

# Cloud Computing Tutorial

Jens Nimis

Tutorial, IPE-Klausurtagung  
30. Juli 2009, Freudenstadt

# Sources

- [JB] Dr. James Broberg, U. Melbourne, CC-Tutorial at CCGrid 2009  
<http://www.slideshare.net/jamesbroberg/introduction-to-cloud-computing-ccgrid-2009>
- [MM] Michael Maximilien, IBM
- [MK] Dr. Marcel Kunze und Christian Baun (comics), SCC Karlsruhe
- Stefan Tai, Alex Lenk, Markus Klems, Sebastian Schmidt & many more...

# Agenda

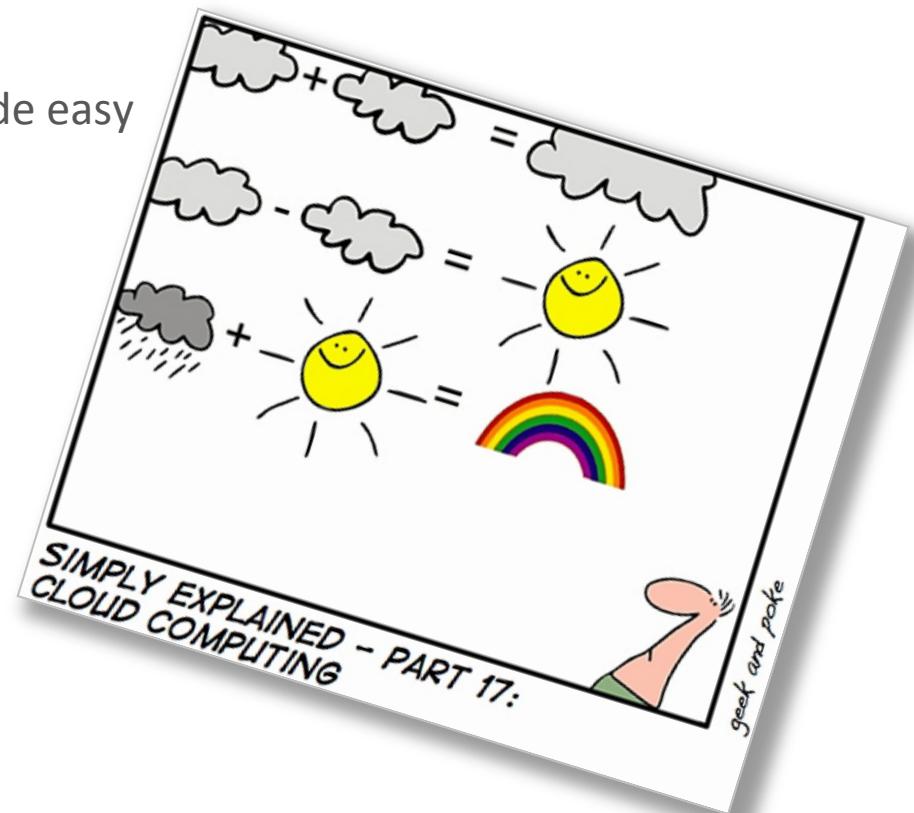
- Part 1: What is Cloud Computing?
- Part 2: The Cloud Ecosystem
- Part 3: Current research questions and interesting directions

# Agenda – Part 1

- Part 1: What is Cloud Computing?
  - Definitions
  - Cloud vs. Grid
  - Challenges and Opportunities
- Part 2: The Cloud Ecosystem
- Part 3: Current research questions and interesting directions

# Some remarks on Cloud Definitions

- Anonymous:  
„[...] unfortunately the marketing guys got hold of the term before the technicians had known what Cloud Computing is [...]“
- A lot of semi-serious definitions:
  - Cloud = Grid made right / Grid made easy
  - Grid: from Science for Science  
Cloud: from Business for Business
- Let's get serious (first...)



# Some serious definitions

- **UCBerkeley RADLabs:** “Cloud computing has the following characteristics: (1) The illusion of infinite computing resources... (2) The elimination of an up-front commitment by Cloud users... (3). The ability to pay for use...as needed...”  
→ business perspective
- **McKinsey:** “Clouds are hardware-based services offering compute, network and storage capacity where: Hardware management is highly abstracted from the buyer, Buyers incur infrastructure costs as variable OPEX, and Infrastructure capacity is highly elastic”  
→ only one kind of Cloud
- **Wikipedia:** “.. a style of computing in which dynamically scalable and often virtualized resources are provided as a service over the Internet”  
→ technical perspective

[JB]

# Our definition

“Building on compute and storage virtualization, **cloud computing** provides scalable, network-centric, abstracted IT infrastructure, platforms, and applications as on-demand services that are billed by consumption.”

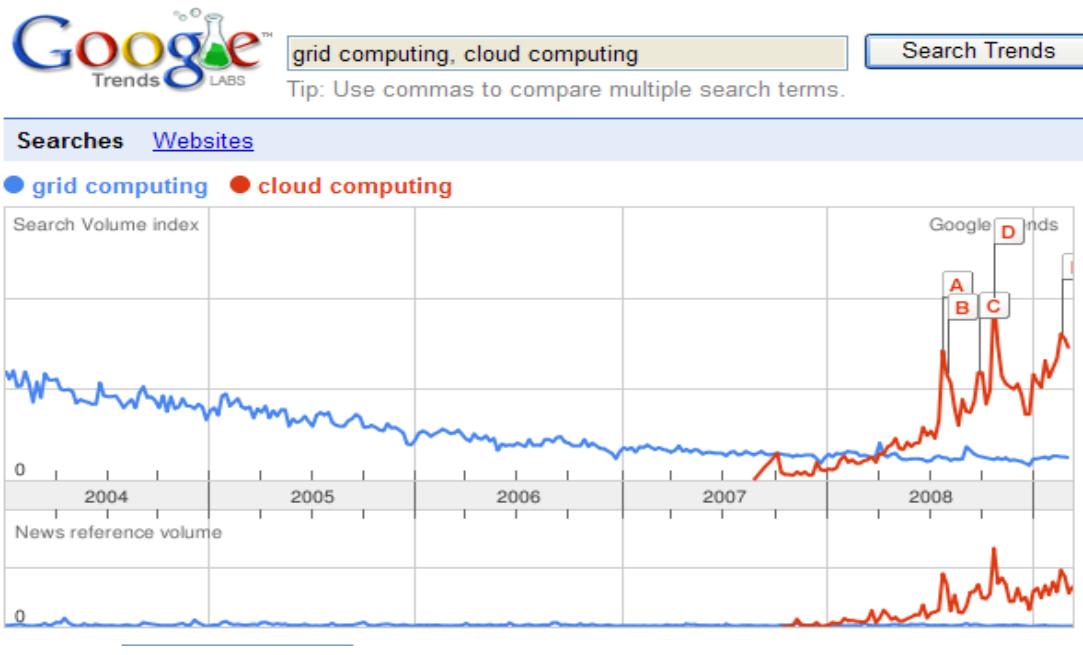
Common ground:

- Web Service and Web Portal access
- Scalability
- Pay per use
- Virtualisation/abstraction
- XaaS

→ Technical enablers:

- WS-Technology: SOAP, REST,...
- Virtualization: VMWare, XEN, Virtual Box,...

