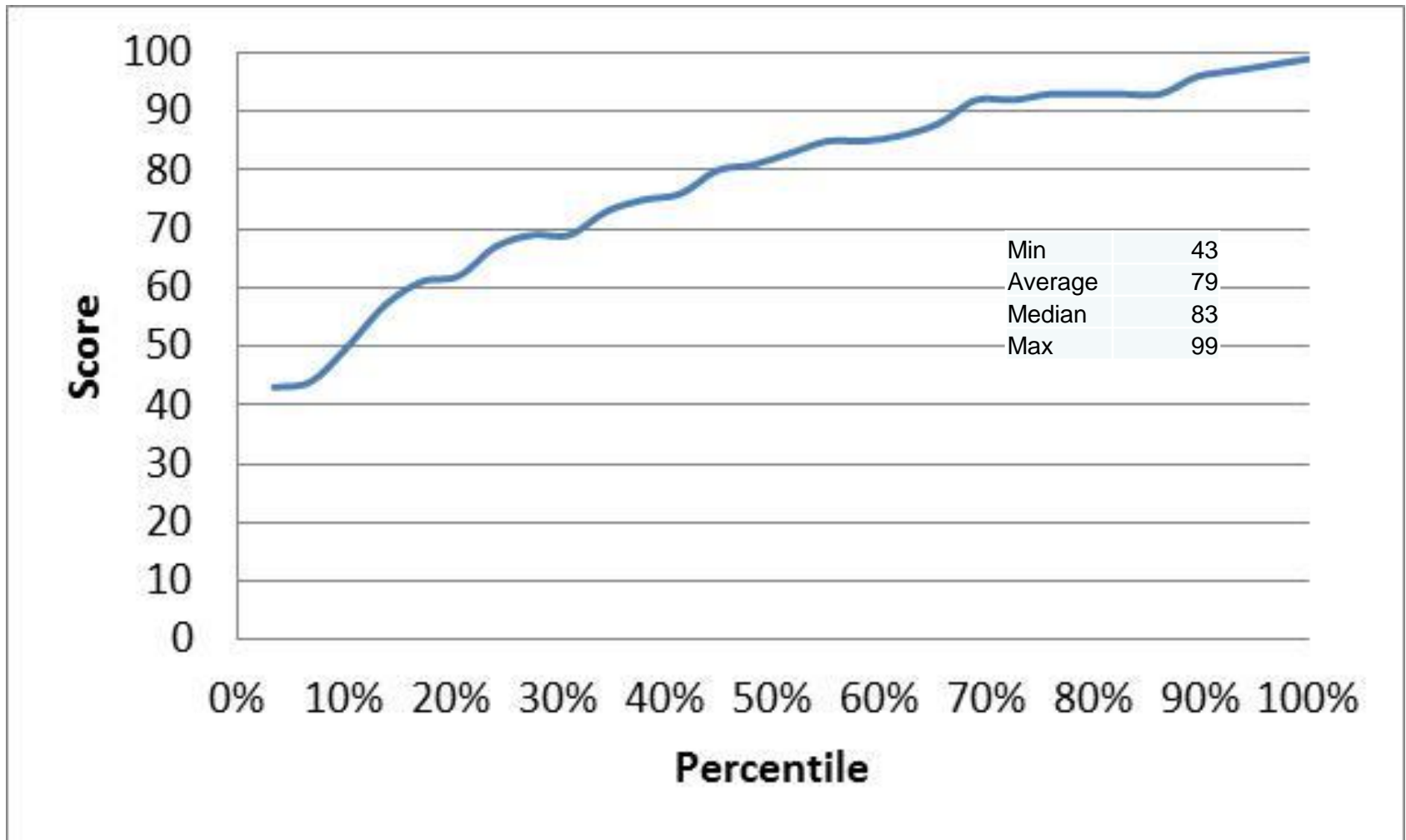
CS554: Data-Intensive Computing
September 23rd, 2013

