Karlsruhe Institute of Technology

The OpenCirrus™ Project: A global Testbed for Cloud Computing R&D

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Universität Karlsruhe (TH)
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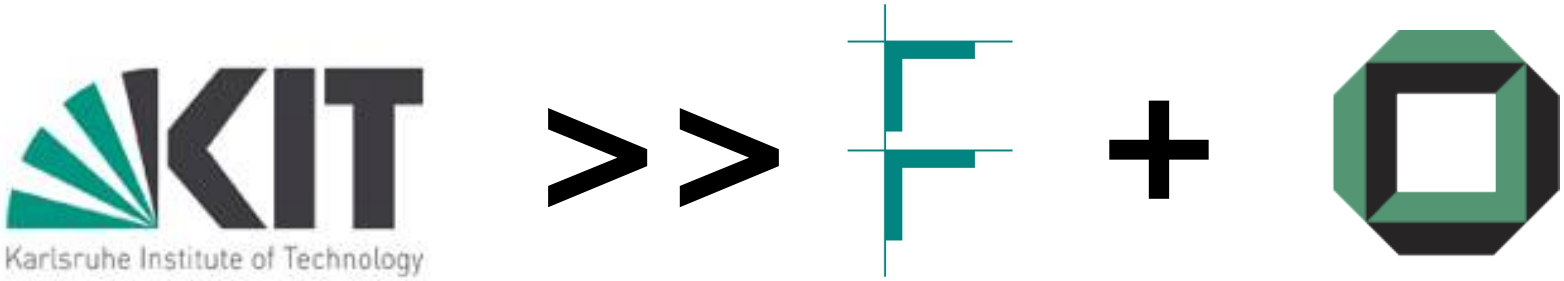
Karlsruhe Institute of Technology (KIT)

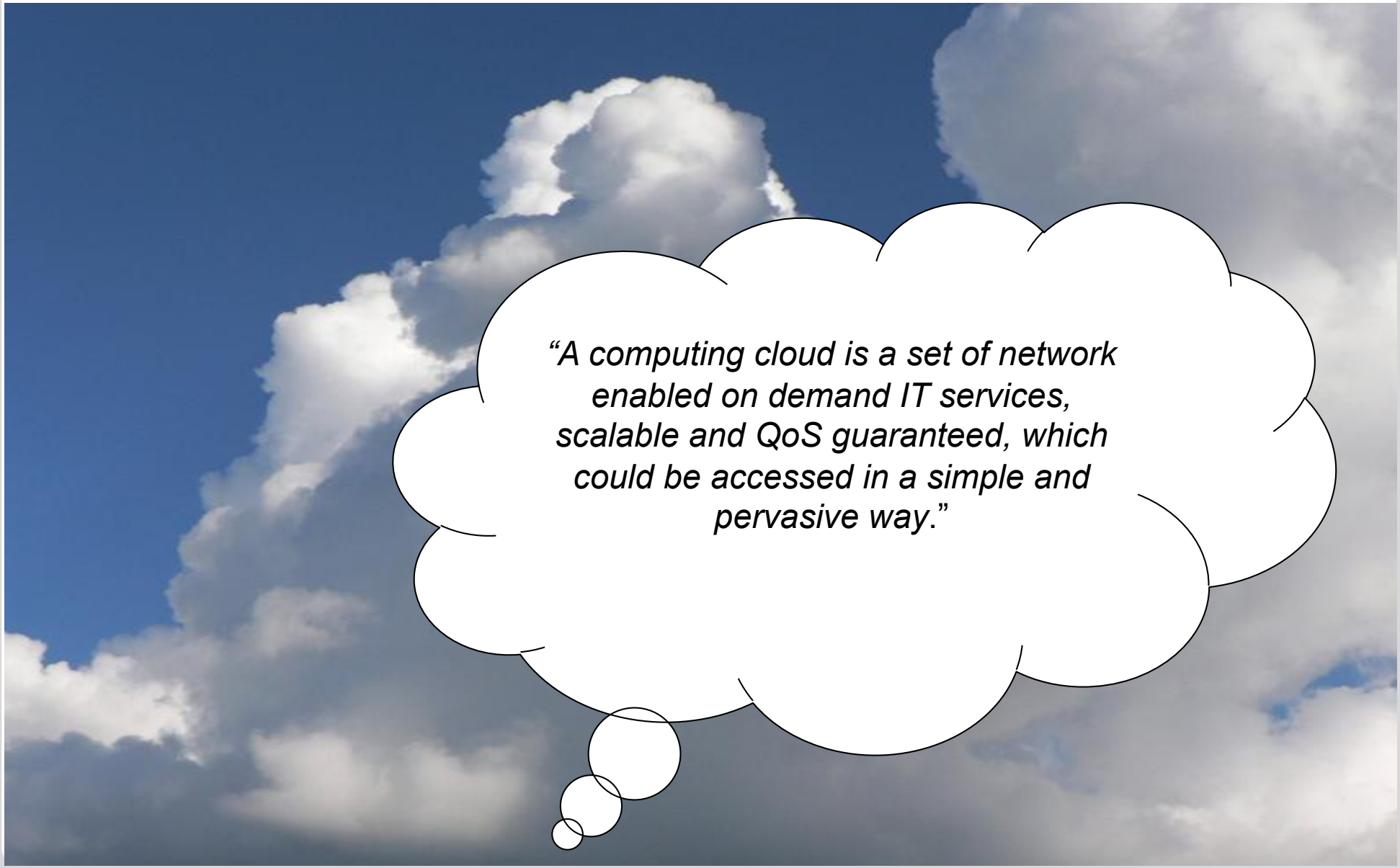
- Cooperation between research centre Karlsruhe und Karlsruhe university
- Largest scientific center in Germany
- 8.000 scientists, 18.000 students
- Annual budget: > 500 Million Euro
- R&D focus: Energy research and nano-technology



Agenda

- What is cloud computing ?
- OpenCirrus™ project
- Programming the cloud
- HPC and big data
- Summary

Cloud Computing: A possible Definition

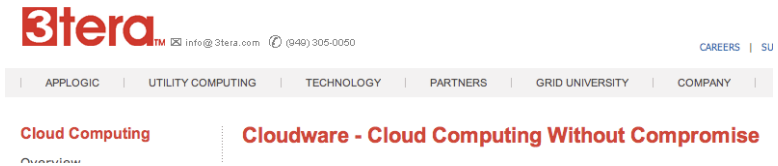


Cloud lives in Web 2.0

- Everything as a Service (XaaS)
  - AaaS: Application as a Service
  - PaaS: Platform as a Service
  - SaaS: Software as a Service
  - DaaS: Data as a Service
  - IaaS: Infrastructure as a Service
  - HaaS: Hardware as a Service
- Industry is pretty much engaged
  - Various commercial offerings exist

Commercial Cloud Offerings (Small Excerpt)