# Grid vs. Cloud



- Cloud has replaced Grid in public visibility, but for the last time: Cloud <> Grid V2 !!!
- Foster's Grid Definition "What is the Grid? A Three Point Checklist"
  - Computing resources are not administered centrally
  - Open standards are used
  - Nontrivial quality of service is achieved
- ➔ Big differences in definitions, but unfortunately promises and the metaphor are similar...

# Cloud Computing provides solutions to a variety of challenges and opportunities



## The classical problem

- Under-utilized server resources waste computing power (and energy)
- Over-utilized servers cause interruption or degradation of service levels



## ...today in an Internet setting

- Resource demands are increasingly of highly dynamic nature and Internet-scale
- On-demand resources are a means for faster time-to-market, and cost-effective innovation processes



## ...and tomorrow in the next-gen Web

- Leveraging the Web as a combined technology, business, and people collaboration platform:
  - Making effective use of sophisticated infrastructure which is increasingly available as (Web) services
  - Enabling dynamic (trans-)formation of open service and business networks

# This was our starting point: Cloud TCO (single consumer viewpoint)

**Collect real-world use cases and identify typical scenarios**



**Examine key aspects from business and IT perspective**

#### **business objectives**

- foster innovation
- rapid prototyping
- leverage Web as platform

#### **demand behavior**

- seasonal
- temporary spikes
- unpredictable

#### **IT requirements**

- scalability
- reliable and stable platform
- high availability

**Understand and valuate benefits from cloud computing**

#### **Estimate costs**

- variable costs
- fixed costs
- time to market

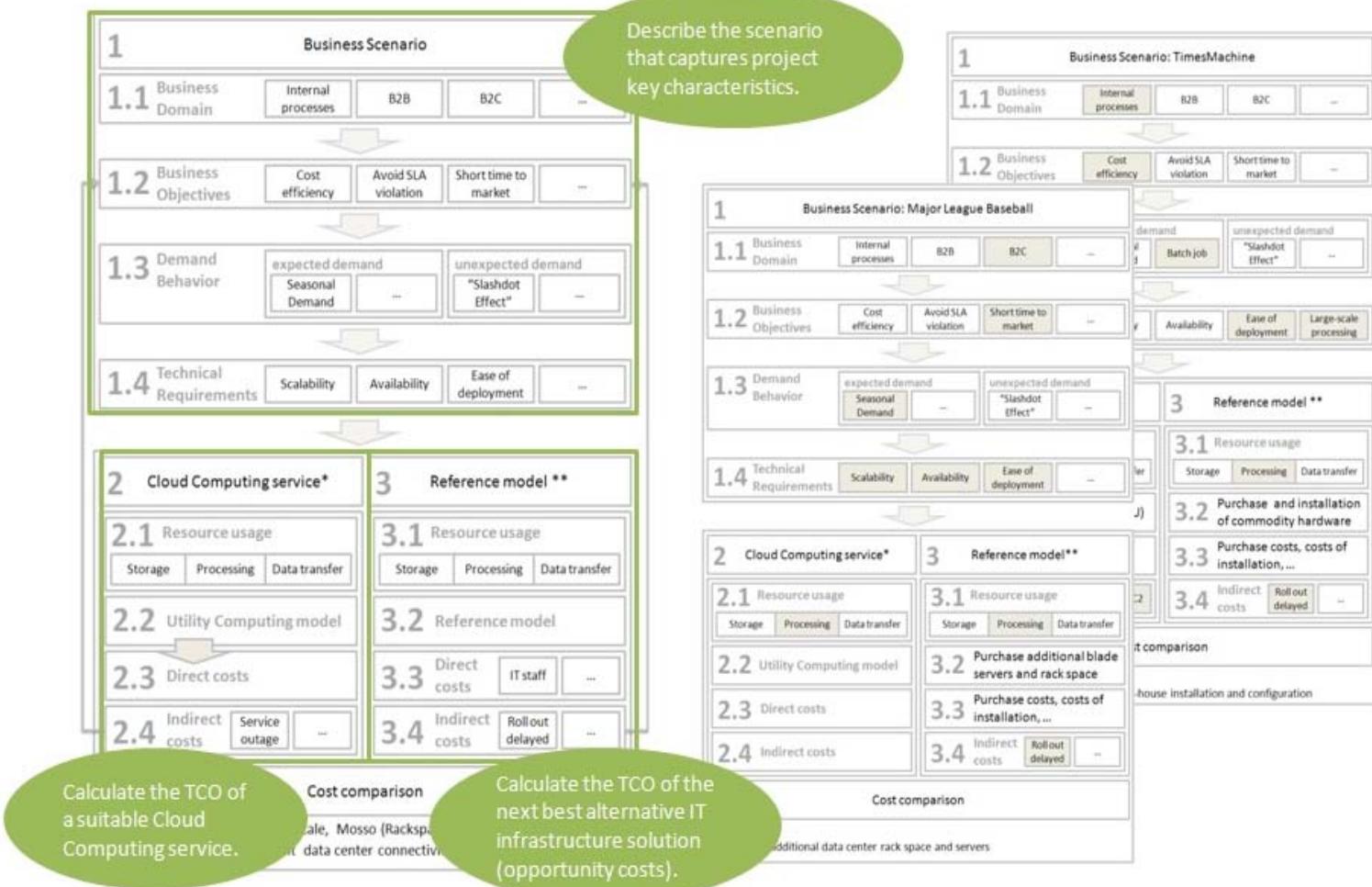
#### **Estimate value**

- Business value
- Economic value

#### **Derive strategies**

- Decision processes
- Recommendations
- Business transformation

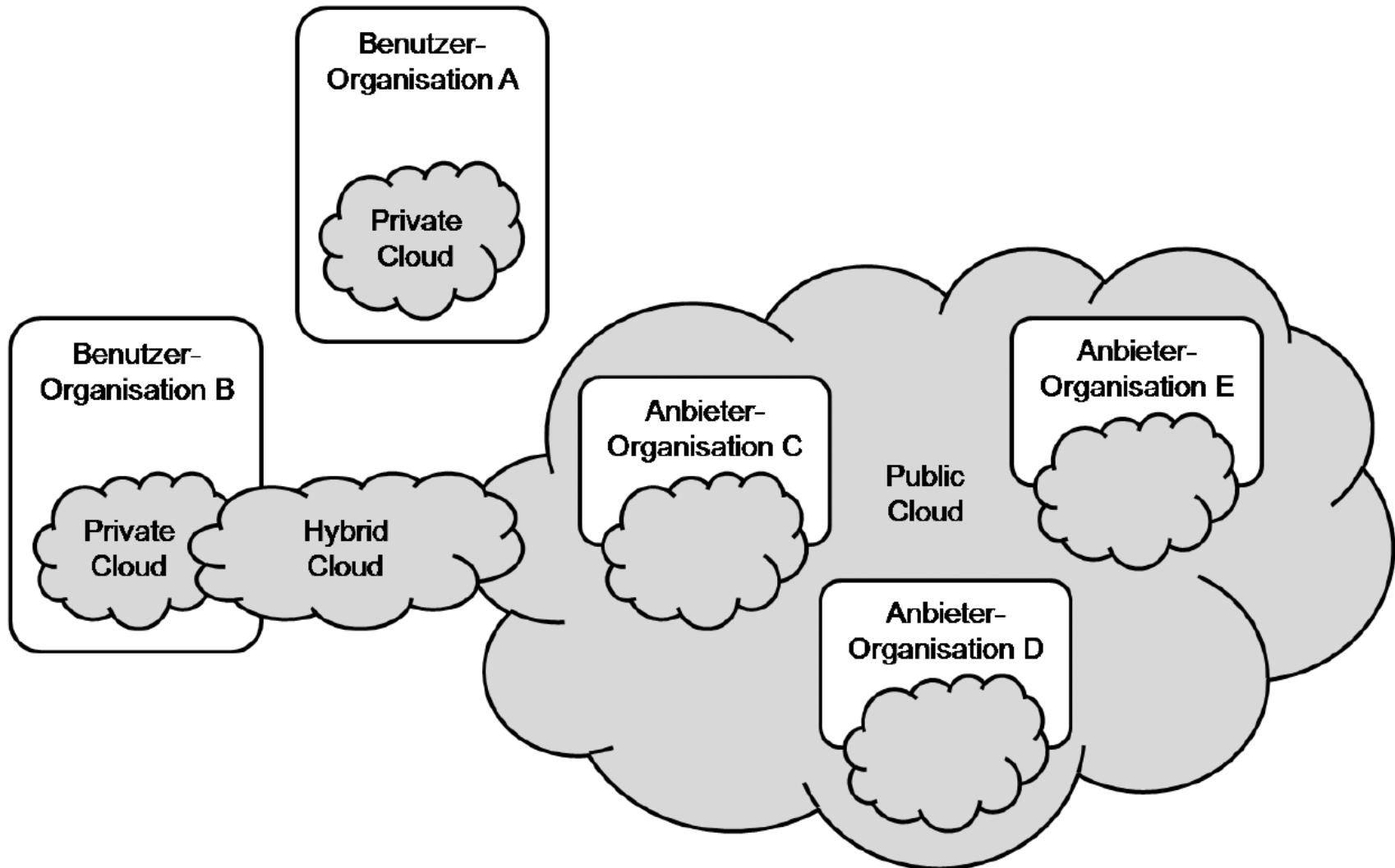
# A Framework for Estimating the Value of Cloud Computing



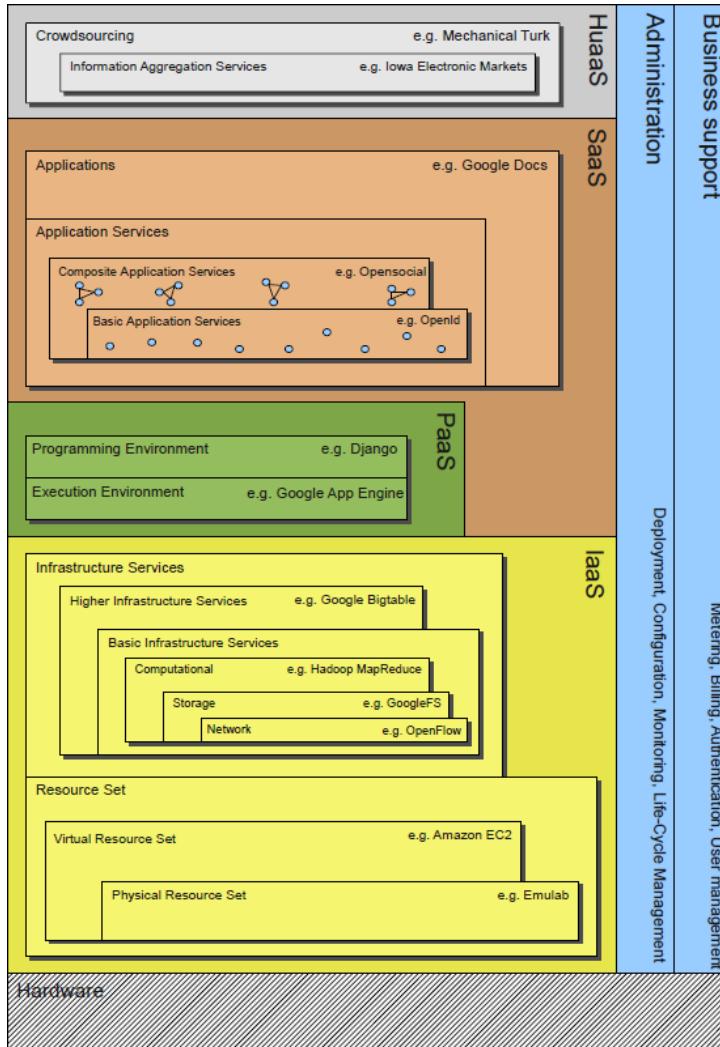
## Agenda – Part 2

- Part 1: What is Cloud Computing?
- Part 2: The Cloud Ecosystem
  - Cloud Architecture
  - Cloud Players
  - Change ahead!
- Part 3: Current research questions and interesting directions

# Organizational Cloud Architecture: Public-/Hybrid-/Private-Cloud

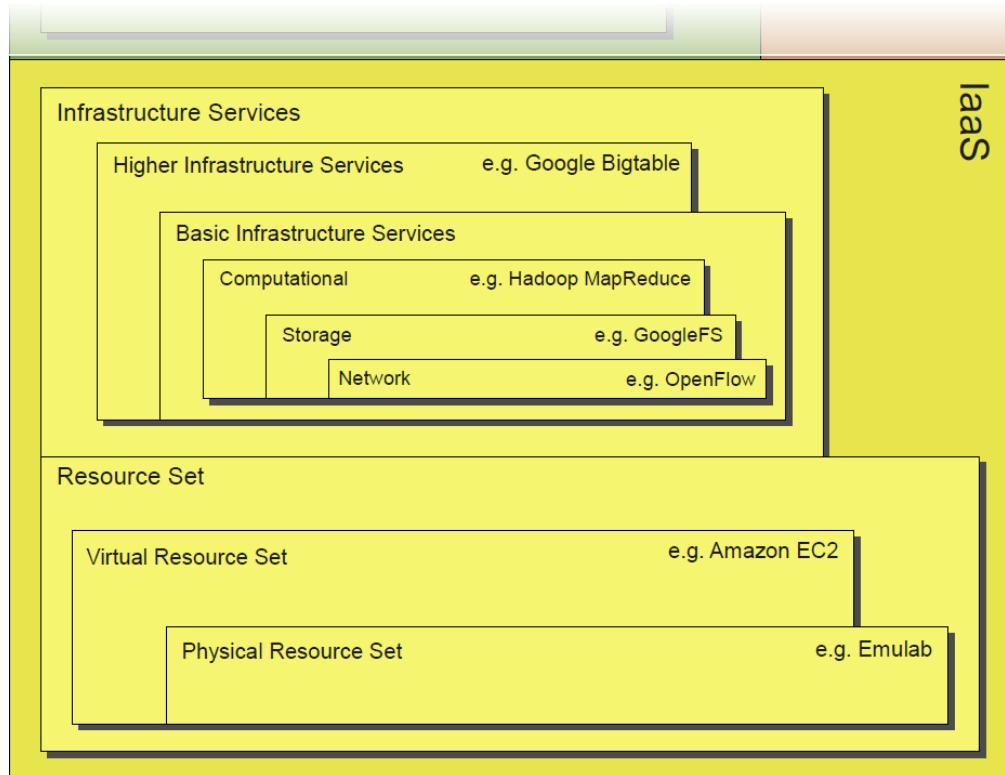


# Technical Cloud Architecture: Cloud Computing Stack



- Generic Approach
- Layered architecture
- Everything as a Service concept
  - Standard layers
    - Infrastructure as a Service
    - Platform as a Service
    - Software as a Service
  - Extra Layers
    - Human as a Service
    - Administration/Business Support