Logistics

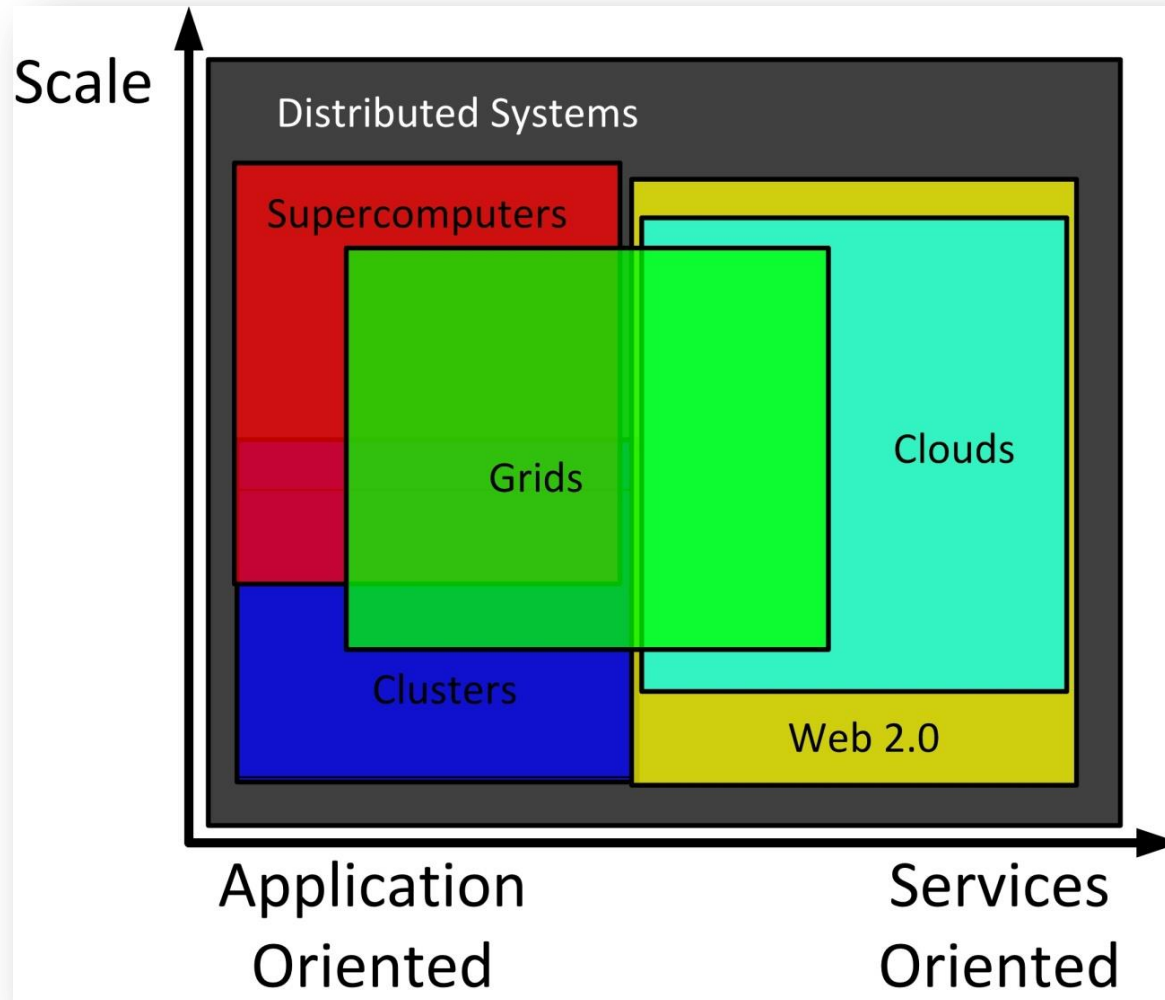
- Project Proposals

Project Acronym	# of Groups	Project Acronym	# of Groups
CloudKon:DTS	5	CloudKon:CKHPC	1
CloudKon:CKMR	3	CloudKon:DQS	1
FusionFS:Cache	2	FailPredict	1
FusionFS:FFSZ	2	GeMTC:GApp	1
MATRIX:DJLSys	2	GeMTC:Power	1
ZHT:Const	2	HRDBMS	1
ZHT-Bench	2	NET:MPNet	1
		OS:DistOS	1
		TAJAHS	1
		ZHT: Graph	1
		ZHT: OHT	1