Amazon Elastic Compute Cloud (Amazon EC2) - *Beta*



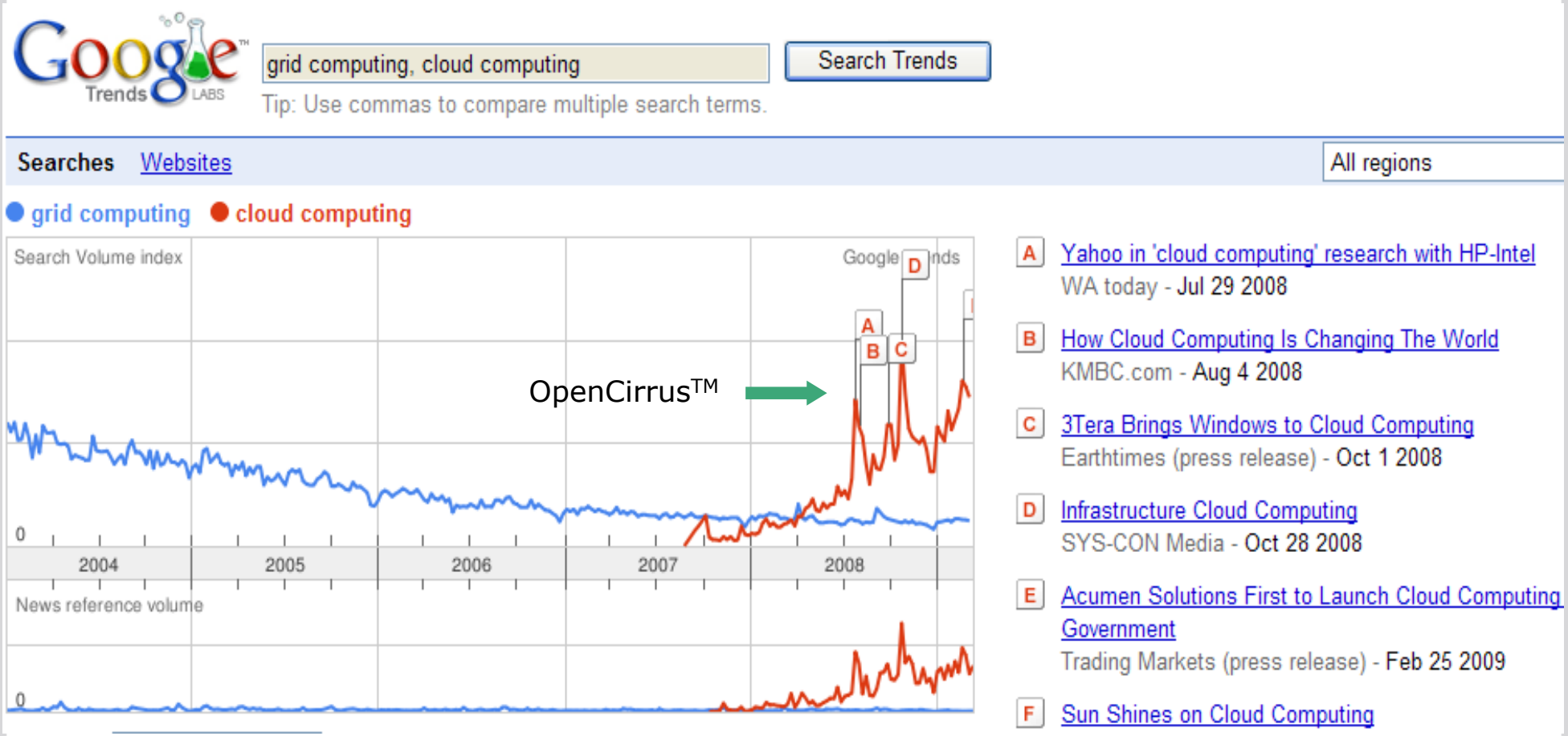
- **Problem: Commercial offerings are proprietary and usually not open for cloud systems research and development**

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

Cloud Computing: A new Hype following Grid



- Cloud computing R&D: OpenCirrus™ project

Clouds vs. Grids: A Comparison

	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

InformationWeek
BUSINESS INNOVATION POWERED BY TECHNOLOGY

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HP, Intel, Yahoo Join Government, Academia In Cloud Computing Research

Each of the founding members will host a cloud-computing infrastructure largely based on HP computers and Intel processors in six data centers.

By Antone Gonsalves, InformationWeek
July 29, 2008
URL: http://www.informationweek.com/story/showArticle.jhtml?articleID=209800449

Hewlett-Packard, Intel, and Yahoo on Tuesday said they have joined government and academia in launching a global, multi-data center test bed for experimentation and research in cloud computing, which many experts believe will be the dominant IT delivery model of the future.

The initiative aims at building a computing network comprised of six data centers spanning three continents. The idea is to have a large-scale platform for testing all technology -- hardware and software -- related to delivering application services over the Internet.

"This is a global collaboration that spans the industry, spans academia and government," Prith Banerjee, senior VP for research at HP, told reporters during a teleconference held by the three founding companies.

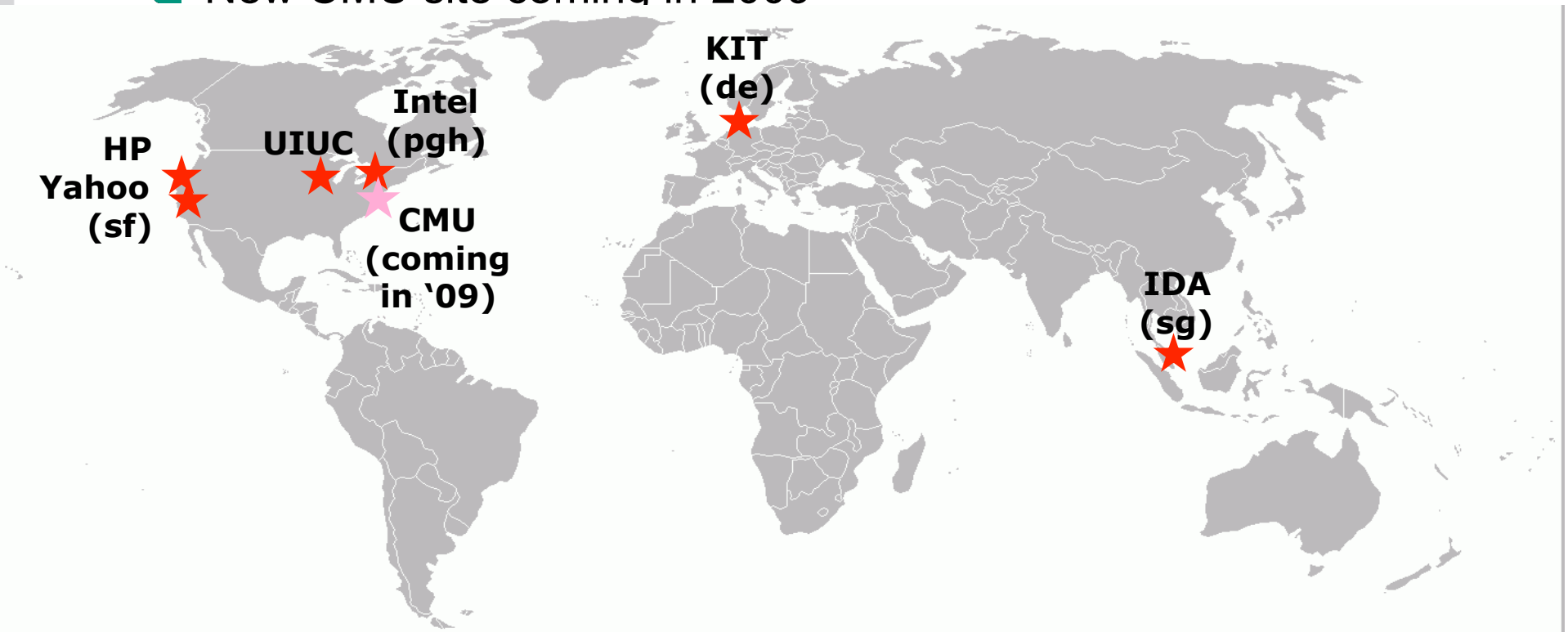
OpenCirrus™ Cloud Computing Research Testbed

http://opencirrus.org

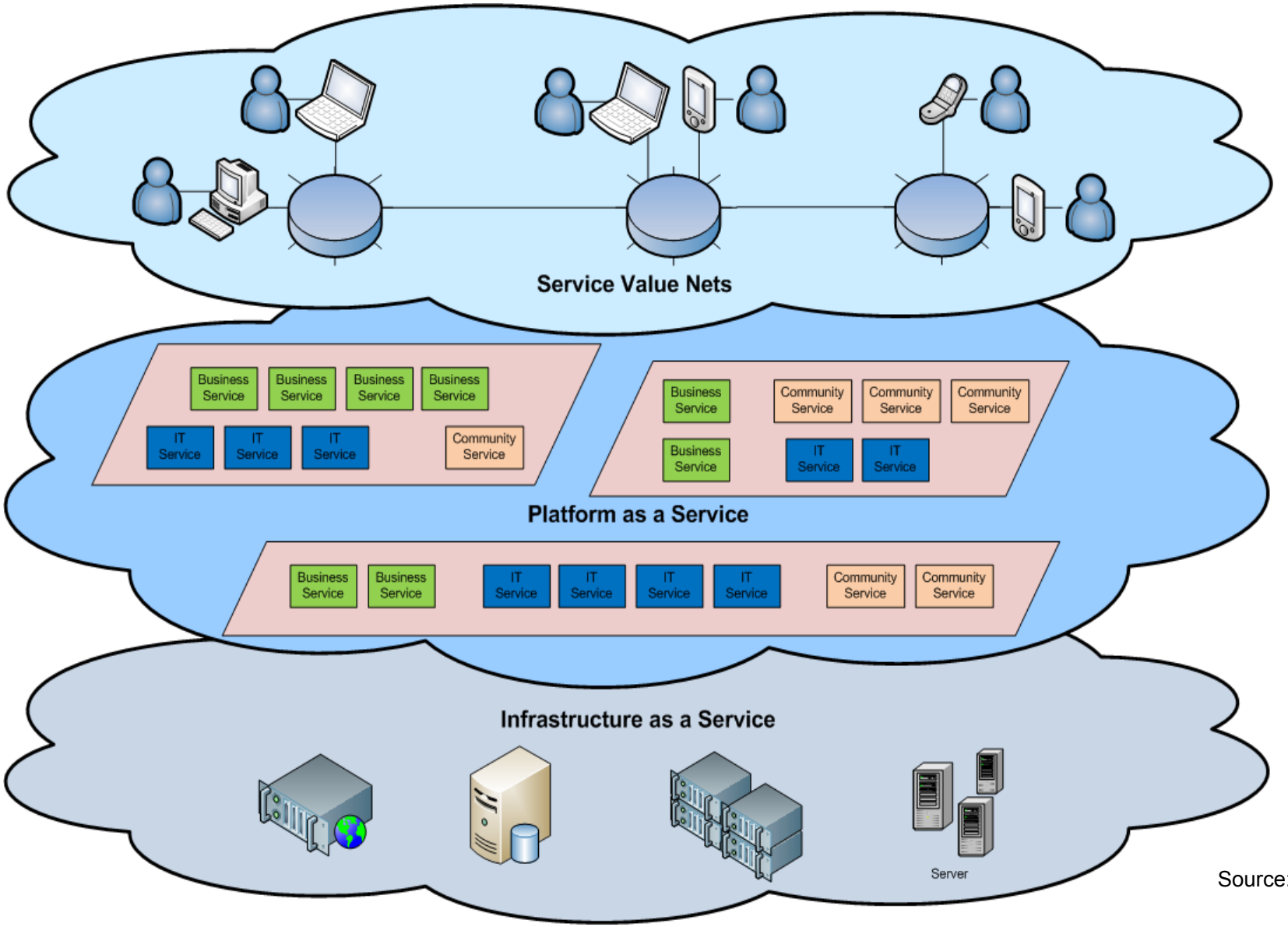
- An open, internet-scale global testbed for cloud computing research
  - Data center management & cloud services
  - Systems level research
  - Application level research
- Structure: a loose federation
  - Sponsors: HP Labs, Intel Research, Yahoo!
  - Partners: UIUC, Singapore IDA, KIT, NSF
  - Members: System and application development
- Great opportunity for cloud R&D