# Infrastructure as a Service



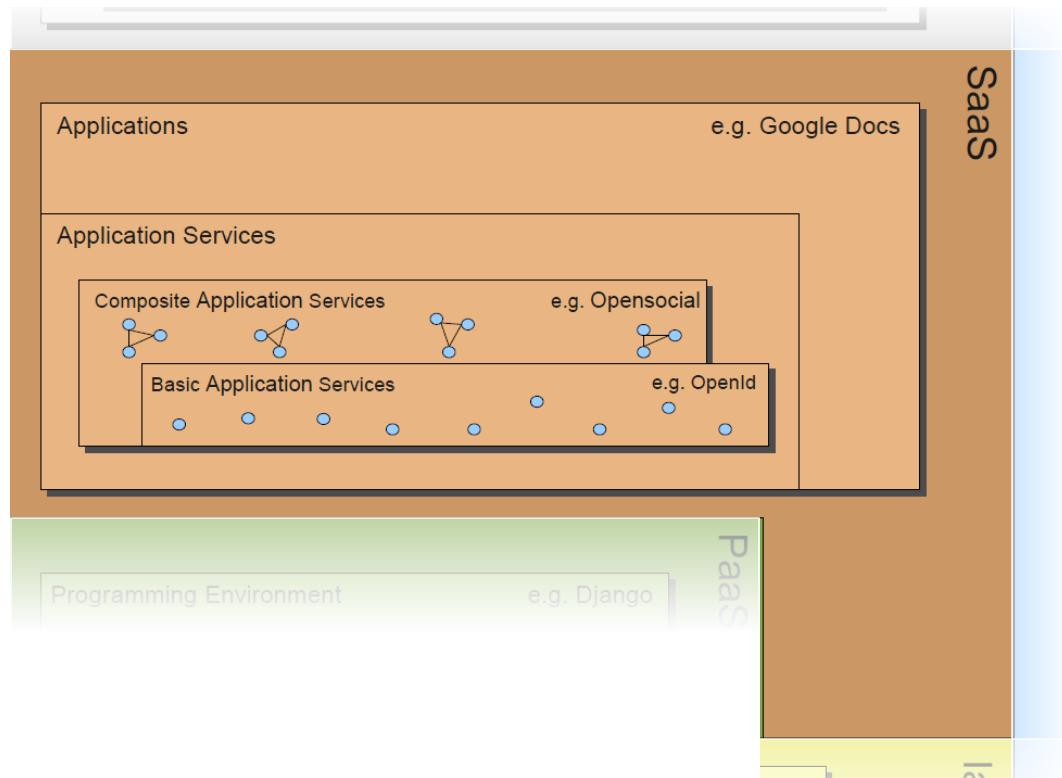
- **Infrastructure Services**
  - Storage
  - Computational
  - Network
  - Database
  - e.g. Google Bigtable, GoogleFS, Hadoop MapReduce, HadoopFS
- **Resource Set**
  - Machine Images
  - e.g. EC2, Eucalyptus

# Platform as a Service



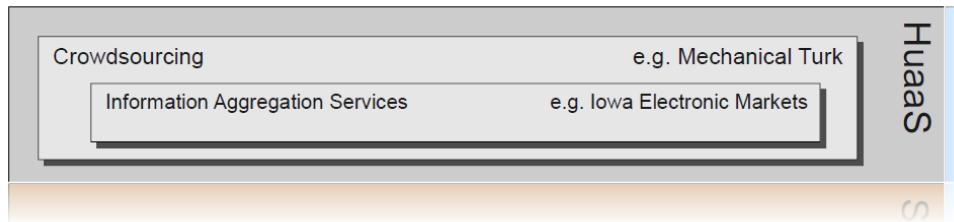
- Programming Environment
  - Programming Language, Libraries
  - e.g. Django, Java
- Execution Environment
  - Runtime Environment
  - e.g. Google App Engine, Java Virtual Machine

# Software as a Service



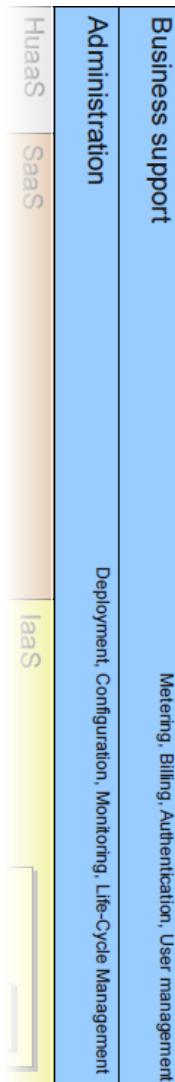
- Applications
  - User Interface
  - Frontend Application
  - e.g. Google Docs, Yahoo Email
  
- Application Services
  - Webservices Interface
  - Basic or Composite
  - e.g. Opensocial, Google Maps