Logistics

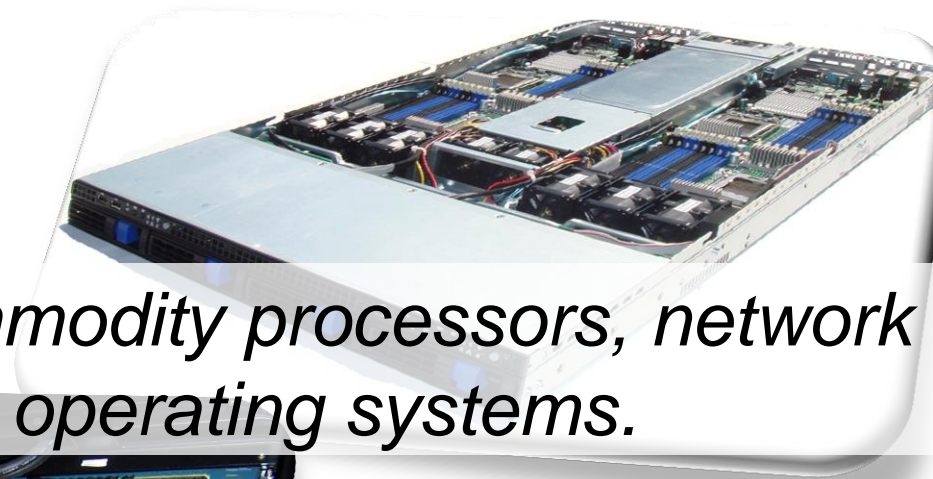


Clusters, Grids, Clouds, and Supercomputers



Cloud Computing and Grid Computing 360-Degree Compared

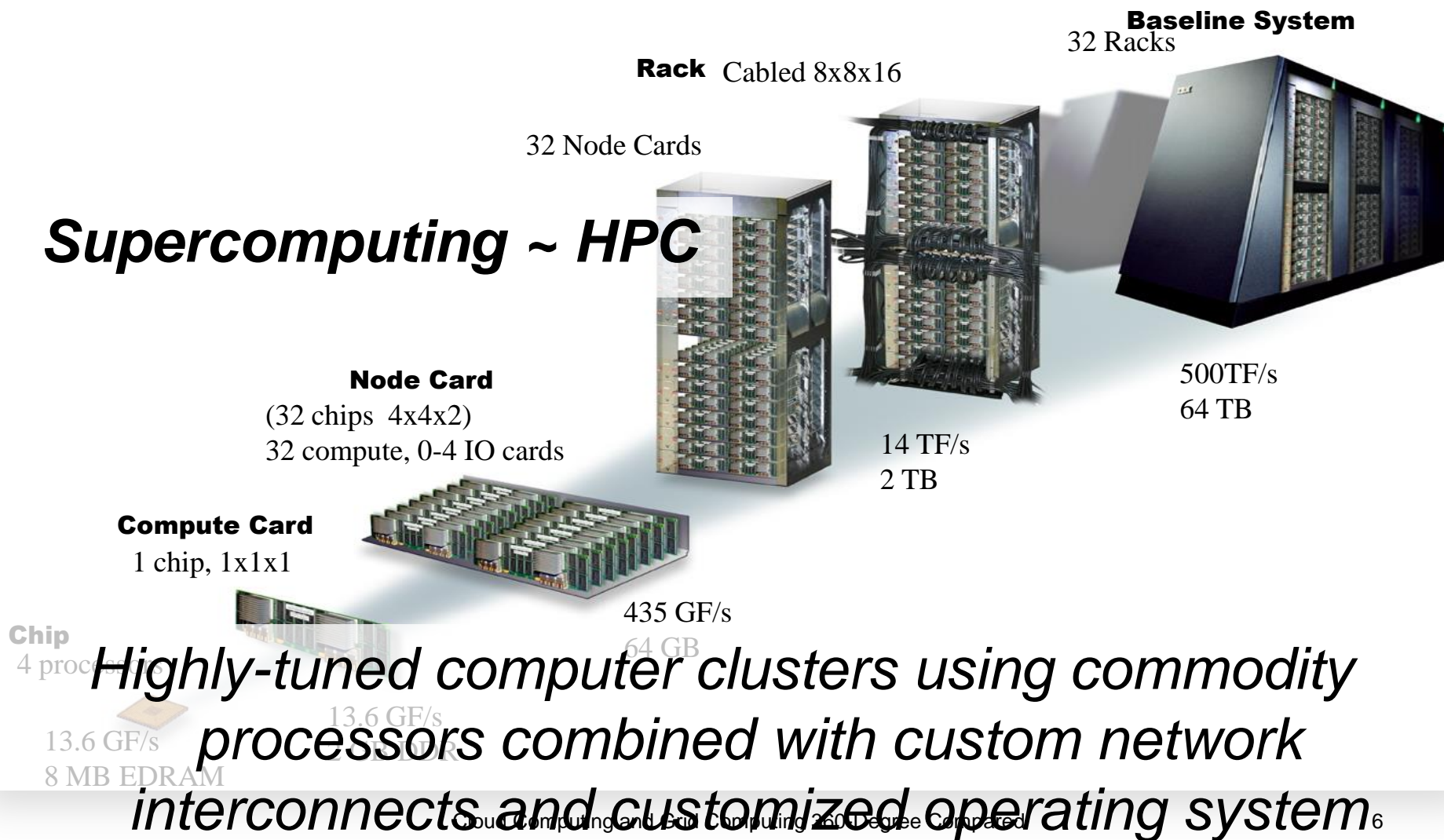
Cluster Computing



Computer clusters using commodity processors, network interconnects, and operating systems.

