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Cloud computing: Impact on software engineering research and practice

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Overview

- Presentation's main message
 - **Sobriety:** Cloud computing is a continuation of distributed models of software development and delivery
 - **Opportunities:** Cloud computing offers new possibilities for software engineering researchers to study multilateral software development
- Outline
 - Part I: Interpretation of the lecture topic
 - Part II: Getting to grips with cloud computing
 - Part III: Implications of cloud computing on software engineering research and practice



Part I: Interpretation of the lecture topic

Outline

- Part I: Interpretation of the lecture topic
 - Defining cloud computing
 - Cloud computing in the software engineering literature
 - The impact debate
 - Interpretation of the topic
- Part II: Getting to grips with cloud computing
- Part III: Implications of cloud computing on software engineering research and practice

Defining cloud computing

"A new paradigm"

"An overall confusing technological picture"

"Simply a hype and a buzzword"

Cloud computing in software engineering

Type	Title	2007	2008	2009
Research journals	IEEE Software	0	0	1
	IEEE Transactions on Software Engineering	0	0	0
	Transactions on Software Engineering Methods	0	0	0
	Journal of Systems and Software	0	0	2
	Information Software and Technology	0	0	0
	Software Practice and Experience	0	0	0
Confer.	Int. Conference on Software Engineering	0	0	9
	Int. Conf. on Software Maintenance	0	0	0
	Int. Symp. on Empirical Software Engineering	0	0	0
Mags	Communications of the ACM	0	3	14
	Computer	0	3	8

*Results from queries with the string "cloud computing" in full paper text

Debating impact



?



Interpretation of the topic

- What is cloud computing?
- What could the impact of cloud computing be on software engineering research and practice?

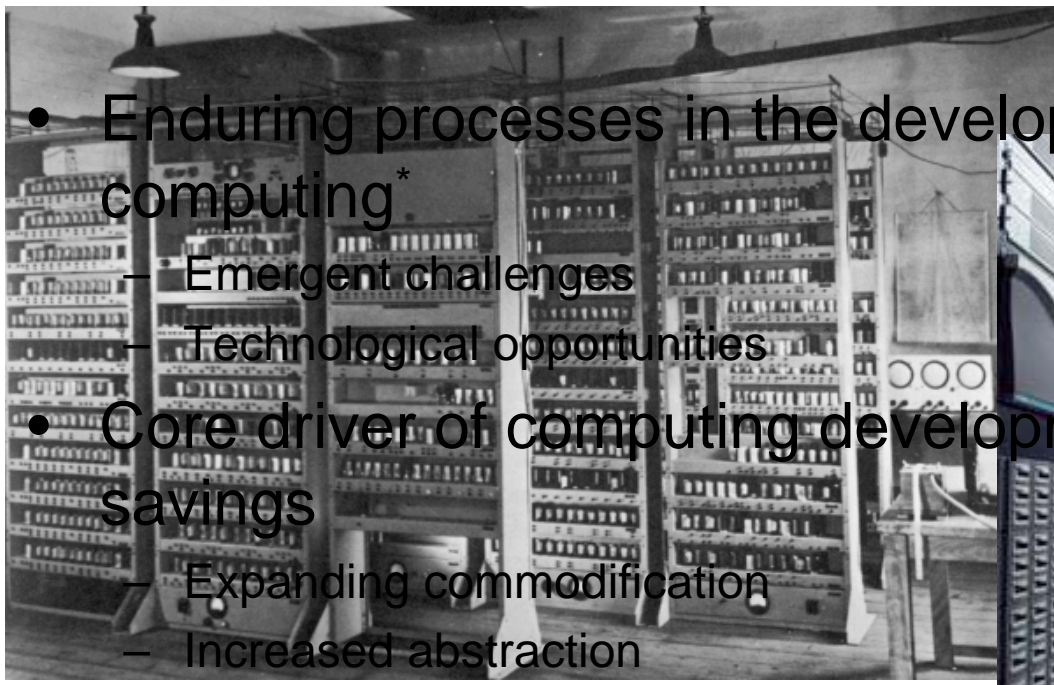


Part II: Getting to grips with cloud computing

Outline

- Part I: Interpretation of the lecture topic
- Part II: Getting to grips with cloud computing
 - Historical development of cloud computing
 - Promises of cloud computing
 - Cloud computing models
 - Cloud computing compared
- Part III: Implications of cloud computing on software engineering research and practice