# Human as a Service



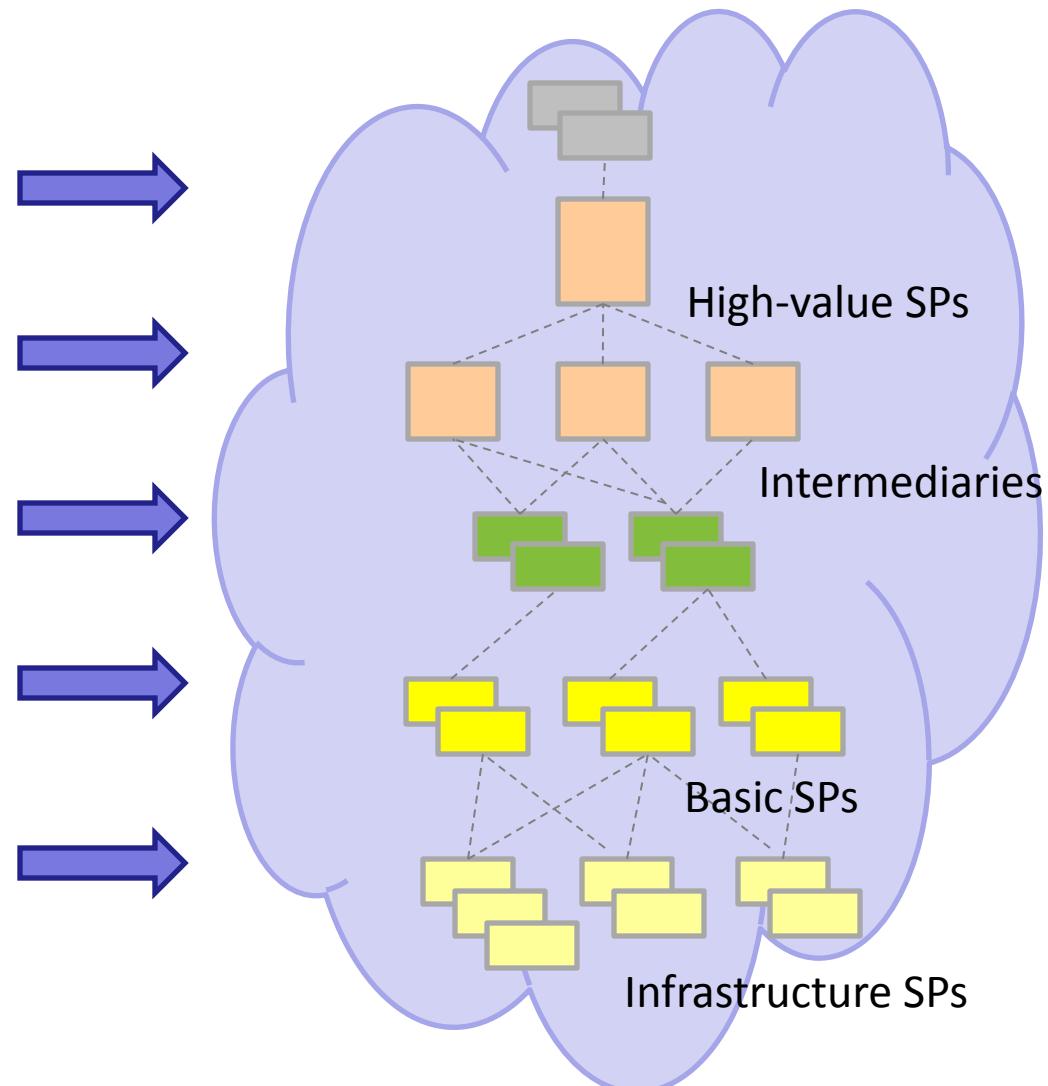
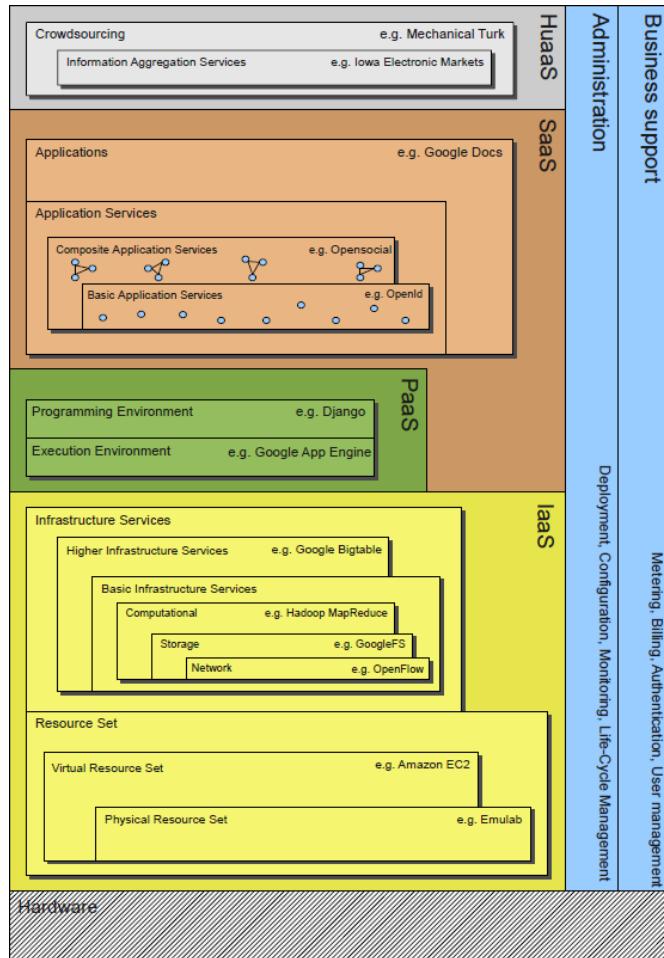
- Crowdsourcing
  - Enabling Collective Intelligence
  - e.g. Mechanical Turk
- Information Markets
  - Prediction of events
  - e.g. Iowa Electronic Markets

# Administration/Business Support



- Available on all layers
- Administration
  - Deployment
  - Configuration
  - Monitoring
  - Life cycle management
- Business support
  - Metering
  - Billing
  - Authentication
  - User management

# Cloud Architecture → Cloud Players



# Players

Cloud **infrastructure service providers** – raw cloud resources  
**IaaS** (infrastructure-as-a-service)

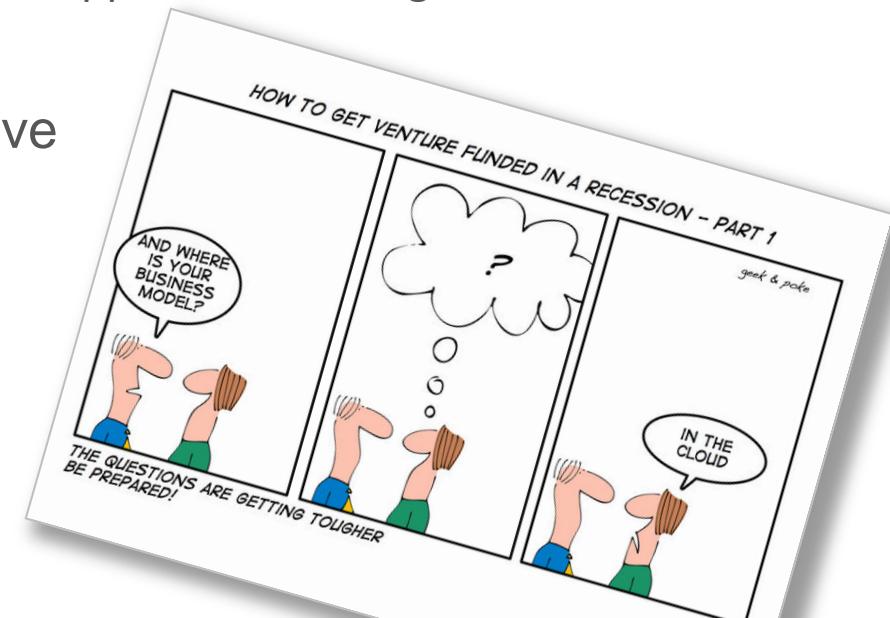
Cloud **platform providers** – resources + frameworks; **PaaS** (platform-as-a-service)

Cloud **intermediaries** – help broker some aspect of raw resources and frameworks, e.g.,

server managers, application assemblers, application hosting

Cloud **application providers** (**SaaS**)

Cloud **consumers** – users of the above



# Players: Providers

Programmatic access via Web Services and/or Web APIs

“Pure” virtualized resources

CPU, memory, storage, and bandwidth

Data store

versus



Virtualized resources plus application framework  
(e.g., RoR, Python, .NET)

Imposes an application and data architecture

Constrains how application is built



**Google App Engine**



# Players: Cloud Intermediaires

Resells (aspects of) raw cloud resources, with added value propositions

- Packaging resources as bundles

- Facilitating cloud resource management,  
e.g., setup, updates, backup, load balancing, etc.