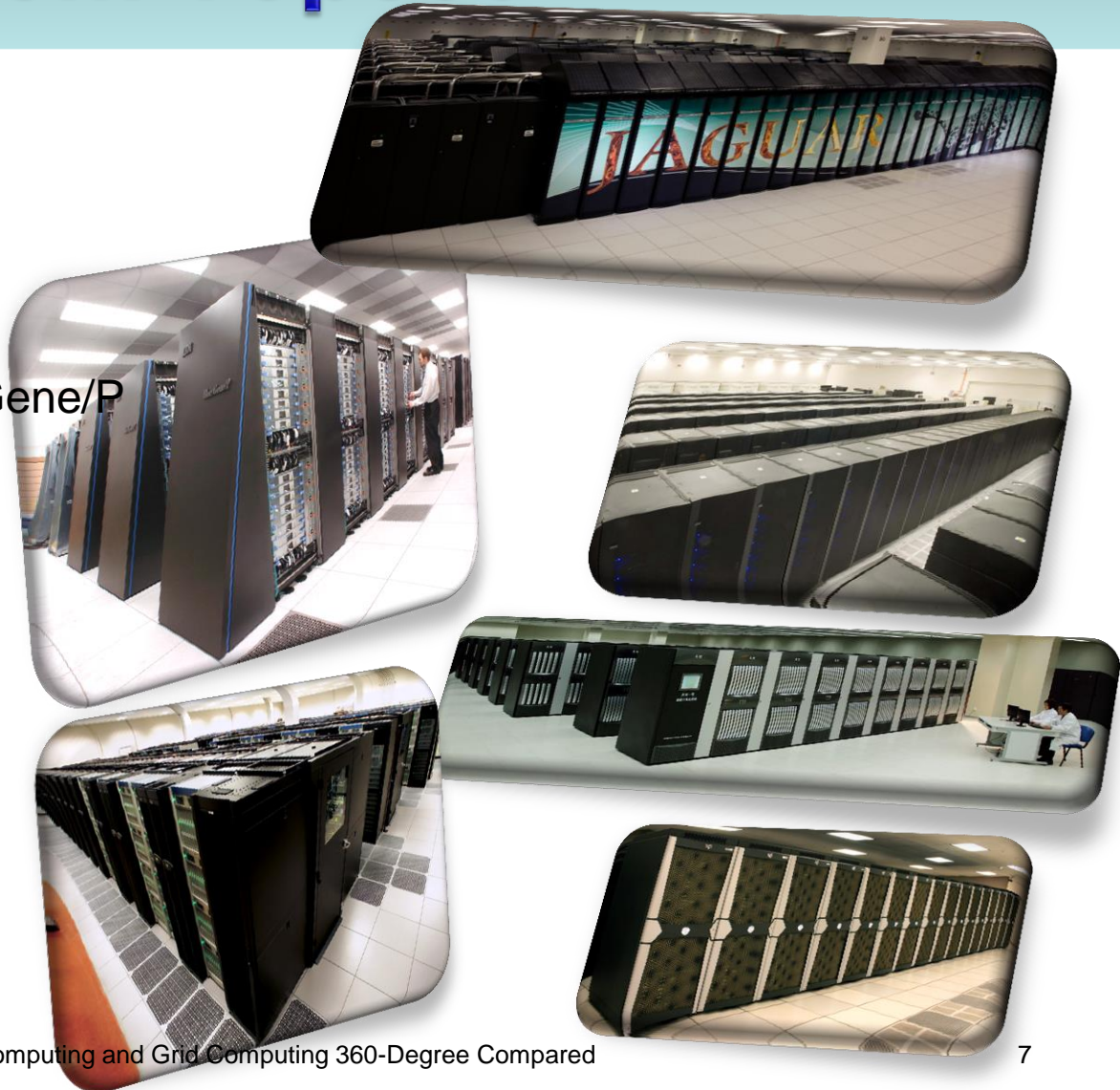
Supercomputing

Supercomputing ~ HPC



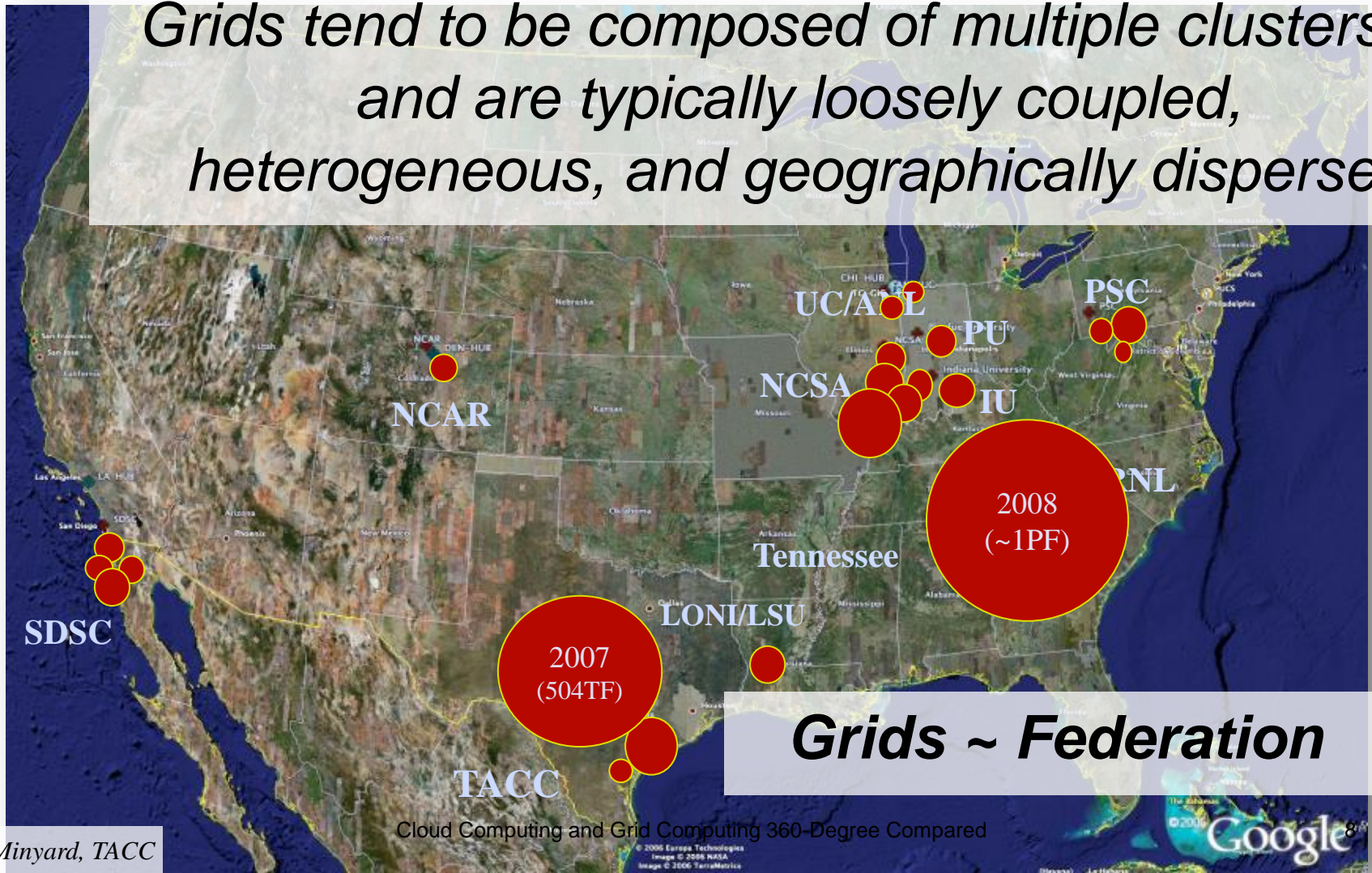
Top 10 Supercomputers from Top500

- Cray XT4 & XT5
 - Jaguar #1
 - Kraken #3
- IBM BladeCenter Hybrid
 - Roadrunner #2
- IBM BlueGene/L & BlueGene/P
 - Jugene #4
 - Intrepid #8
 - BG/L #7
- NUDT (GPU based)
 - Tianhe-1 #5
- SGI Altix ICE
 - Plaiedas #6
- Sun Constellation
 - Ranger #9
 - Red Sky #10



Grid Computing

Grids tend to be composed of multiple clusters, and are typically loosely coupled, heterogeneous, and geographically dispersed