From mainframes to clouds

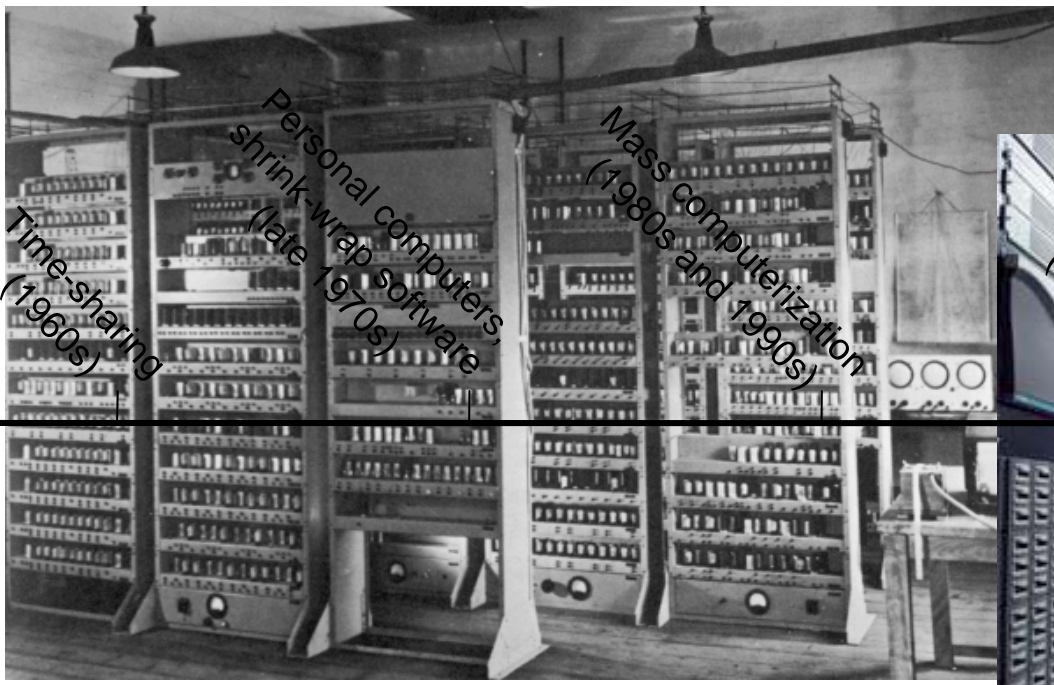


- Enduring processes in the development of computing*
 - Emergent challenges
 - Technological opportunities
- Core driver of computing development: Realizing cost savings
 - Expanding commodification
 - Increased abstraction



* Interpretive framework draws on Friedman and Cornford (1989)

Expanding commodification



Time-sharing
(1960s)

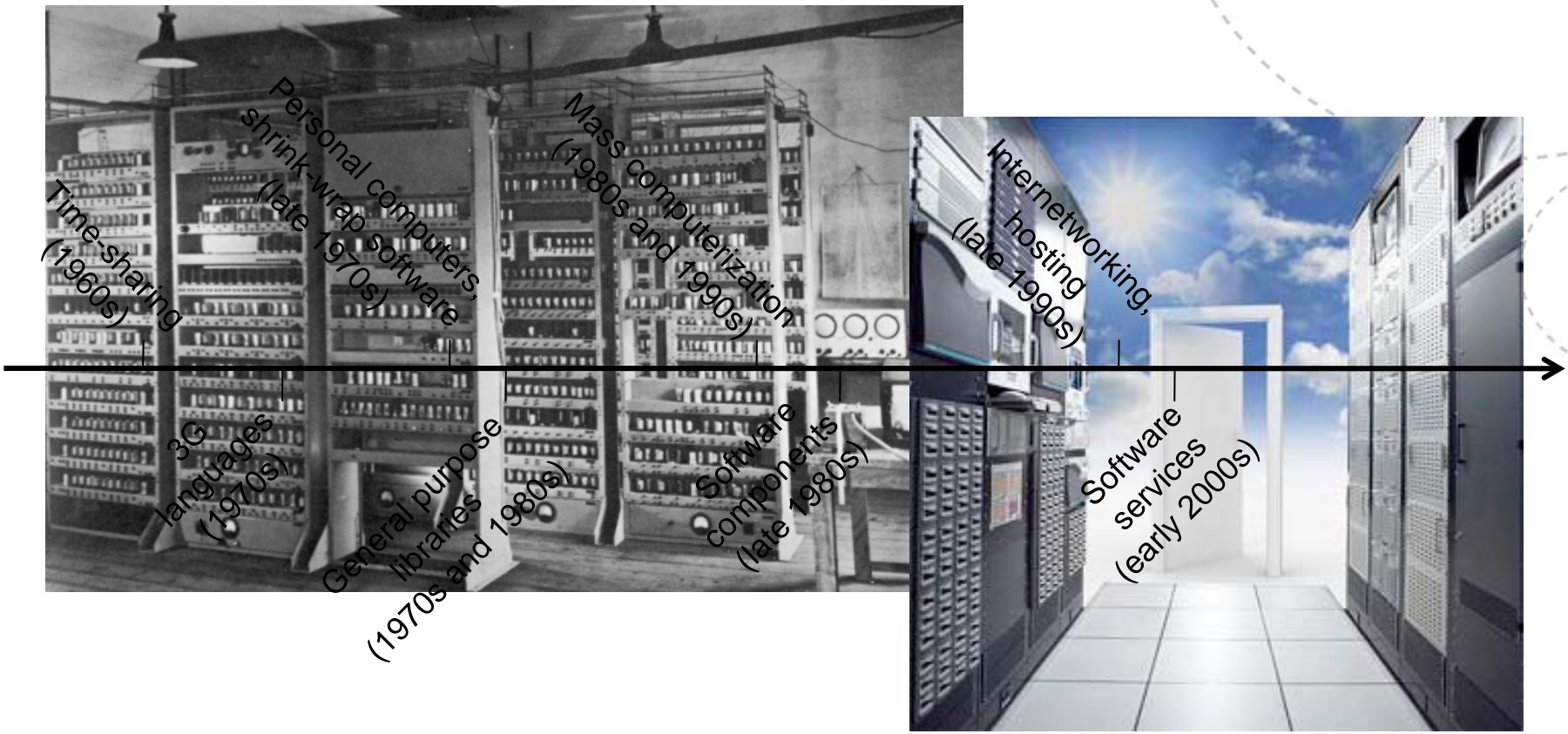
Personal computers,
shrink-wrap software
(late 1970s)