- Providing tools and dashboards

Enabler of the cloud ecosystem



# Players: Application Providers

Software as a Service (SaaS):

Applications provided and consumed over the Web

Infrastructure usage (mostly) hidden



 **Gmail**  
Email with up to 25 GB of storage per custom email address, mail search tools and integrated chat.

 **Google Docs**  
Create, share and collaborate on documents in real-time.

 **Google Calendar**  
Coordinate meetings and company events with sharable calendars.

 **Google Sites**  
One-stop sharing for team information.

 **Google Talk**  
Free text and voice calling around the world.

 **Security and compliance**  
Set email policies and recover deleted messages.

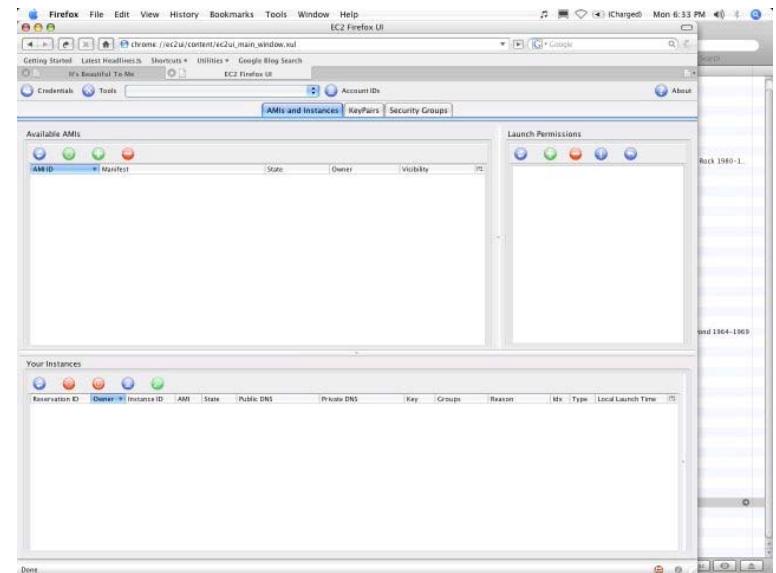
## Amazon AWS Cloud Offerings:

- Amazon Elastic Compute Cloud (Amazon EC2)
- Amazon Simple Storage Service (Amazon S3)
- Amazon Simple Queuing Service (Amazon SQS)
- Amazon SimpleDB
- Amazon Elastic MapReduce
- Amazon CloudFront
- Amazon DevPay
- AWS Import/Export

## Typical Workflow:

- Selection of AMI selection
- Selection of instance size and availability zone
- Generation of Key-pair
- Start of Instance
- Definition of Security Zone / Accessibility
- Persistence of States → EBS
- Generation of individual AMIs

→ E.g. GUI tool support



Typical Workflow:

- Anlegen von Buckets  
`s3cmd mb s3://Bucket`
- Hochladen von Objekten in einen Bucket  
`s3cmd put LokaleDatei s3://Bucket/EntfernteDatei`
- Auslesen von Meta-Daten z.B. Bucketinhalten  
`s3cmd ls s3://Bucket`
- Herunterladen von Objekten aus einem Bucket  
`s3cmd get s3://Bucket/EntfernteDatei LokaleDatei`
- Löschen von Dateien  
`s3cmd del s3://Bucket/EntfernteDatei`
- Löschen von (leeren) Buckets  
`s3cmd rb s3://Bucket`

→ E.g. command line tool support

## Typical Workflow:

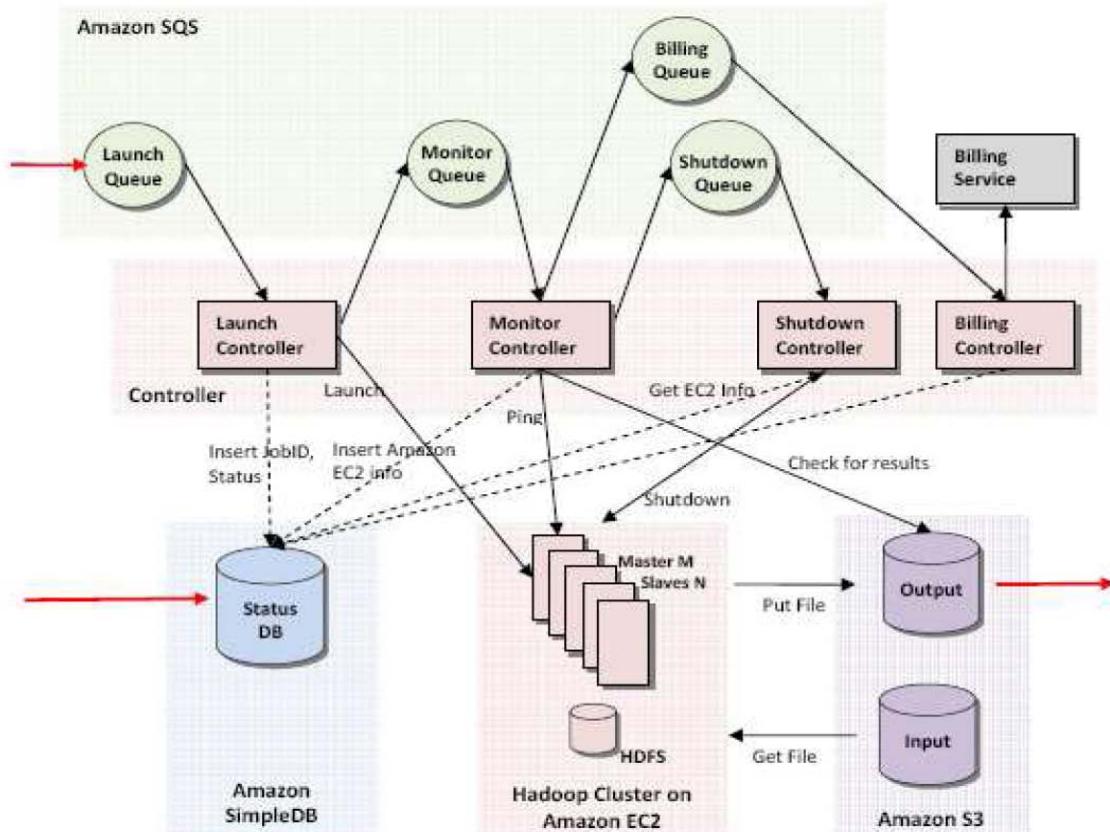
- `CreateQueue`: Anlegen einer Queue im AWSBenutzerkontext
- `ListQueues`: Aufzählung der existierenden Queues
- `DeleteQueue`: Löschen einer Queue
- `SendMessage`: Einstellen einer Nachricht in eine Queue
- `ReceiveMessage`: Auslesen einer (oder mehrerer) Nachrichten aus einer Queue
  