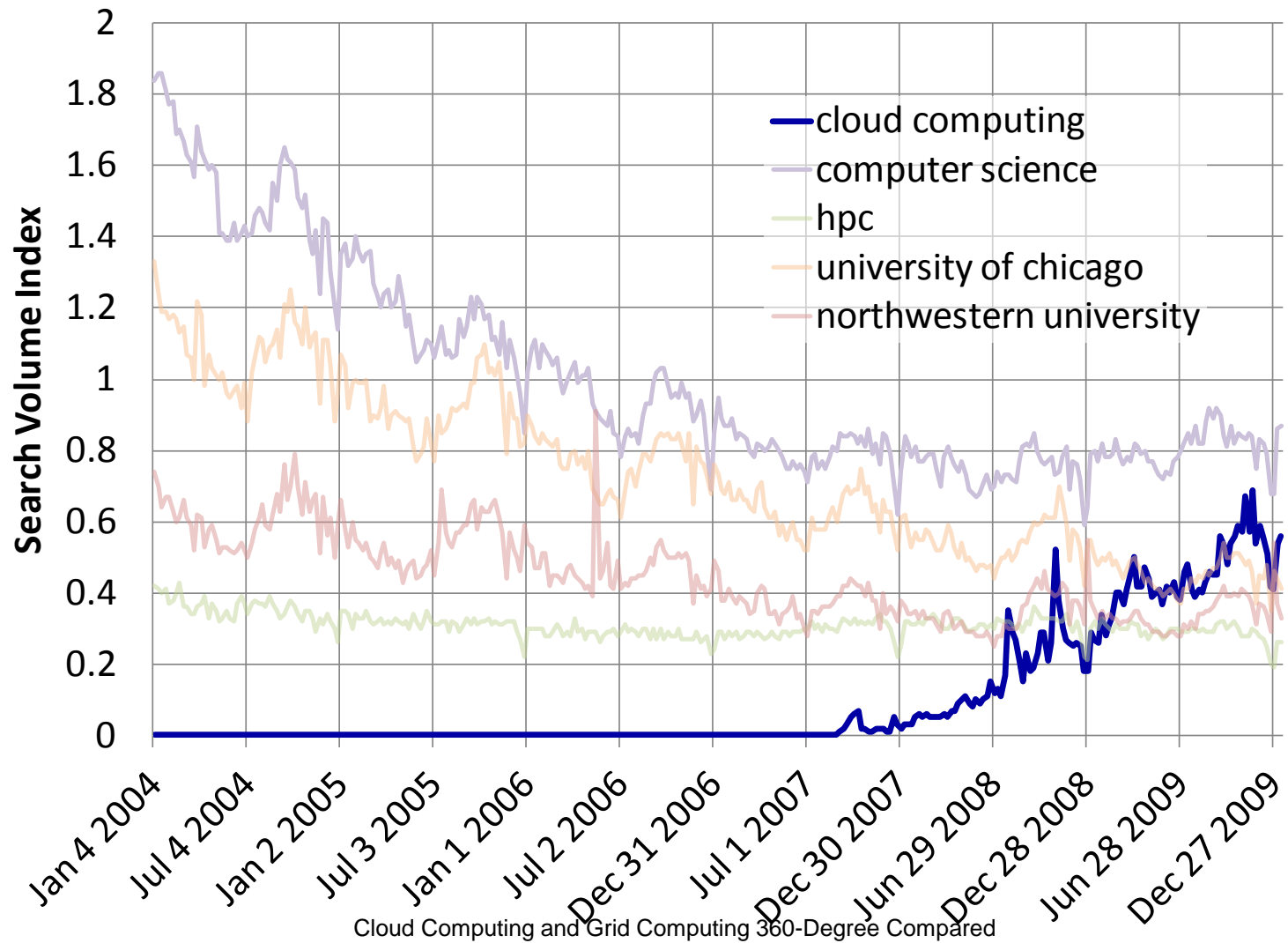


Grids ~ Federation

Major Grids

- TeraGrid (TG)
 - 200K-cores across 11 institutions and 22 systems over the US
- Open Science Grid (OSG)
 - 43K-cores across 80 institutions over the US
- Enabling Grids for E-scienceE (EGEE)
- LHC Computing Grid from CERN
- Middleware
 - Globus Toolkit
 - Unicore