Where are the OpenCirrus™ sites?

- Six sites initially:
  - Sites distributed world-wide: HP Research, Yahoo!, UIUC, Intel Research Pittsburgh, KIT, Singapore IDA
  - 1000-4000 processor cores per site
  - New CMU site coming in 2009

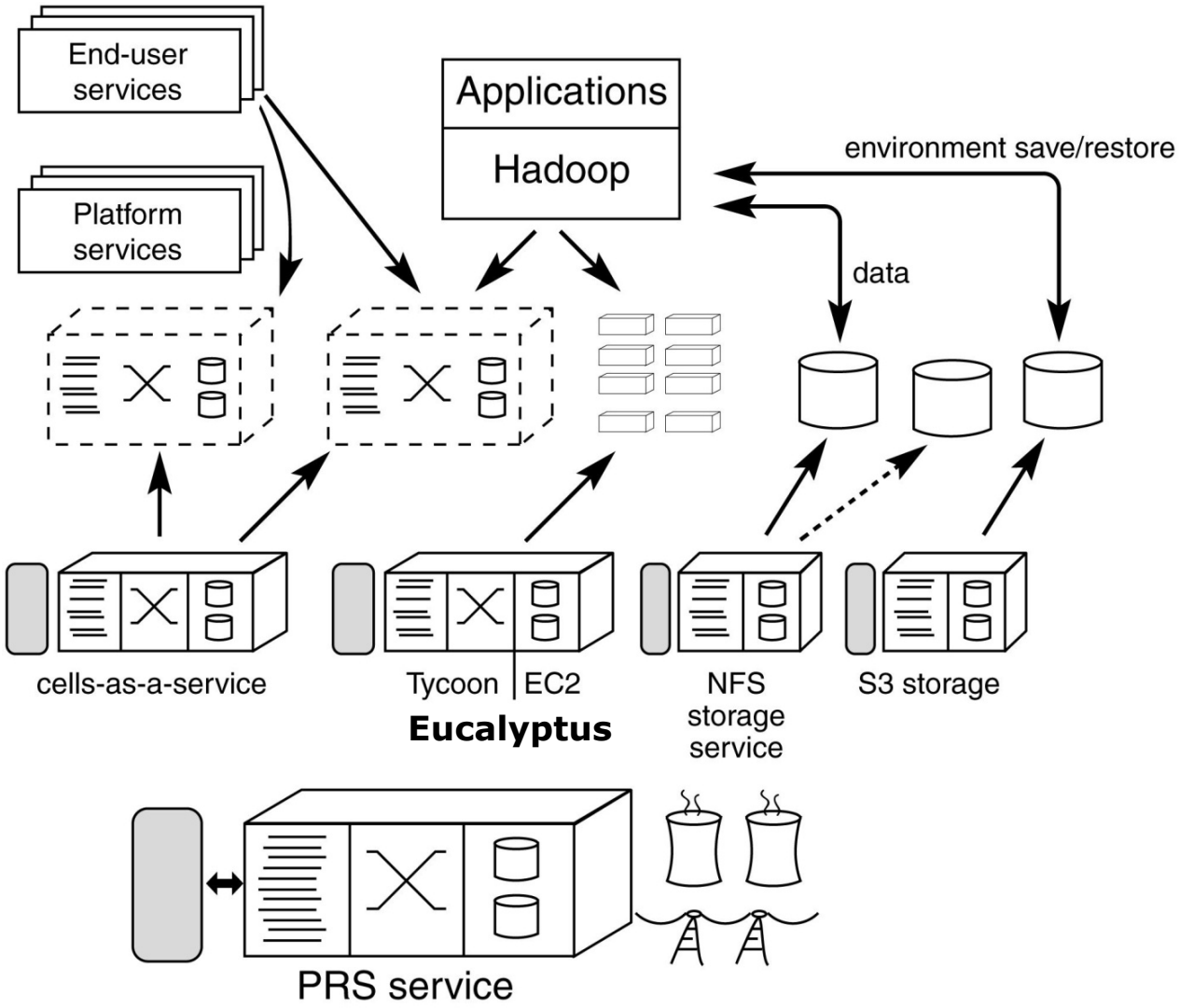


Cloud Architecture



Source: S.Tai

OpenCirrus™ Blueprint



Cloud application services

Virtual Resource Sets

Cloud infrastructure services

IT infrastructure layer (Physical Resource Sets)

Physical Resource Sets (PRS)

- PRS service goals
  - Provide mini-datacenters to researchers
  - Isolate experiments from each other
  - Stable base for other research
- PRS service approach
  - Allocate sets of physical co-located nodes, isolated inside VLANs.
  - Leverage existing software (e.g. Utah Emulab, HP OpsWare)
  - Start simple, add features as we go
  - Base to implement virtual resource sets
- Hardware as a Service (HaaS)

Virtual Resource Sets (VRS)

- Basic idea: Abstract from physical resource by introduction of a virtualization layer
- Concept applies to all IT aspects: CPU, storage, networks and applications, …
- Main advantages
  - Implement IT services **exactly** fitting customer‘s varying need
  - Deploy IT services on demand
  - Automated resource management
  - Easily guarantee service levels
  - Live migration of services
  - Reduce both: CapEx and OpEx
- Infrastructure as a Service (IaaS)
  - Implement Compute and Storage services
  - De-facto standard: Amazon Web Services interface

Amazon Web Services

http://aws.amazon.com/

Infrastructure As A Service

- Amazon Simple Storage Service
- Amazon Elastic Compute Cloud
- Amazon Simple Queue Service
- Amazon SimpleDB (New!)

Payments/Billing As A Service

- Amazon Flexible Payments Service
- Amazon DevPay (New!)