Mass computerization
(1980s and 1990s)

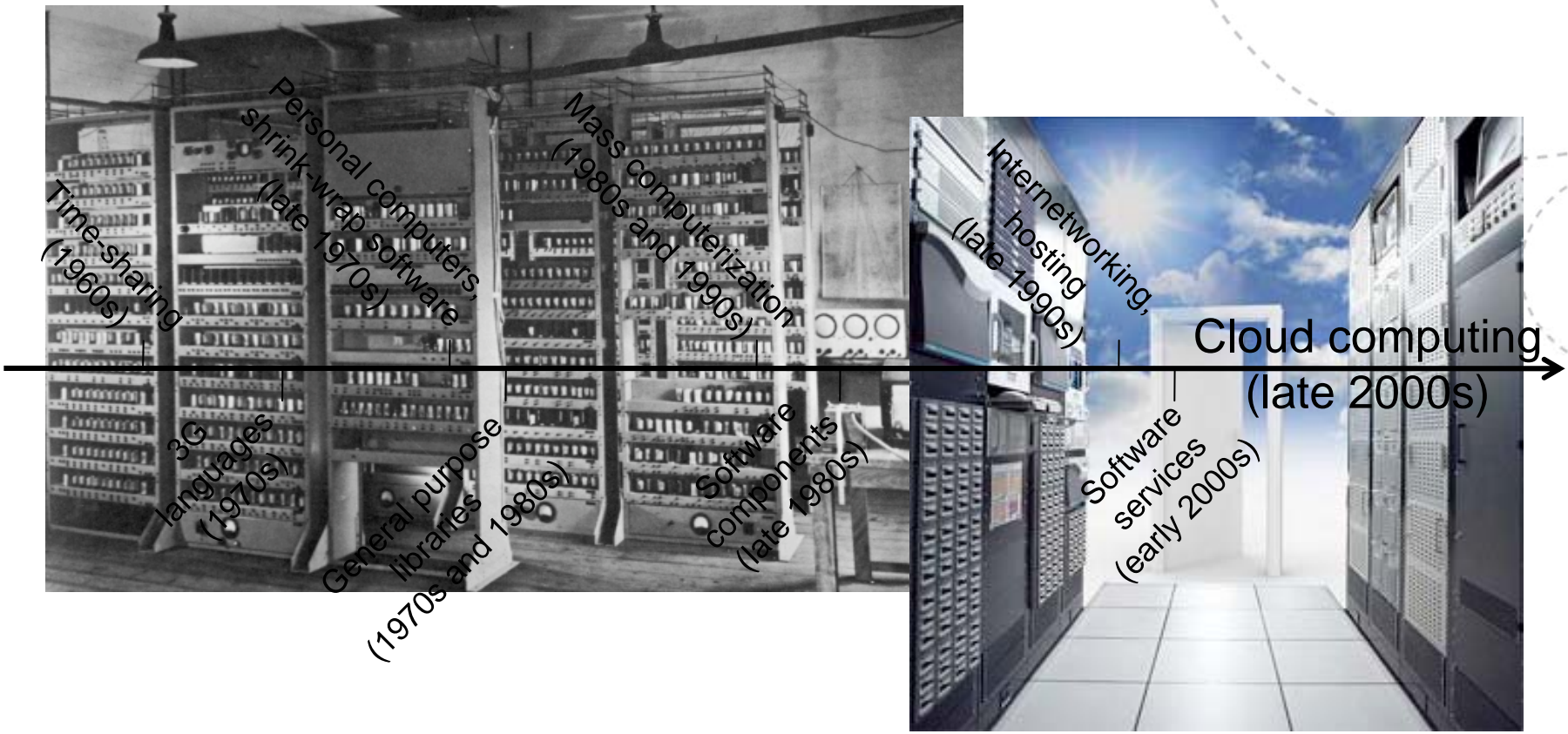


Internetworking,
hosting
(late 1990s)