Cloud Computing: An Emerging Paradigm



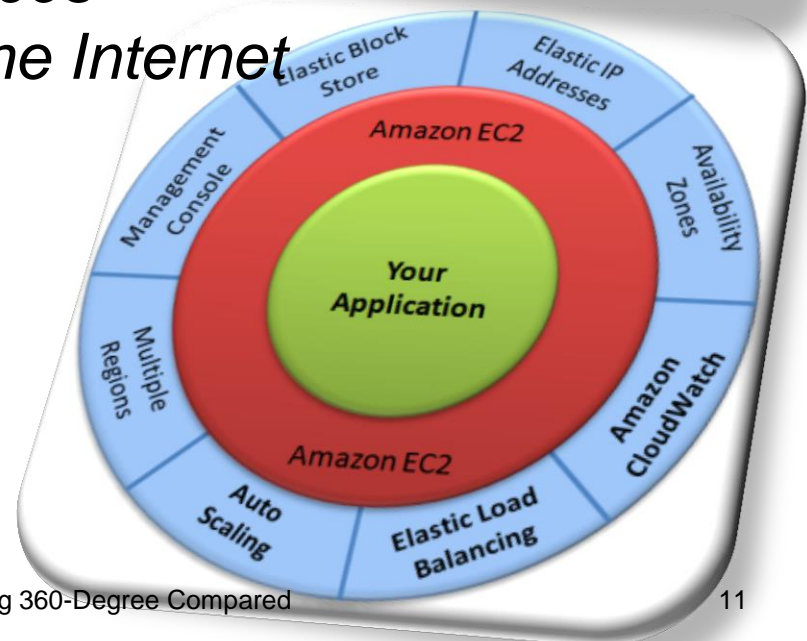
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Cloud Computing

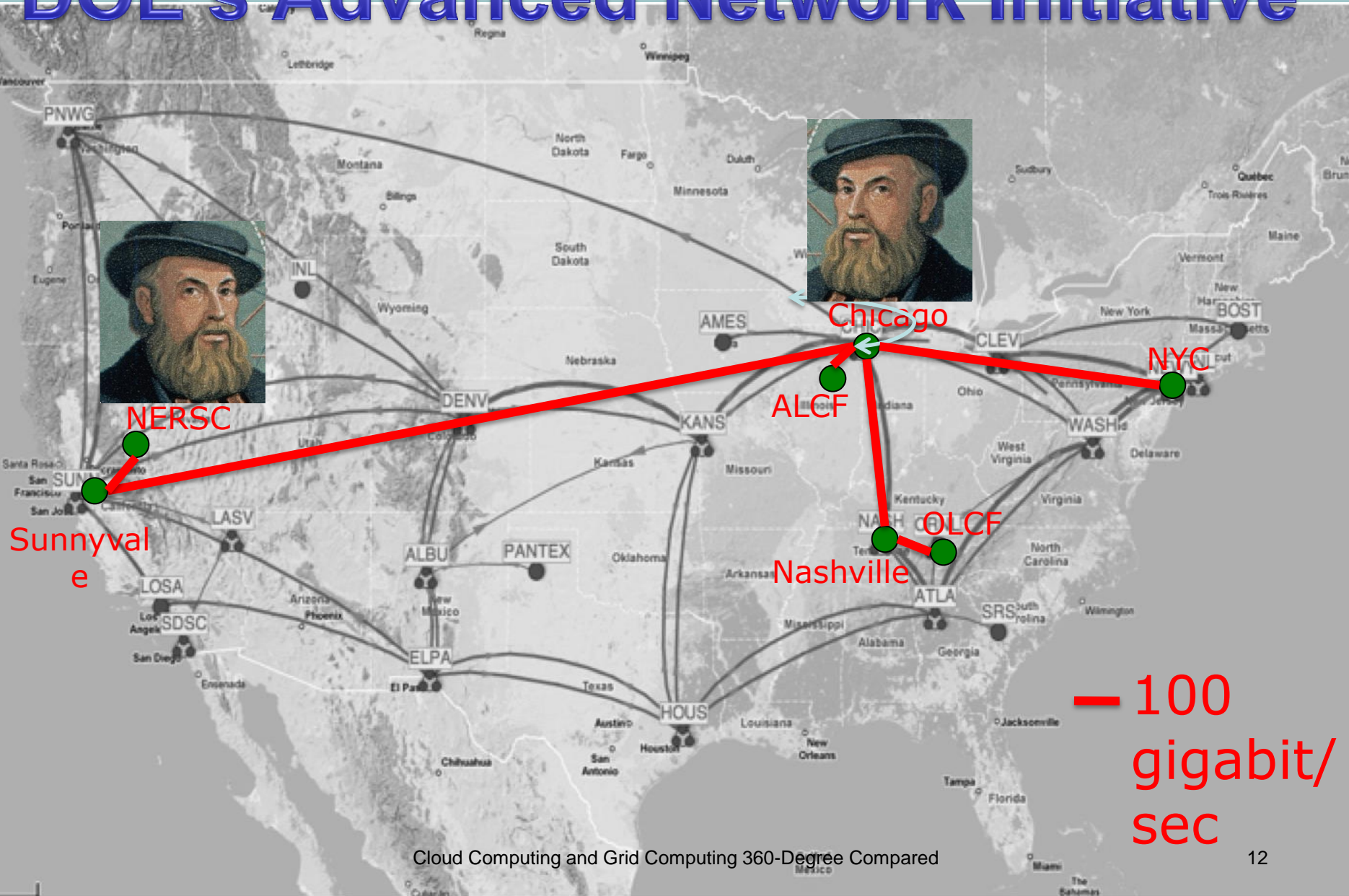
- *A large-scale distributed computing paradigm driven by:*
 1. *economies of scale*
 2. *virtualization*
 3. *dynamically-scalable resources*
 4. *delivered on demand over the Internet*