People As A Service

- Amazon Mechanical Turk

E-Commerce As A Service

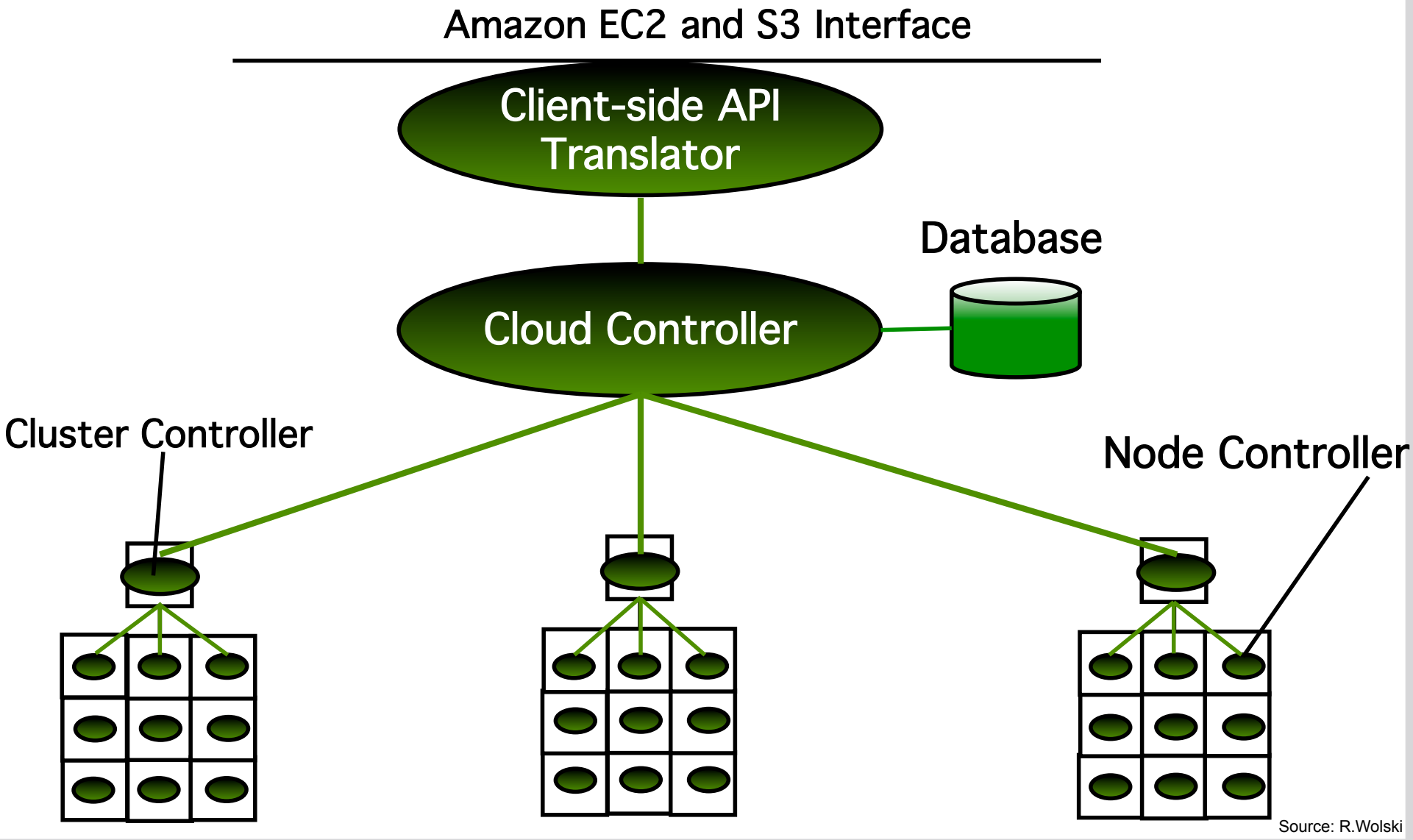
- Amazon Associates Web Service
- Amazon Fulfillment Web Service (New!)

Search As A Service

- Alexa Web Information Service
- Alexa Top Sites
- Alexa Site Thumbnail
- Alexa Web Search

Eucalyptus: A potential VRS layer

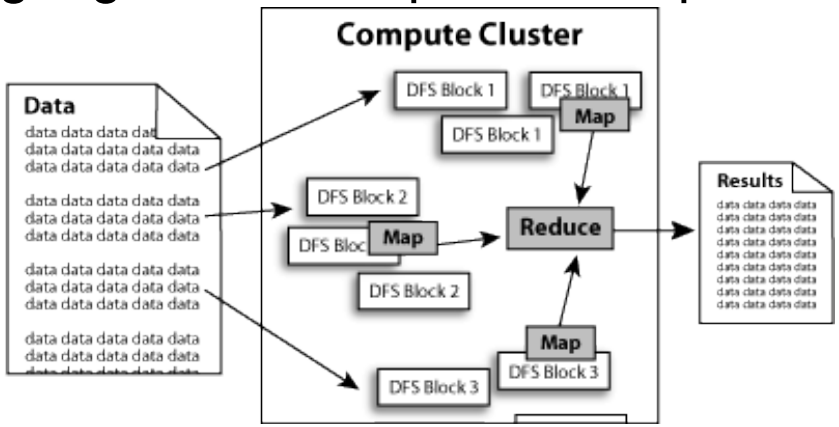
http://eucalyptus.cs.ucsb.edu/



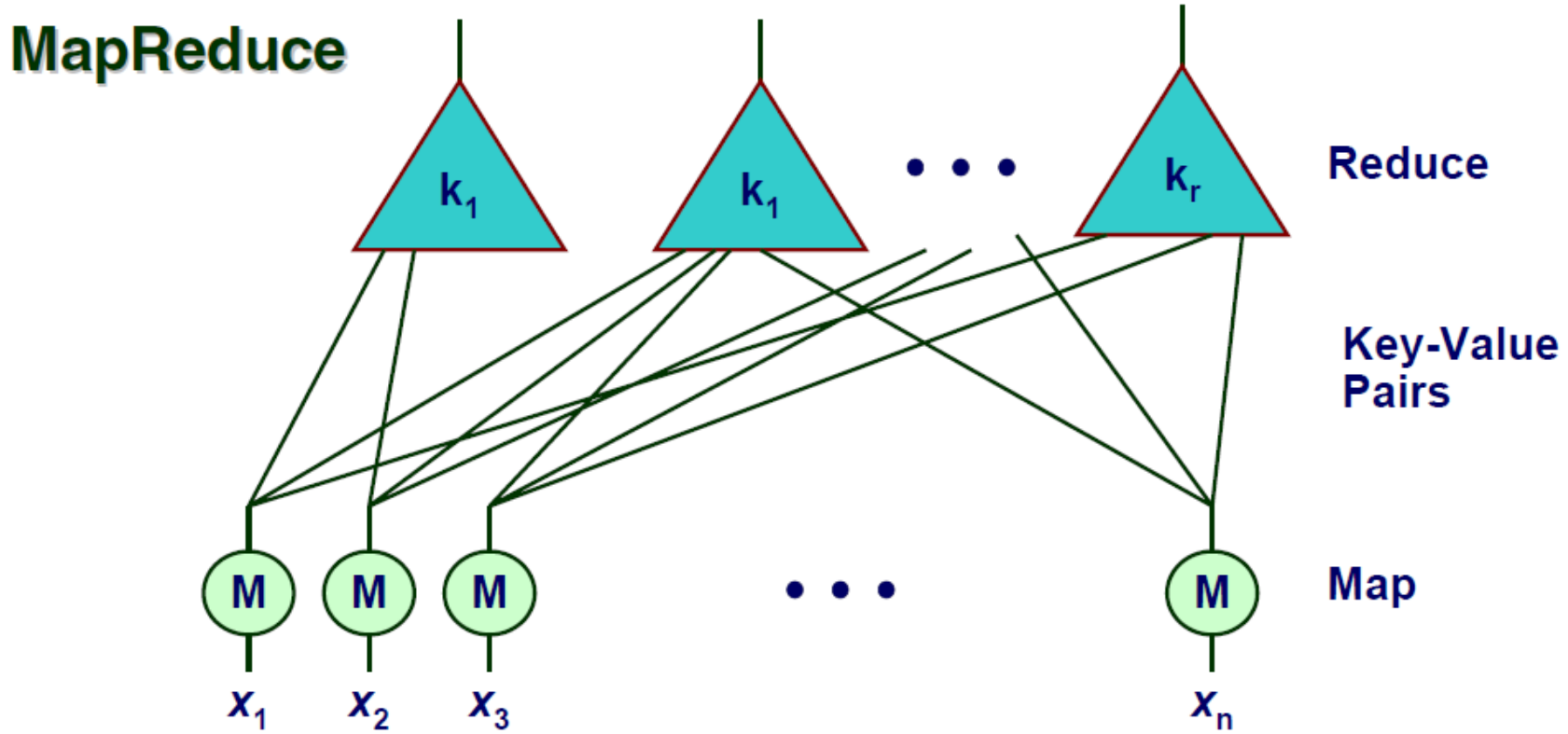
Source: R.Wolski

Programming the Cloud: Hadoop

- An open-source Apache software foundation project sponsored by Yahoo!
  - http://wiki.apache.org/hadoop/ProjectDescription
  - intent is to 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