Increasing abstraction



Convergence into clouds

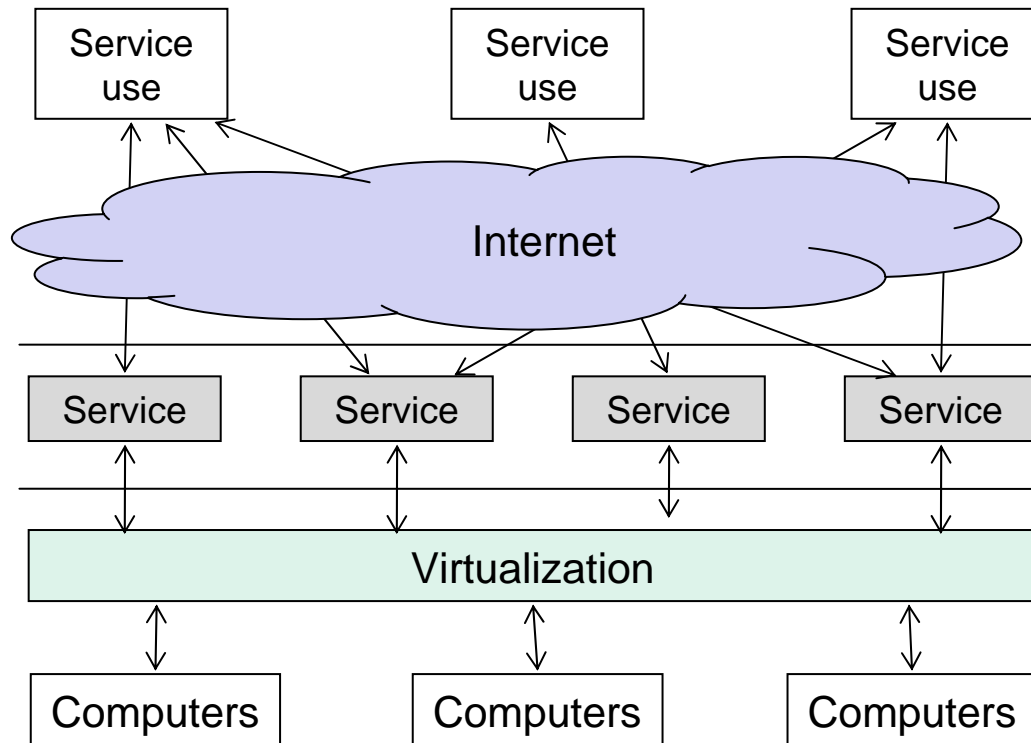


Promises of cloud computing

- Three promises for cost savings
 - Reduced costs of operations and delivery
 - Effective utilization of computing resources
 - Reduced development costs
- Realizing the promised cost savings
 - Models for software delivery
 - Distributed hardware resources

Conceptual level model for cloud computing

Layers



Stakeholders

Cloud service user

Cloud service provider

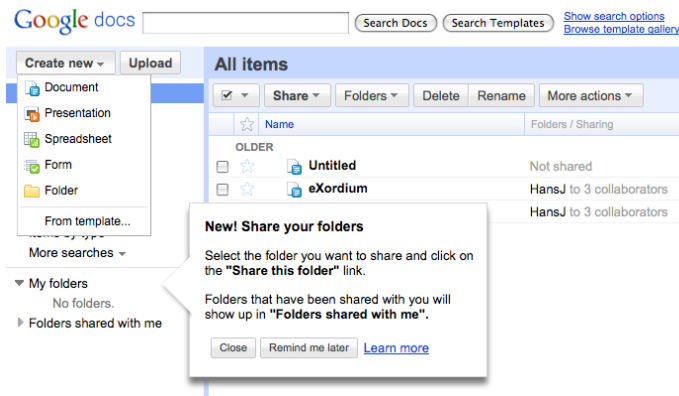
Infrastructure provider

Three models for separating ownership from use

Model	Cloud service user	Cloud service provider	Example
Software-as-a-service	End-user	Turnkey application	Google Docs
	Software developer	Web service	Amazon S3
Platform-as-a-service	Software developer	Application development and deployment platform	Force.com
Infrastructure-as-a-service	End-user organization	Computing infrastructure	ElasticHost

End-user Software-as-a-Service

- **Cloud service user:** End user (organization)
- **Cloud service provider:** Turnkey software application
- **Promises**
 - Subscription fee replaces cost of operations and delivery
 - Utilization of computing resources through pay-per-use model



Software-as-a-Service

Amazon Simple Storage Service (Amazon S3)

Amazon S3 is storage for the Internet. It is designed to make web-scale computing easier for developers.

Amazon S3 provides a simple web services interface that can be used to store and retrieve any amount of data, at any time, from anywhere on the web. It gives any developer access to the same highly scalable, reliable, fast, inexpensive data storage infrastructure that Amazon uses to run its own global network of web sites. The service aims to maximize benefits of scale and to pass those benefits on to developers.