Clouds ~ hosting



Magellan + DOE's Advanced Network Initiative



Major Clouds

- Industry
 - Google App Engine
 - Amazon
 - Windows Azure
 - Salesforce
- Academia/Government
 - Magellan
 - FutureGrid
- Opensource middleware
 - Nimbus
 - Eucalyptus
 - OpenNebula

So is “Cloud Computing” just a new name for Grid?

- IT reinvents itself every five years
- The answer is complicated...
- **YES:** the vision is the same
 - to reduce the cost of computing
 - increase reliability
 - increase flexibility by transitioning from self operation to third party

So is “Cloud Computing” just a new name for Grid?

- **NO:** things are different than they were 10 years ago
 - New needs to analyze massive data, increased demand for computing
 - Commodity clusters are expensive to operate
 - We have low-cost virtualization
 - Billions of dollars being spent by Amazon, Google, and Microsoft to create real commercial large-scale systems with hundreds of thousands of computers
 - The prospect of needing only a credit card to get on-demand access to *infinite computers is exciting; *infinite $O(1000)$

So is “Cloud Computing” just a new name for Grid?

- **YES:** the problems are mostly the same
 - How to manage large facilities
 - Define methods to discover, request, and use resources
 - How to implement and execute parallel computations
 - Details differ, but issues are similar

Outline

- Business model
- Architecture
- Resource management
- Programming model
- Application model
- Security model

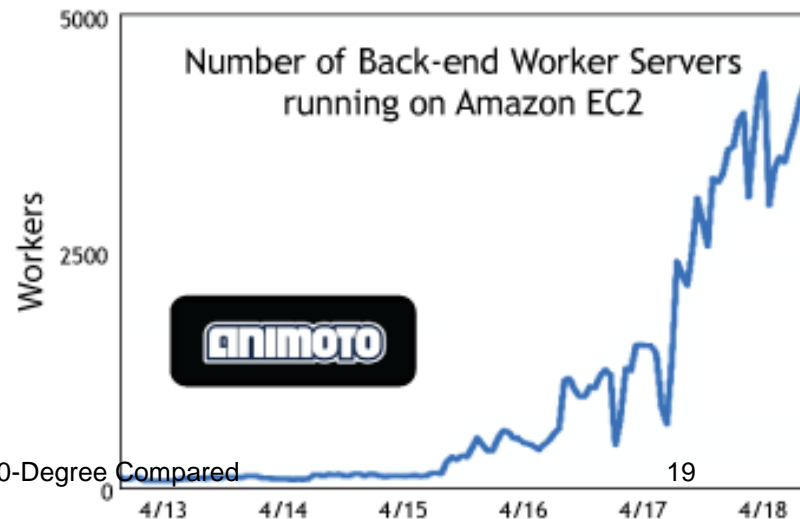
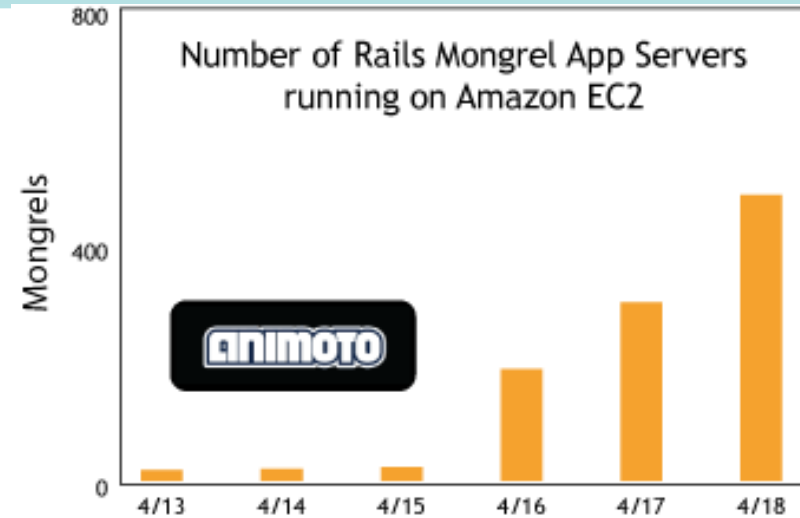
Business Model