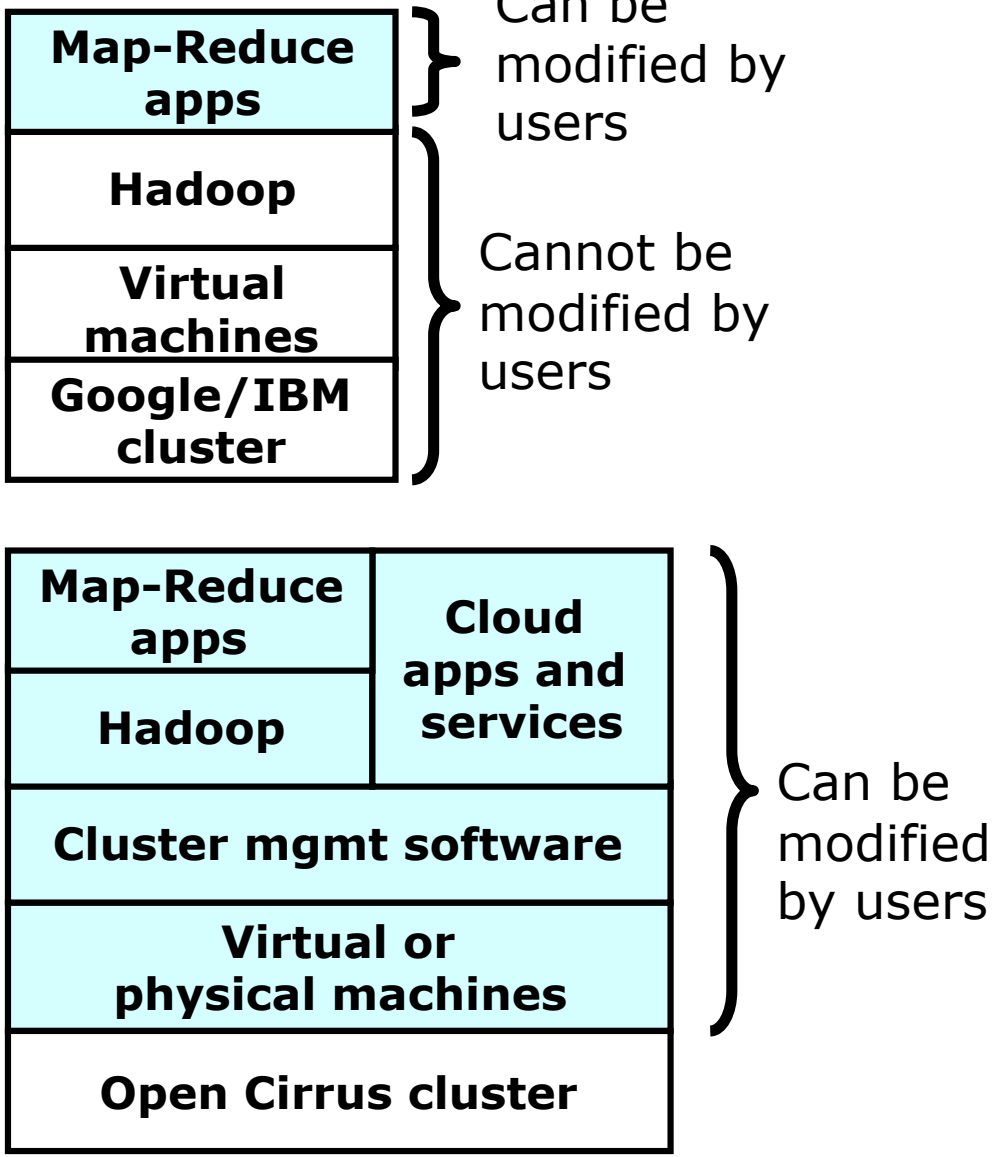
The MapReduce Programming Model



- Map computation across many objects
  - Extract a set of key value pairs of e.g. 10^{10} Web pages
- Reduce results in many different ways
  - Combine it with other values that share the same key
- System deals with issues of resource allocation & reliability

How is OpenCirrus™ different from other testbeds?

- OpenCirrus™ supports both system- and app-level research
  - n/a at Google/IBM and EC2/S3
  - OpenCirrus™ researchers will have complete access to the underlying hardware and software platform.
  - OpenCirrus™ allows Intel platform features that support cloud computing (e.g. DCMI, NM) to be exposed, and exploited.



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 (which goes live Q1)
  - 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.

Who can use the OpenCirrus™ Resources ?

- Three different types of users can use OpenCirrus™ sites:
  - (a) Individual PIs from academic research groups
  - (b) Industry researchers from the OpenCirrus™ partners
  - (c) Industry researchers who have a customer relationship with the OpenCirrus™ partners
- What is the expected mix of these groups?
  - The majority of users will be (a) academic researchers and (b) researchers who work for the OpenCirrus™ partners.
  - There will be a few carefully chosen users who are (c) industry researchers with a customer relationship with an OpenCirrus™ partner

What kinds of research projects are OpenCirrus™ 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

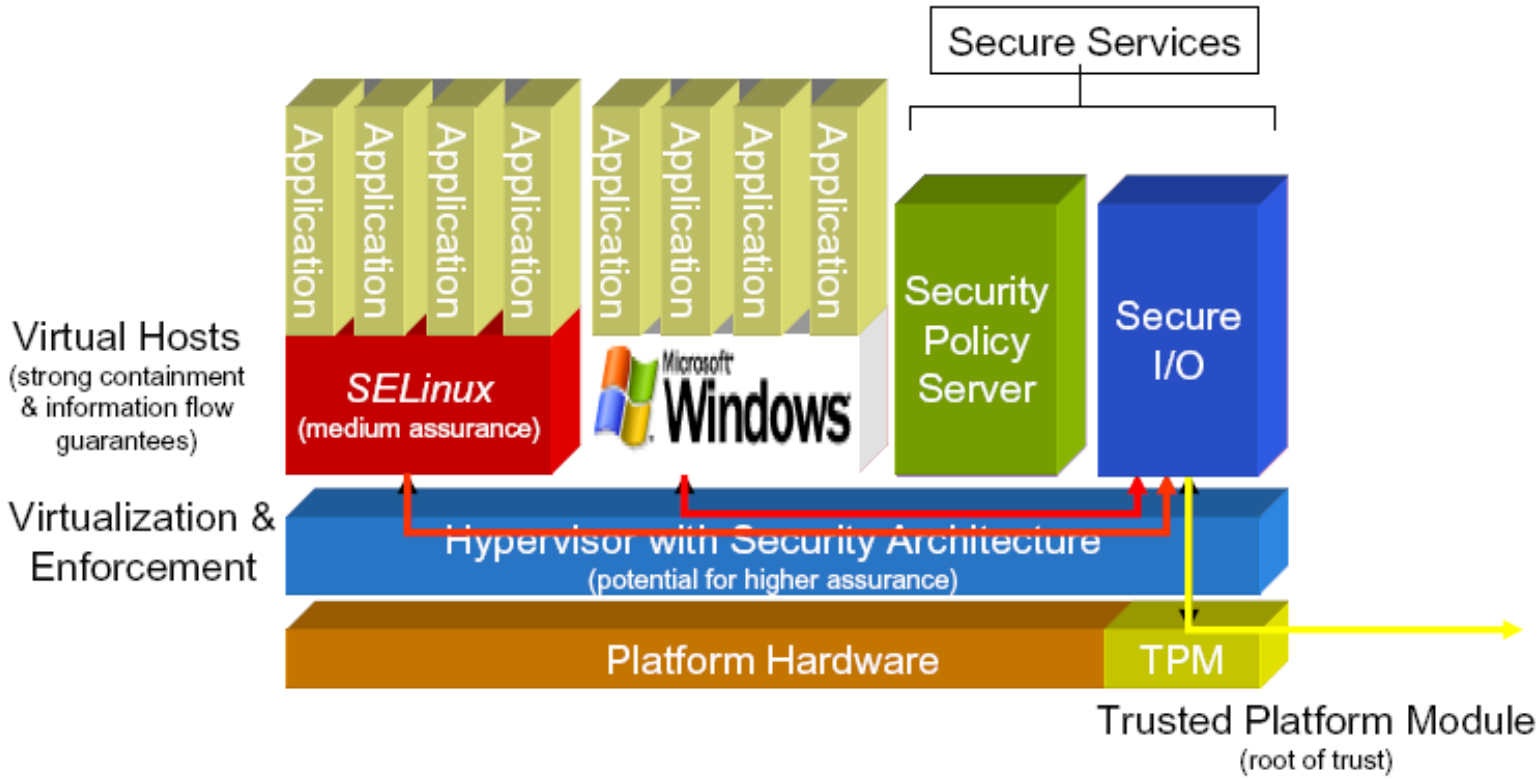
- The following kinds of projects are not of primary interest:
  - Traditional HPC application development.
  - Production applications that just need lots of cycles.
  - Closed source system development.