Sign Up For Amazon S3

This page contains the following categories of information. Click to jump down:

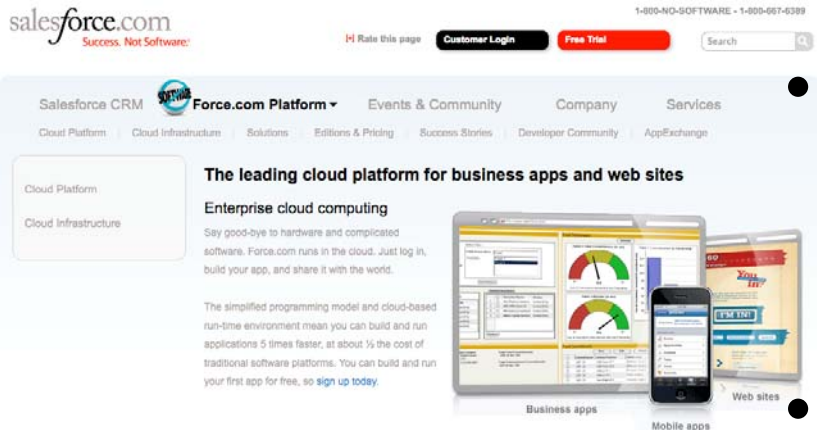
- Amazon S3 Functionality
- Amazon S3 Design Requirements
- Pricing
- Amazon S3 Design Principles
- Transferring Large Amounts of Data
- Intended Usage and Restrictions
- Resources

- **Cloud service user:**
Software developer
(organization)
- **Cloud service provider:**
Reusable software services
- **Promises**
 - Reduced development time through use of high-level service
 - Maximum utilization of resources: pay for what you use
 - Reduced operations costs

Platform-as-a-Service

- **Cloud service user:**
Software development organizations
- **Cloud service provider:**
Virtual platform for application development and deployment
- **Promises**

- Reducing cost of operations and delivery
- Increased development productivity



The screenshot shows the Salesforce.com website. At the top left is the Salesforce logo with the tagline "Success. Not Software.". To the right, there is a phone number "1-800-NO-SOFTWARE - 1-800-067-6399" and a search bar. Below the header, there are navigation links for "Salesforce CRM", "Force.com Platform", "Events & Community", "Company", and "Services". Under "Force.com Platform", there are sub-links for "Cloud Platform", "Cloud Infrastructure", "Solutions", "Editions & Pricing", "Success Stories", "Developer Community", and "AppExchange". The main content area features a heading "The leading cloud platform for business apps and web sites" and a sub-heading "Enterprise cloud computing". Below this, there is a paragraph: "Say good-bye to hardware and complicated software. Force.com runs in the cloud. Just log in, build your app, and share it with the world." Another paragraph follows: "The simplified programming model and cloud-based run-time environment mean you can build and run applications 5 times faster, at about 1/3 the cost of traditional software platforms. You can build and run your first app for free, so [sign up today](#)." To the right of the text is an image showing a desktop monitor displaying a dashboard with charts and gauges, a smartphone, and a tablet. Labels "Business apps", "Mobile apps", and "Web sites" are placed below the respective devices.

Infrastructure-as-a-Service

ElasticHosts
Flexible servers in the cloud

Free hosting trial

Products Why us About us Blog My account

Buy cloud hosting from ElasticHosts

- Create servers instantly
- Resize capacity immediately
- Run any PC operating system and software
- Control via the web or by API
- Buy on-demand capacity by the hour

Free Hosting Trial
Prices from \$10/hour or £20/month
5 day free trial on the system