- `ChangeMessageVisibility`: Einstellen weitere Sichtbarkeit gelesener Nachrichten
- `DeleteMessage`: Löschen einer gelesenen Nachricht
- `SetQueueAttributes`: z.B. Zeit zw. zwei Leseoperationen auf dieselbe Nachricht
- `GetQueueAttributes`: z.B. Anzahl der aktuell in der Queue befindlichen Nachrichten
- `AddPermission`: Freigabe von Queues zum geteilten Zugriff verschiedener Benutzer
- `RemovePermission`: Widerrufen der Freigabe für andere Benutzerkontakte

## Typical Workflow:

- CreateDomain, ListDomains, DeleteDomain: Domäne ≈ Relation
- DomainMetadata: Auslesen z.B. von aktuellem Speicherplatzbedarf
- PutAttributes: Hinzufügen oder Aktualisieren eines Datensatzes basierend auf einem Datensatzidentifikator und Attribut/Wert-Paaren
- BatchPutAttributes: Gleichzeitiges Anstoßen mehrerer Einfügeoperationen zur Performance-Erhöhung
- GetAttributes: Lesen eines identifizierten (Teil-)Datensatzes
- DeleteAttributes: Löschen von Datensätzen, Attributen oder Werten
- Select: Anfrage in SQL-ähnlicher Syntax (ohne Joins!)

# Change Ahead!

Caveat: AWS are not 1:1 replacements for traditional IT infrastructure components – they change the way how to build systems!



E.g. GrepTheWeb

# Agenda – Part 3

- Part 1: What is Cloud Computing?
- Part 2: The Cloud Ecosystem
- Part 3: Current research questions and interesting directions
  - In general
  - At IPE
  - „Near“ IPE

# Open Issues in General

Table 1: Quick Preview of Top 10 Obstacles to and Opportunities for Growth of Cloud Computing.

	Obstacle	Opportunity
1	Availability of Service	Use Multiple Cloud Providers; Use Elasticity to Prevent DDOS
2	Data Lock-In	Standardize APIs; Compatible SW to enable Surge Computing
3	Data Confidentiality and Auditability	Deploy Encryption, VLANs, Firewalls; Geographical Data Storage
4	Data Transfer Bottlenecks	FedExing Disks; Data Backup/Archival; Higher BW Switches
5	Performance Unpredictability	Improved VM Support; Flash Memory; Gang Schedule VMs
6	Scalable Storage	Invent Scalable Store
7	Bugs in Large Distributed Systems	Invent Debugger that relies on Distributed VMs
8	Scaling Quickly	Invent Auto-Scaler that relies on ML; Snapshots for Conservation
9	Reputation Fate Sharing	Offer reputation-guarding services like those for email
10	Software Licensing	Pay-for-use licenses; Bulk use sales

→ Reliability, Portability, Security/Trust, Scalability, SLAs, Licenses,...

## Overview

# CC Research Questions@IPE

- And many more activities like:
- Cloud Computing Book and Lecture w. SCC
- Strategic alliance w. U. Stgt & IBM BB
- Mobile Cloud Computing ideas w. 1und1

## Business Cases & Perspectives

Business Cases and Cloud TCO

Research paper: „Do Clouds Compute?“

Project ICE (T-Labs): CC business cases for T-Com

Cloud Computing Adoption

MTh & IBM GBS: CC Maturity Model w. online tool

Cloud Value Creation

Cloud offering value creation esp. for intermediaries

Architecture of „the Cloud“

Research paper: „What's inside the Cloud?“

Cloud Engineering

Project ICE (T-Labs): Dev. support for IntraCloud-Patterns

Cloud Application Development

MTh (OpenCirrus/HP): „Cloudification“ of apps

Cloud service composition, Cloud application arch.

SAP Landscape Provisioning

MThs & Project Proposal (ZIM fluidOps): Reliability of VPDC

SAP Cloud-Demo

Project (SAP CEC): SLA mgmt for complex systems

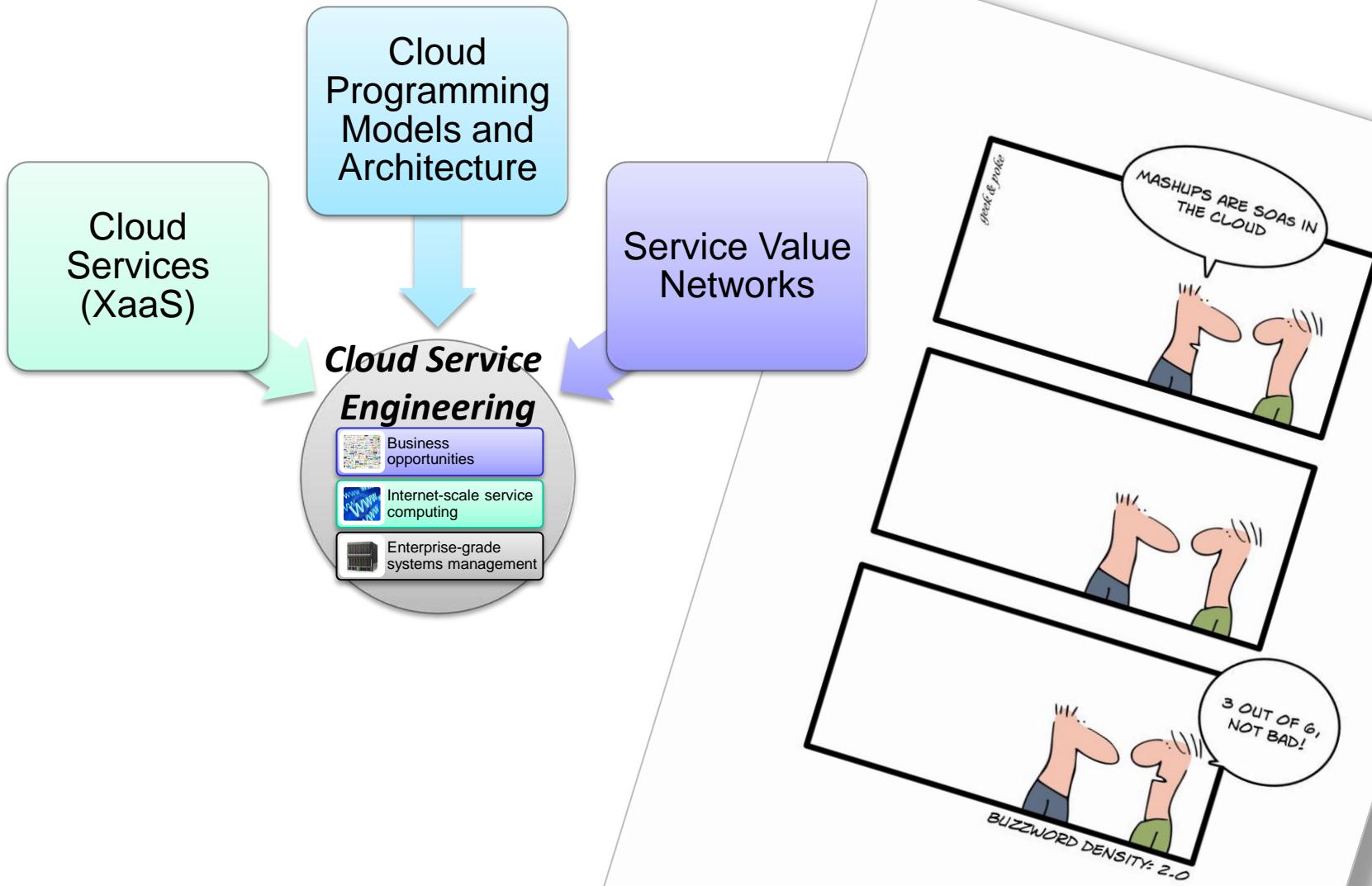
„The Cloud“

Cloud Ecosystem

Cloud  
Engineering

Cloud Management & Provisioning

# Condensed Topics at [www.eOrganization.de](http://www.eOrganization.de) Cloud Service Engineering



# OpenCirrus™ Cloud Computing Research Testbed



- 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!
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  - Members: System and application development
- Great opportunity for cloud R&D