Potential Fields of Cloud System Development (1)

- Virtual organizations and social networks
  - Science is team work, clouds are rather for individuals right now
- Integration of cloud services
  - Standardization of APIs and protocols
  - Hyperclouds may integrate services of various providers (Stratosphere ?)
- Management of service quality
  - Negotiation and monitoring of SLAs
  - How does this work for Web service mashups ?
- Privacy, data protection and security
  - Importance of AAA and encryption
  - e.g. use of Trusted Platform Module (TPM)

Cloud Security: A possible Solution

Hypervisor Security Architecture complements OSes with strong isolation, controlled sharing, & verifiable / attestable environments



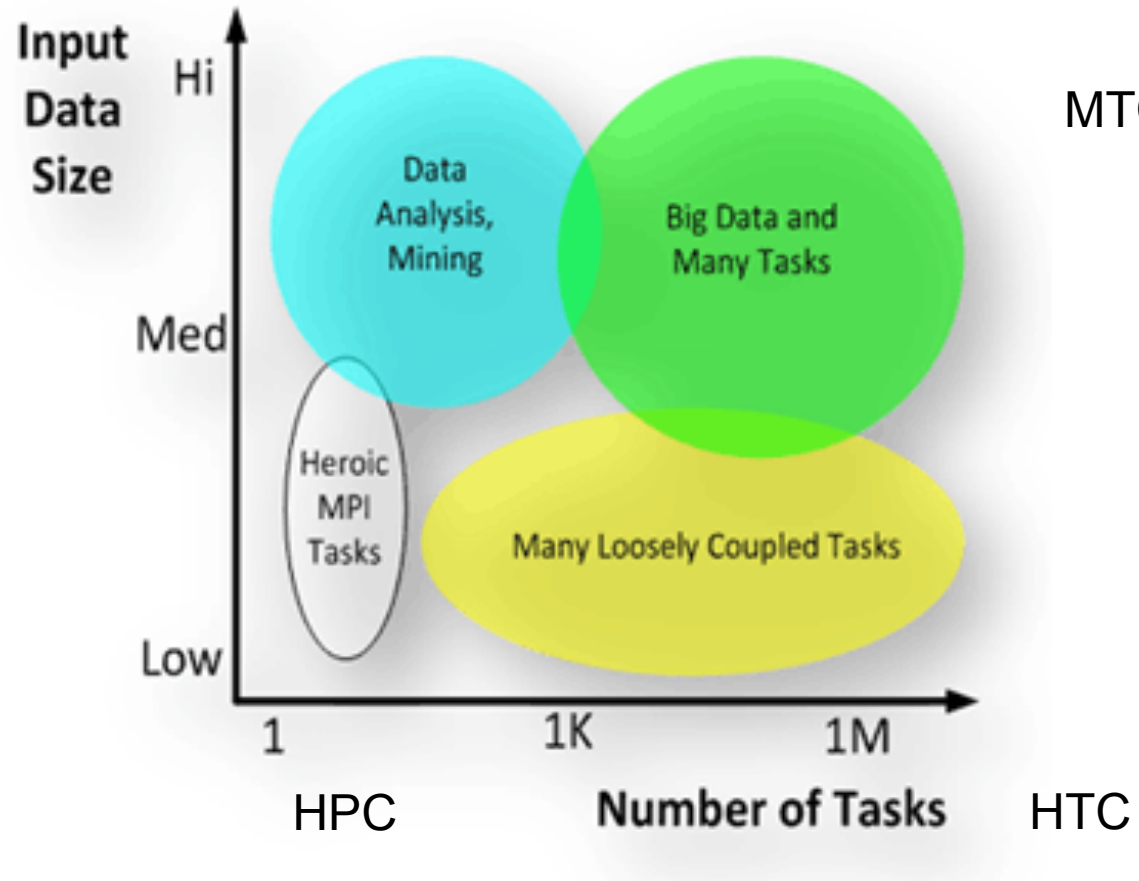
Source: IBM

Potential Fields of Cloud System Development (2)

- New infrastructure services
  - HPCaaS: High Performance Computing as a Service
  - LSDFaaS: Large Scale Data Facility as a Service
  - GenomeDBaaS: Genome Database as a Service

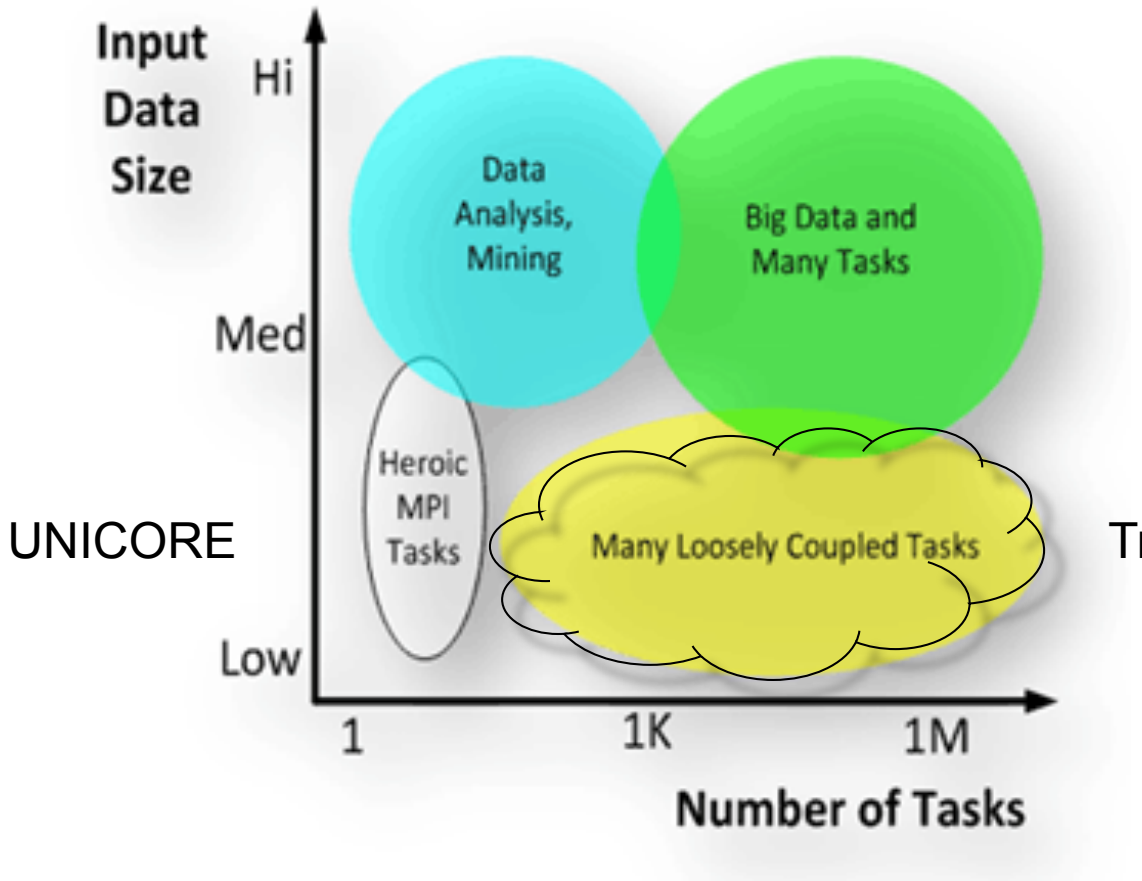
- How does this relate to Grid computing ?

HPC vs. HTC vs. MTC (Many Task Computing)