Watch video demo

elastic@elastichosts.com
(0845) 688-8842

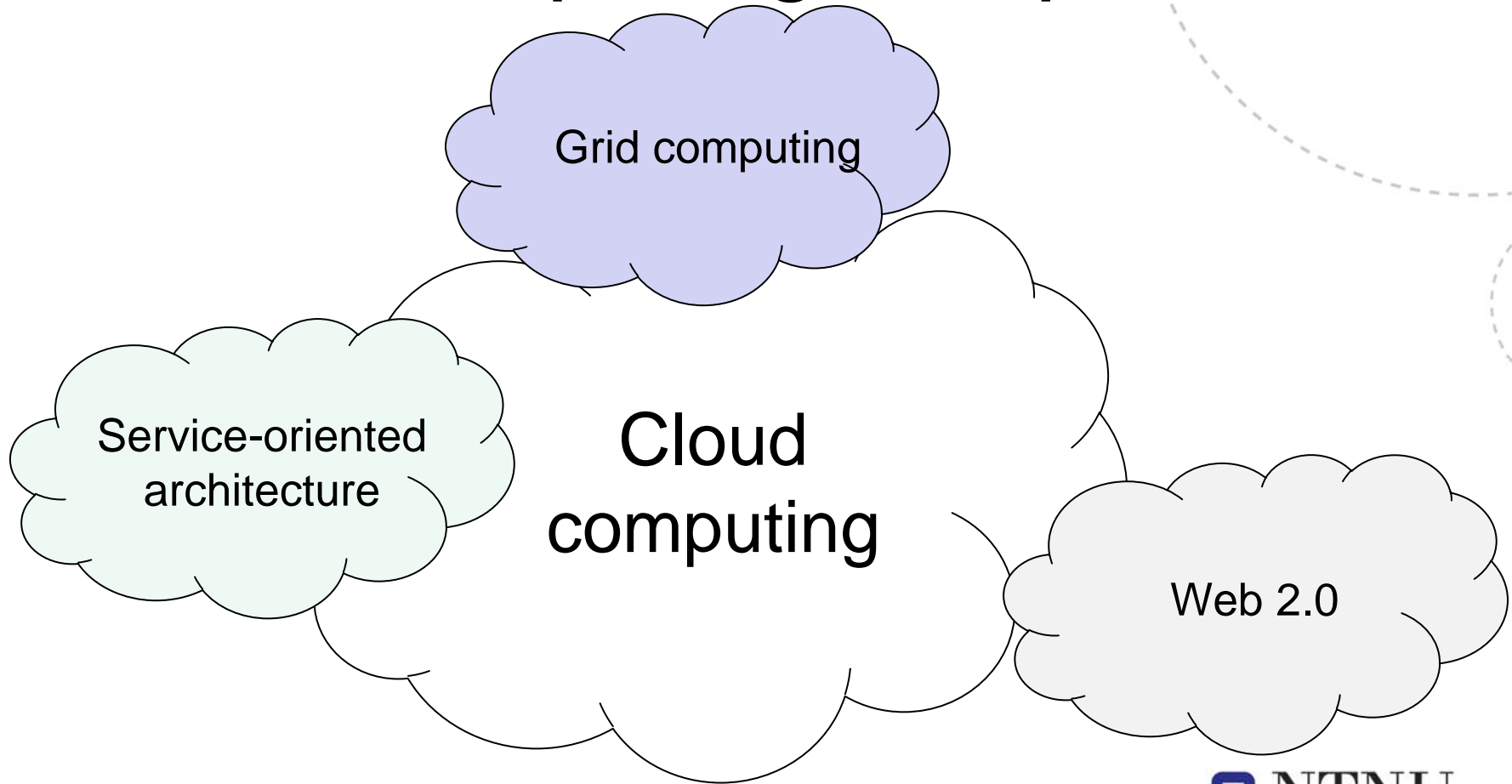
Cloud hosting that's easy to use
when you need scalable, flexible capacity on demand
from 4p/hour or £29/month

Competitive prices
buy exactly the capacity you need, when you need it, by the hour or by monthly subscription.

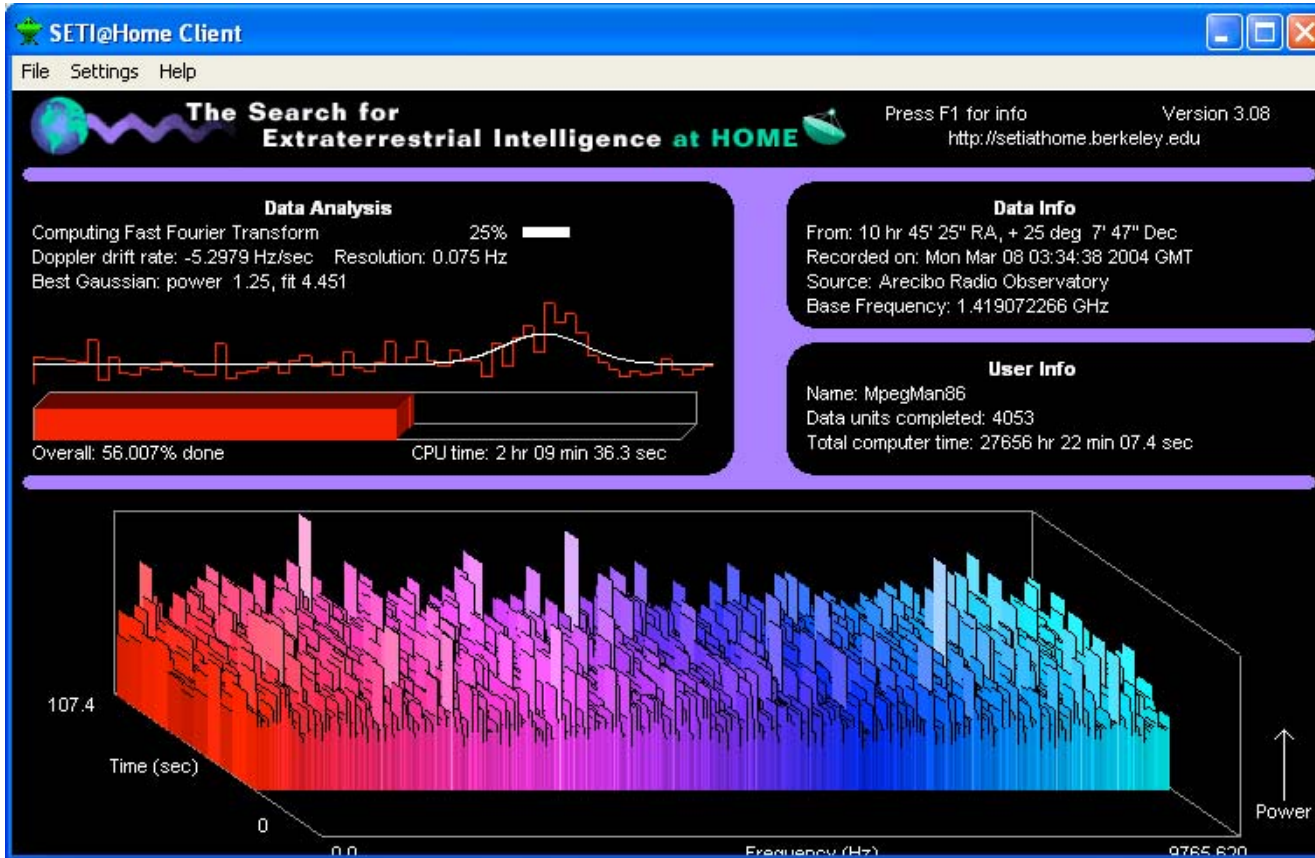
Customer testimonials
"I found ElasticHosts and I realised that I would be able to add a lot of flexibility for no extra cost. I now have quite a few servers with ElasticHosts. We can buy exactly the capacity that we need today and then scale it when we need more, which is a huge benefit and saves a lot of money!"
Andrew Fair, Triana eCommerce Ltd