<http://opencirrus.org>



# More information:

<http://cloudwiki.fzi.de>

navigation

- Main Page
- News
- Hot Trends
- Learning
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Main Page

Welcome to FZI Cloud Wiki

**Introduction to Cloud Computing**

"Building on compute and storage virtualization, and leveraging the modern Web, cloud computing provides scalable, network-centric, abstracted IT infrastructure as on-demand services that are billed by consumption."

[Overview](#) | [Learning material](#) | [Hot Trends in Cloud Computing](#) | [CloudyTimes Blog](#)

**Cloud Computing Research Focus: Business Engineering**

Cloud computing is widely perceived as a disruptive technology that is about to change the fundamentals of ICT business. Within the scope of our research activities we want to understand the cloud ecosystem and its players, evaluate the benefit that this emerging technology provides and discuss the strategic implications. Doing so, we are going to present a structured framework on how to approach a TCO calculation in order to compare cloud computing services to alternative ICT solutions.

[Cloud TCO calculation and comparison](#) | [Key players and the cloud ecosystem](#) | [Cloud computing use cases and typical scenarios](#)

**Cloud Computing Research Focus: Service Technology**

Cloud computing is an exciting technology that offers new ways to design and program ICT services. Our research activities concentrate on cloud programming models, frameworks and middleware as well as engineering cloud applications.

In the news

- Hypertable
- Opera Unite
- I.B.M. to Help Clients Fight Cost and Complexity
- The Dawn of Maneuver Warfare in IT Security
- New York Times: Data Center Overload
- Google Wave Federation Protocol
- Annelidous ? Virtual Infrastructure Management Framework
- Drizzle ? A Lightweight SQL Database for Cloud and Web
- McKinsey Report: Clearing the Air on Cloud Computing
- Amazons Bl-on-the-fly using MapReduce-as-a-service brings huge cloud data crunching to the masses
- Amazon Elastic Map Reduce
- Envisioning the Cloud (marketspace)
- AppScale Overlay for Eucalyptus
- AWS Toolkit for Eclipse available
- Google App Engine Lets Your Web
- Berkeley Releases Cloud Computin
- Processor Value Unit [PVI] licensin
- IBM partners with AWS
- Cloud Computing: Forscher haben r
- iPhone Console for EC2
- Small Web Hosts Turning to Mini Cl
- Combining Clouds: Appirios ReferM
- Facebook To Salesforce
- Cloud Computing Ontology
- Bringing IT to Underserved Markets
- A maturity model for cloud computi



## Cloudy Times

Random Thoughts of Markus Klems

**Opera Unite**  
June 16, 2009 by Markus Klems



Opera 10 introduces a technology called [Opera Unite](#), that extends your browser to become a Web server. The idea is to enable non-technical people to serve and share content and services from their local computer, such as file sharing, chat rooms, Web hosting, remote access to music files, etc.

In a way, Opera Unite is an opposite trend to Cloud Computing where content is distributed and services are provided from large-scale data centers under the administrative domain of single providers, such as Amazon or Google. Instead, Opera Unite is a technology that throws ideas known in P2P and Grid Computing where hybrid user/provider models are common.

I have been a big Opera fan ever since due to the browser's incredible speed (much faster and less resource-hungry than Firefox, at least on my system). Opera Unite could be the game changer that [Opera needs to compete with IE and Firefox](#).

Pages

- About
- Cloud Classification
- CloudDebug
- Internal Cloud

Top Posts

- Cloud Classification
- Cloud vs. Grid
- Mozilla's Jingle/Disk helps you manage your research sources
- OpenSocial Applications in the Cloud
- Google Datastore API

Blogroll

- Giles Bowkett
- Ian Foster
- Kent Langley
- Kevin L Jackson
- Patrick Chamezon
- Rails Env
- Randy Bias
- Refresh the Net
- Tom White
- Werner Vogels

search this site

- See also <http://markusklems.wordpress.com/>
- and soon the new ICE-Cloud-Feed

36

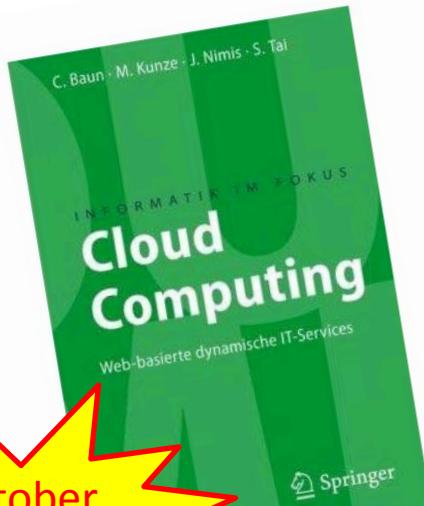
# And more Information (in German):

<http://tinyurl.com/CloudBuch>



Christian Baun, Marcel Kunze,  
Jens Nimis, Stefan Tai:

Cloud Computing: Web-basierte  
dynamische IT-Services  
(Reihe: Informatik Im Fokus)



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**Cloud Computing**  
Web-basierte dynamische IT-Services  
Reihe: Informatik im Fokus  
Baun, C., Kunze, M., Nimis, J., Tai, S.  
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Über dieses Lehrbuch | Inhaltsverzeichnis

### Über dieses Lehrbuch

- Erstes deutschsprachiges Buch zum Thema
- Liefert eine standardisierende Erklärung der oft unterschiedlich verwendeten Begriffe

Cloud Computing erlaubt die Bereitstellung und Nutzung von IT-Infrastruktur, von Plattformen und von Anwendungen aller Art als im Web elektronisch verfügbare Dienste. Cloud Computing folgt dabei den Ideen des Utility Computing, dh. es wird immer die aktuell benötigte Menge an Ressourcen zur Verfügung gestellt und abgerechnet. Dieses Buch will einen Überblick über Cloud Computing Architektur, Anwendungen und Entwicklung vermitteln. Ziel ist es, die Leserinnen und Leser auf einen einheitlichen Stand zu bringen und so eine gemeinsame Diskussionsgrundlage zu erreichen. Technische Vorkenntnisse sind nicht erforderlich.

Geschrieben für:  
Studierende, Wissenschaftler und Praktiker im Bereich Informatik

Schlagworte:

- Cloud Computing
- Distributed Computing
- IT Service Management
- Service-oriented Computing
- Verteiltes Rechnen

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