Source: I.Foster

The Grid and Cloud Space

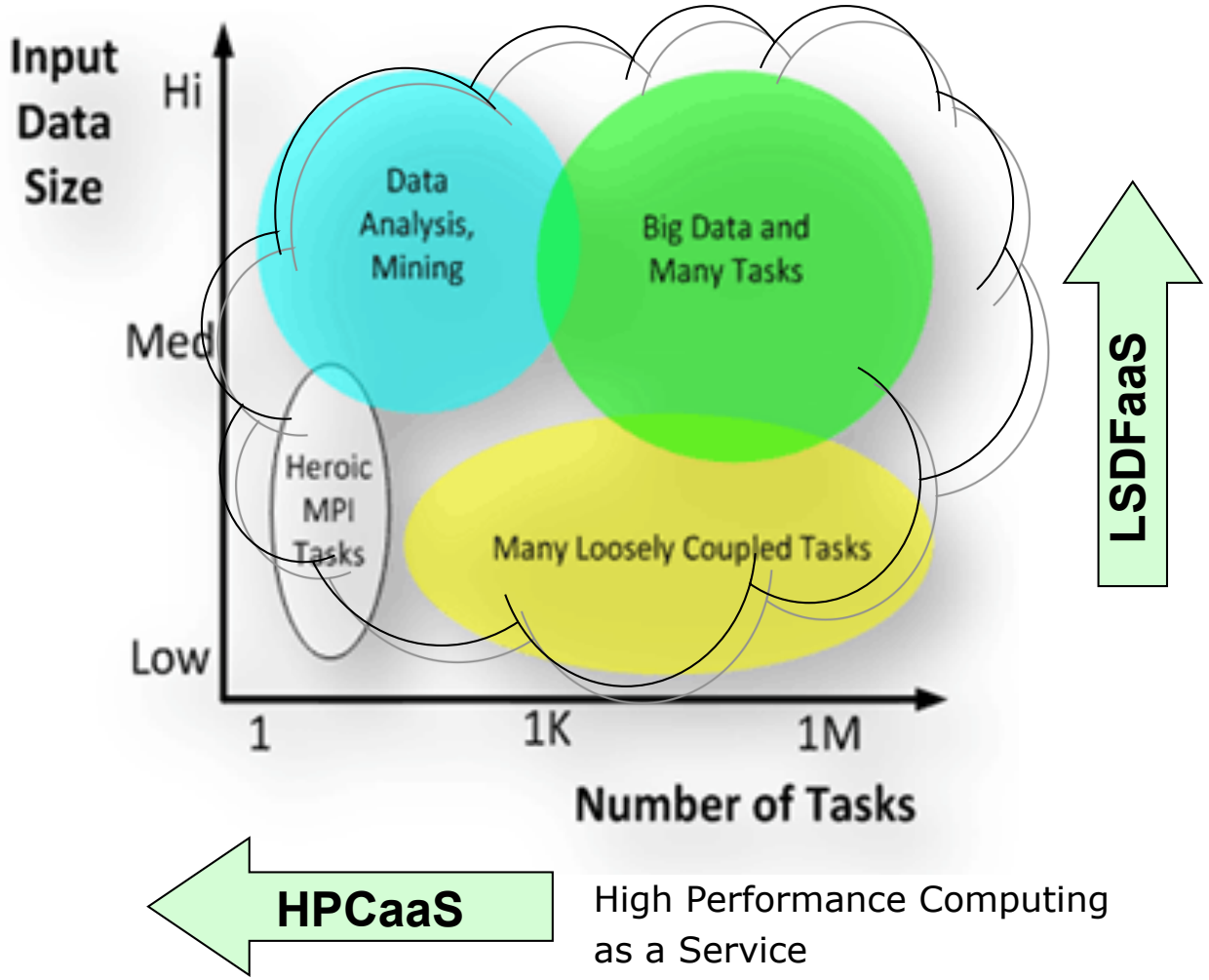


gLite

UNICORE

Traditional Cloud / Web 2.0

Extension of the Cloud Space to all Areas



Large Scale Data Facility as a Service

High Performance Computing as a Service

HPCaaS

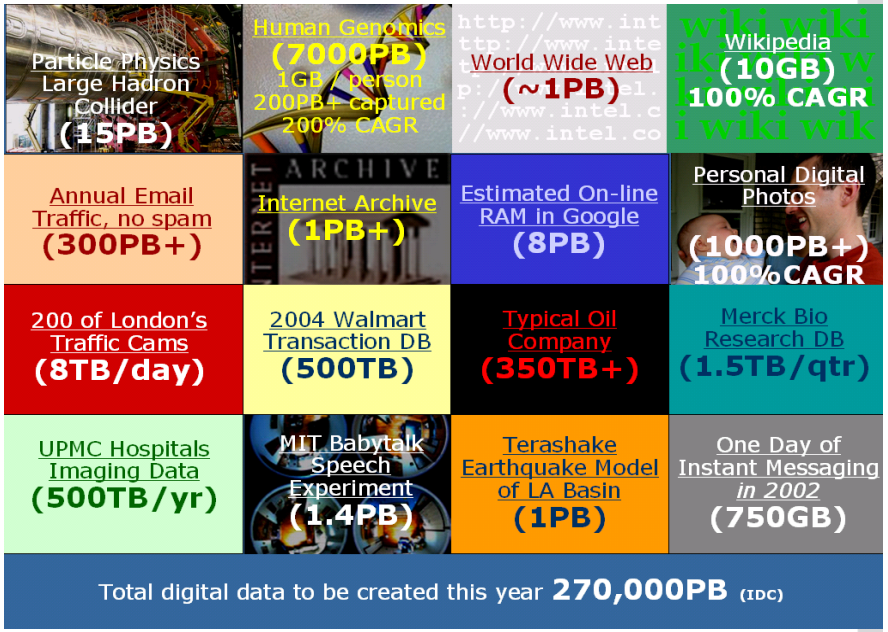
- High Performance Computing as a Service
- Interesting Fields for R&D in Open Cirrus™
  - Flexible platform services for HPC customers
  - Development of MPI services for clouds
  - Development of scheduling services for clouds
  - Management of software licenses
  - Integration of Grid resources: Grid as a Service (GaaS)

LSDFaaS

- Large Scale Data Facility as a Service
- Actual projects at KIT in this field:
  - Data storage for LHC computing
  - Data storage for ITER (EUFORIA)
  - Project ANKA (synchrotron radiation source)
  - Activities in materials research
- Long-term data filing due to legal requirements
- Development of big data services

Big Data

- Interesting applications are *data hungry*
- The data grows over time
- The data is immobile
  - 100 TB @ 1Gbps ~= 10 days
- Compute comes to the data
- Big Data clusters are the new libraries



(J. Campbell, et al., Intel Research Pittsburgh, 2007)

The value of a cluster is its data

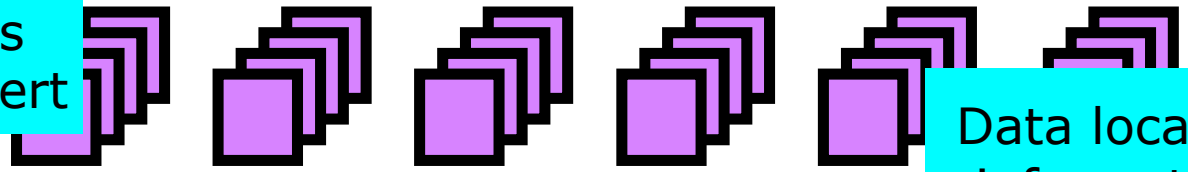
Tashi High-Level Design

http://wiki.apache.org/incubator/TashiProposal

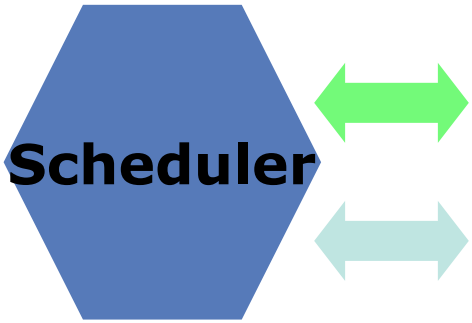
OpenCirrus™ at
Intel Research Pittsburgh

Services are instantiated through virtual machines

Most decisions happen in the scheduler; manages compute/storage in concert



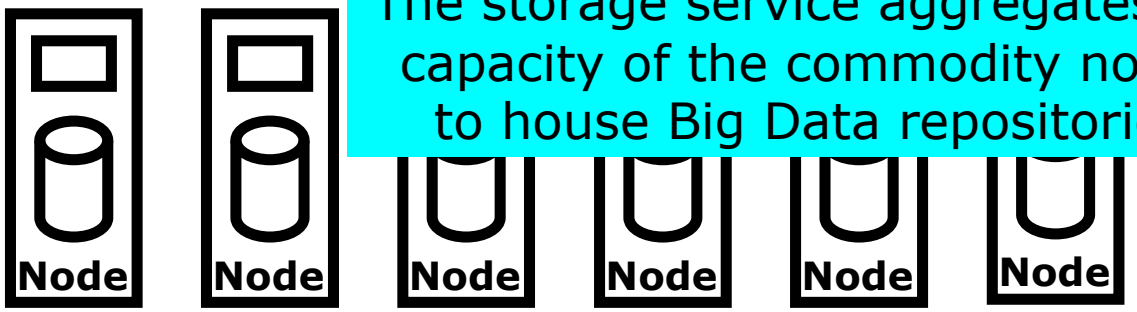
Data location information is exposed to scheduler and services