- **Cloud service user:**
Computing organization
- **Cloud service provider:**
Offers scalable virtual machines
- **Promises**
 - Utilization of computing resources
 - Reduced costs of operations (of hardware)

Cloud computing compared



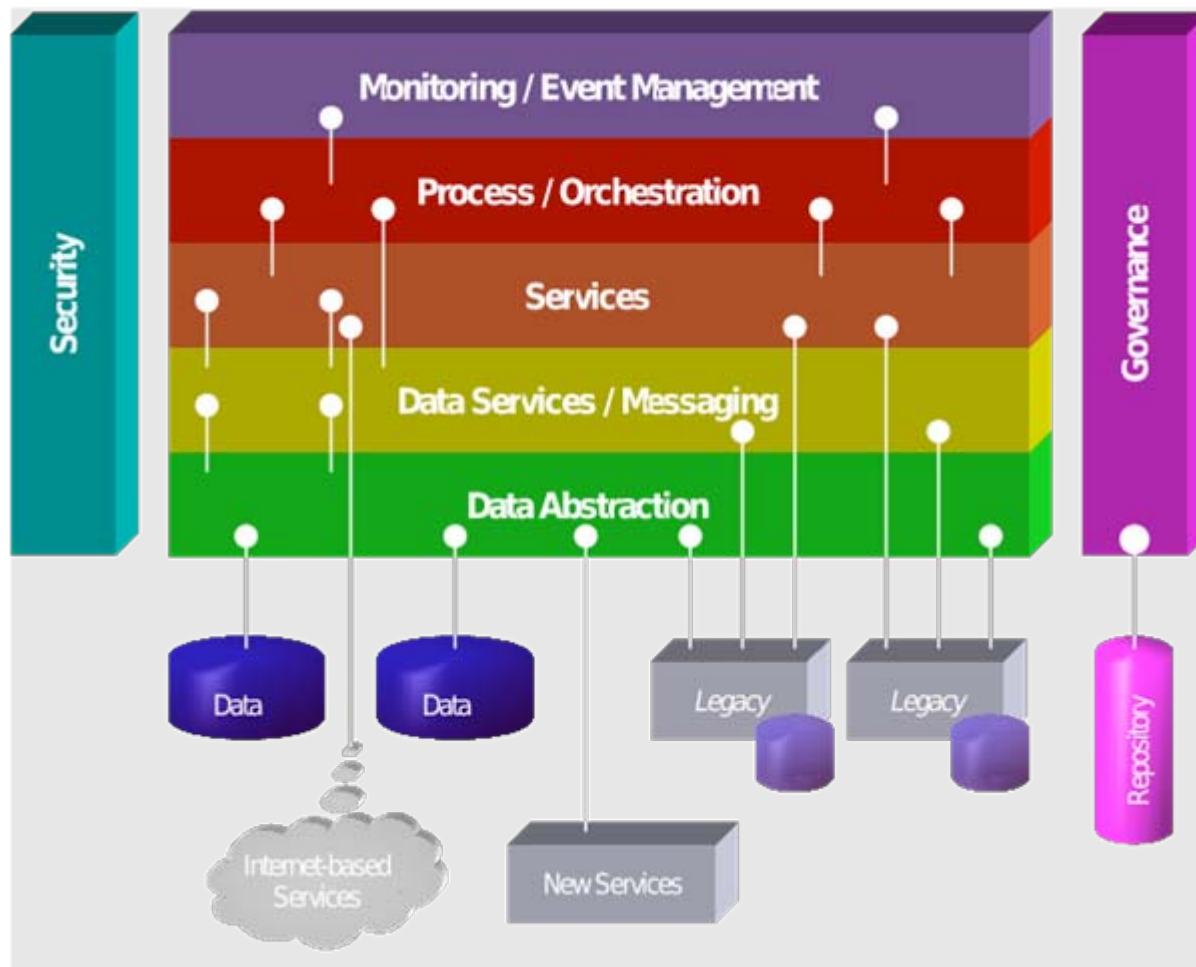
Grid computing



Grid vs. cloud computing

- Similarities
 - Deliver computing power through distributed networks of computers
- Differences
 - Grids typically batch-oriented
 - Cloud computing business flows and functionality
- Proposed convergence of the two