- Grids:
 - Largest Grids funded by government
 - Largest user-base in academia and government labs to drive scientific computing
 - Project-oriented: service units
- Clouds:
 - Industry (i.e. Amazon) funded the initial Clouds
 - Large user base in common people, small businesses, large businesses, and a bit of open science research
 - Utility computing: real money

Business Model

Why is it a big deal?

- Why is this a big deal?
 - No owned infrastructure
 - All resources rented on demand
- Critical for startups with risky business plans
- Not possible without Cloud Computing and a credit card
 - Launched in 2007/2008 timeframe



An Example of an Application in the Cloud

- Animoto

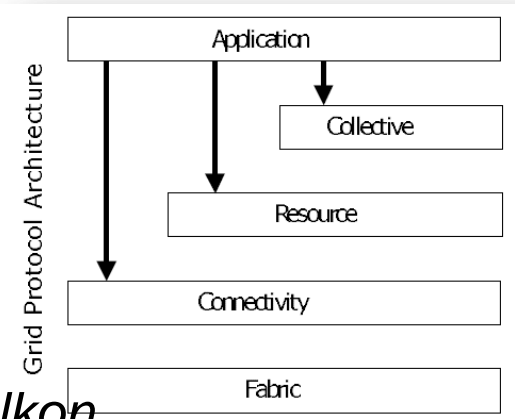
- Makes it **easy** to create videos with **web browser**



Architecture

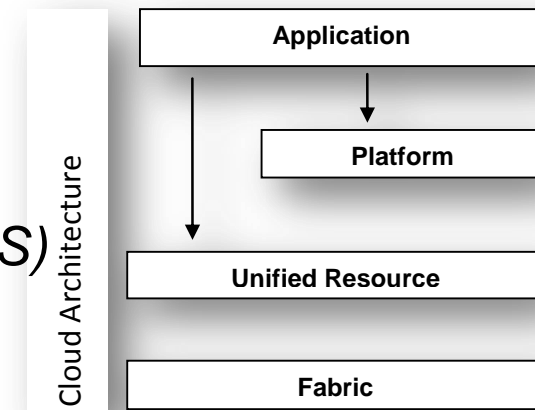
- Grids:

- Application: *Swift, Grid portals (NVO)*
- Collective layer: *MDS, Condor-G, Nimrod-G*
- Resource layer: *GRAM, Falkon, GridFTP*
- Connectivity layer: *Grid Security Infrastructure*
- Fabric layer: *GRAM, PBS, SGE, LSF, Condor, Falkon*



- Clouds:

- Application Layer: *Software as a Service (SaaS)*
- Platform Layer: *Platform as a Service (PaaS)*
- Unified Resource: *Infrastructure as a Service (IaaS)*
- Fabric: *IaaS*



Resource Management

- Compute Model
 - batch-scheduled vs. time-shared
- Data Model
 - Data Locality
 - Combining compute and data management
- Virtualization
 - Slow adoption vs. central component
- Monitoring
- Provenance

Programming and Application Model

- Grids:
 - Tightly coupled
 - High Performance Computing (MPI-based)
 - Loosely Coupled
 - High Throughput Computing
 - Workflows
 - Data Intensive
 - Map/Reduce
- Clouds:
 - Loosely Coupled, transactional oriented

Programming Model Issues

- **Multicore** processors
- Massive **task parallelism**
- Massive **data parallelism**
- Integrating **black box applications**
- Complex **task dependencies** (task graphs)
- **Failure**, and other execution management issues
- **Dynamic task graphs**
- Documenting **provenance** of data products
- **Data management**: input, intermediate, output
- **Dynamic data access** involving large amounts of data

Gateways

- Aimed to simplify usage of complex resources
- Grids
 - Front-ends to many different applications
 - Emerging technologies for Grids
- Clouds
 - Standard interface to Clouds

An Example of an Application in the Grid



Security Model

- Grids
 - Grid Security Infrastructure (GSI)
 - Stronger, but steeper learning curve and wait time
 - Personal verification: phone, manager, etc
- Clouds
 - Weaker, can use credit card to gain access, can reset password over plain text email, etc

Conclusion

- Move towards a mix of micro-production and large utilities, with load being distributed among them dynamically
 - Increasing numbers of small-scale producers (local clusters and embedded processors—in shoes and walls)
 - Large-scale regional producers
- Need to define protocols
 - Allow users and service providers to discover, monitor and manage their reservations and payments
 - Interoperability

Conclusion (cont)

- Need to combine the centralized scale of today's Cloud utilities, and the distribution and interoperability of today's Grid facilities
- Need support for on-demand provisioning
- Need tools for managing both the underlying resources and the resulting distributed computations
- Security and trust will be a major obstacle for commercial Clouds by large companies that have in-house IT resources to host their own data centers