Virtualization Service

Storage Service

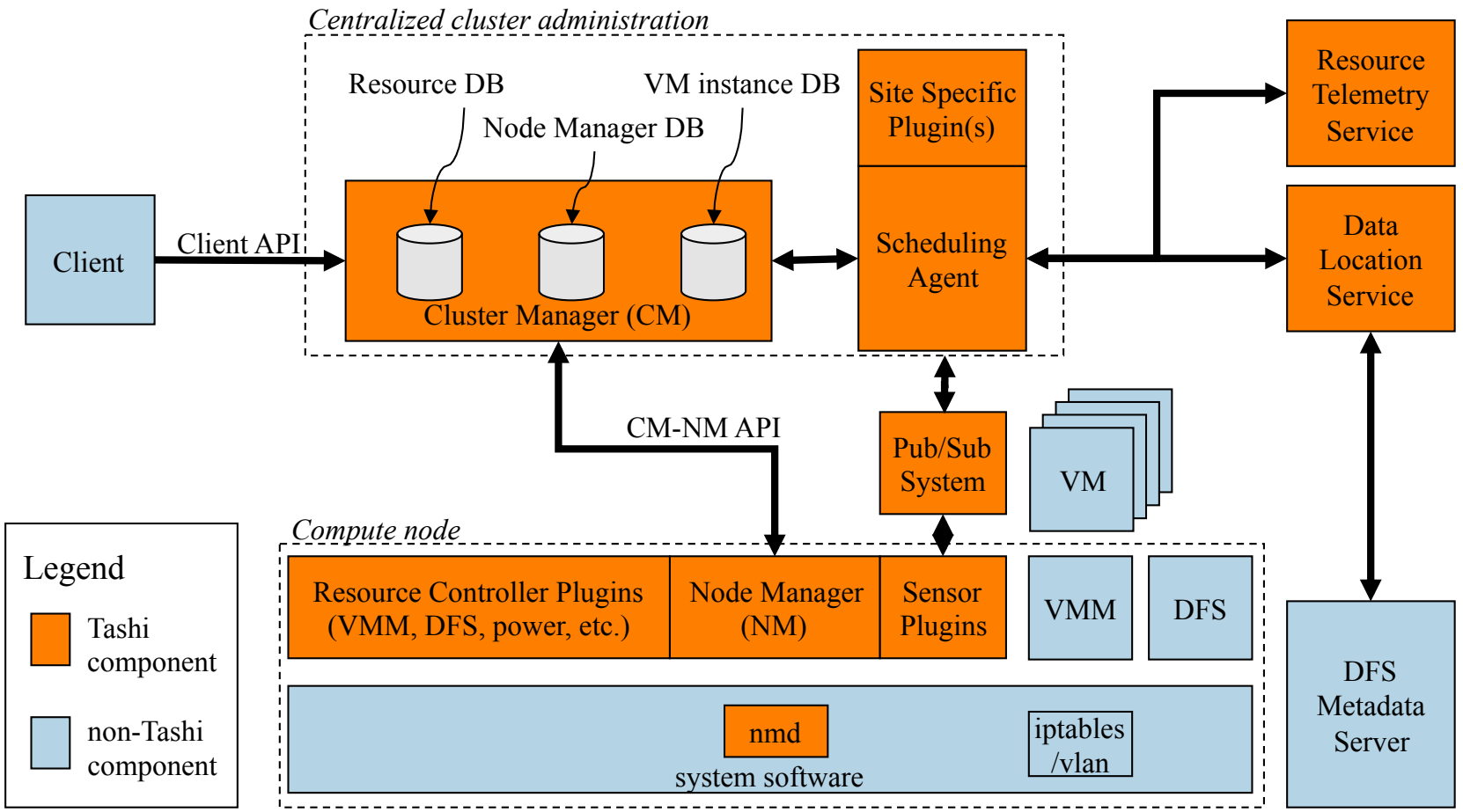
The storage service aggregates the capacity of the commodity nodes to house Big Data repositories.



CM maintains databases and routes messages; decision logic is limited

Cluster nodes are assumed to be commodity machines

Tashi Software Architecture

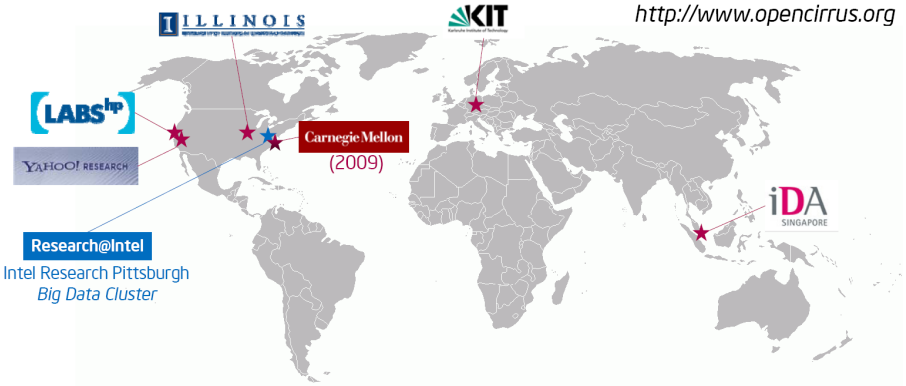


Tashi is both…

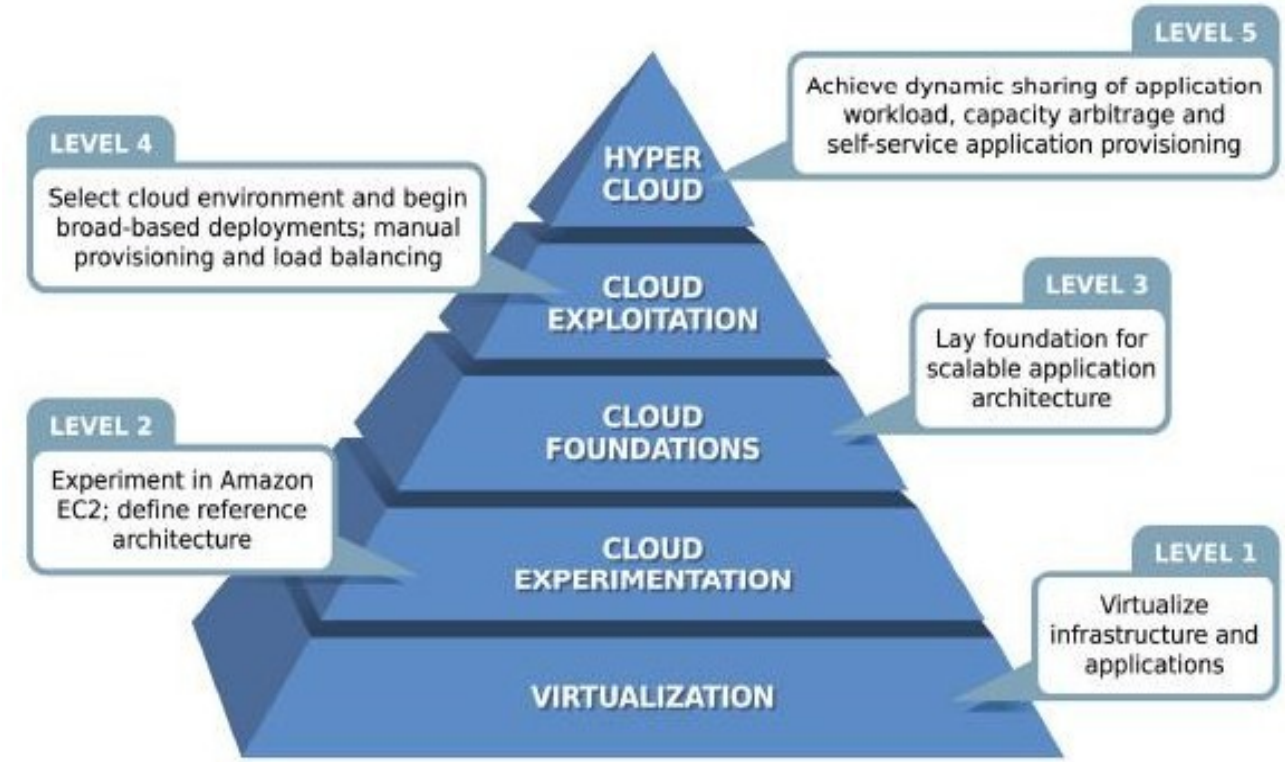
OpenCirrus™ at
Intel Research Pittsburgh

- An open source software project
  - http://incubator.apache.org/tashi/
  - The implementation is intended to become worthy of production use.
  - Alpha deployment running on OpenCirrus™ cluster at Intel Research Pittsburgh since October 2008.
- An open research project
  - http://www.pittsburgh.intel-research.net/projects/tashi/
  - Key question: *How should compute, storage, and power be managed in a Big Data cluster to optimize for performance, energy, and fault-tolerance?*

- Initial sponsors include:
  - Intel Research Pittsburgh
  - Carnegie Mellon University
  - Yahoo!



The Way to Cloud Nirvana



Source: rpath

- The roadmap for cloud services
  - Leads to dynamic data centers
  - Ranges from infrastructure services to dynamic applications
  - Complements traditional IT services in the medium term

Summary

- Cloud computing is the next big thing
  - 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 development
  - Cloud application development
  - Accepting research proposals soon
- OpenCirrus™ workshop at HP Palo Alto on June 8/9

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Steinbuch Centre for Computing (SCC)

Thank you for your attention.