Service-oriented architecture



Services in clouds vs. SOA

- Similarities
 - Most similar to software-as-a-service model
 - Emphasizes services over products
 - Web services seem the best current technology for realizing both
- Differences
 - Cloud computing specifically over the Internet
 - SOA also intranet within single or among several organizations
 - Cloud computing mainly for developing new applications
 - Legacy applications important for SOA

Web 2.0

Google docs [Show search options](#)
[Browse template gallery](#)

Create new ▾ Upload

- Document
- Presentation
- Spreadsheet
- Form
- Folder
- From template...

More searches ▾

- My folders
 - No folders.
- Folders shared with me

All items

▾ ▾ ▾ ▾

<input type="checkbox"/>	<input type="checkbox"/>	Name	Folders / Sharing
OLDER			
<input type="checkbox"/>	<input type="checkbox"/>	Untitled	Not shared
<input type="checkbox"/>	<input type="checkbox"/>	eXordium	HansJ to 3 collaborators
			HansJ to 3 collaborators

New! Share your folders

Select the folder you want to share and click on the **"Share this folder"** link.

Folders that have been shared with you will show up in **"Folders shared with me"**.

[Learn more](#)

Web 2.0 in the clouds

- Focus on interactive web applications
- Overlaps with end-user oriented software-as-a-service
- Software-as-service enabling for rapid development of Web 2.0 applications

Summary

- Cloud computing: Commodification of computing resources
- Conceptual-level model for cost reduction
 - Reduced costs of operations and delivery
 - Effective utilization of computing resources
 - Reduced development costs
- Three cloud computing models
 - Software-as-a-Service
 - Platform-as-a-Service
 - Infrastructure-as-a-Service



Part III: Impact of cloud computing on software engineering research and practice

Outline

- Part I: Interpretation of the lecture topic
- Part II: Getting to grips with cloud computing
- Part III: Implications of cloud computing on software engineering research and practice
 - Assessing possible impact
 - Multilateral software development
 - Impact on software engineering practice
 - Impact on software engineering research

Cloud computing mainly an industry phenomenon

Type	Title	2007	2008	2009
Research journals	IEEE Software	0	0	1
	IEEE Transactions on Software Engineering	0	0	0
	Transactions on Software Engineering Methods	0	0	0
	Journal of Systems and Software	0	0	2
	Information Software and Technology	0	0	0
	Software Practice and Experience	0	0	0
Confer.	Int. Conference on Software Engineering	0	0	9
	Int. Conf. on Software Maintenance	0	0	0
	Int. Symp. on Empirical Software Engineering	0	0	0
Mags	Communications of the ACM	0	3	14
	Computer	0	3	8

*Results from queries with the string "cloud computing" in full paper text

Assessing possible impact

- Software engineering: Research-informed software development
 - Application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software
 - Research: The study of these applications
 - Practice: The application of these approaches
- Focus
 - Lifecycle issues over technology issues
 - Research perspective

Multilateral software development

Aspect	Application software development	Multilateral software development
Software composition	Coherent set of software modules	Interoperable third-party components
Source code	Full source available	No source code for third-party components
Execution model	Single computer	Often <u>distributed</u> between multiple computers
Ownership and control	Single team or organization	<u>Distributed</u> between multiple organizations

*Adapted from T. Østerlie (2009). "Problems and solutions: Maintaining an integrated system in a community of volunteers", Unpublished Ph.D. Thesis.

Challenges to practice

Aspect	Cloud computing	Challenges
Software composition	Interoperable third-party services	•Service selection
Source code	No source code for third-party components	•System comprehension
Execution model	Often <u>distributed</u> between multiple computers	•State inspection and debugging
Ownership and control	<u>Distributed</u> between multiple organizations	<ul style="list-style-type: none"> •Separation of ownership and possession from use •Interaction effects among services from different providers •Coping with evolution of third-party services

Implications for research

- Theory generation
 - Existing theory aimed at application software development
 - Generate theory for multilateral software development
 - Cloud computing one of many venues for this
- Research approaches
 - Experimental studies reiterates old theoretical assumptions
 - Theory generation requires practice studies
 - Importance of bringing the socio-technical into account
- Research challenges
 - Provider perspective remains underdeveloped
 - Depart with the modernistic images of 'control'
 - Embrace contingent forms of control and opportunism
 - Manage increased complexity leniently

Summary

- Cloud computing is a continuation of distributed models of software development and delivery
- Cloud computing offers new possibilities for software engineering researchers to study multilateral software development