

INGI2145: CLOUD COMPUTING (Fall 2014)



Introduction

18 September 2014

Lecture slides adapted from Upenn NETS212 by A. Haeberlen, Z. Ives

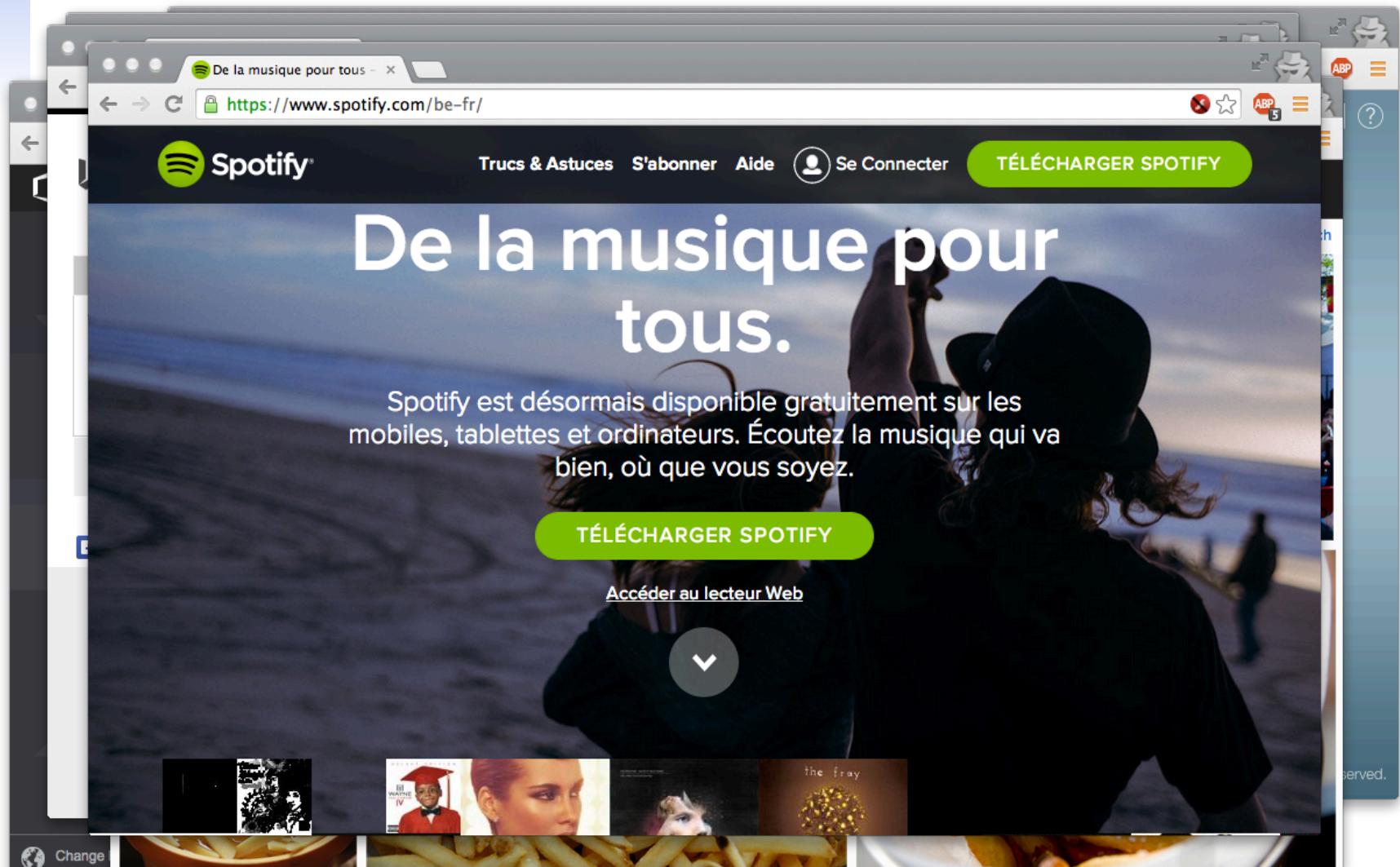
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Welcome!

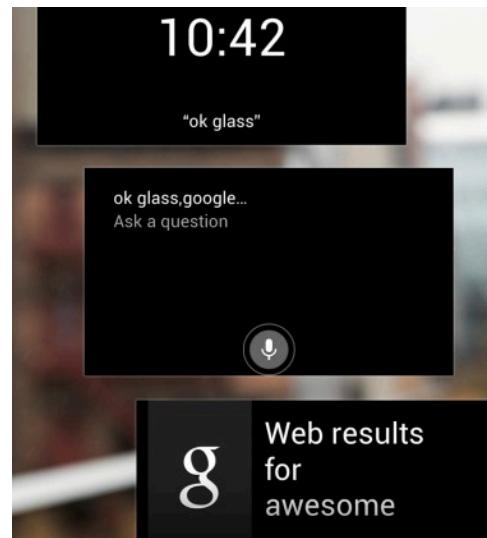
- My name: Marco Canini
- Faculty member at INGI
- Research interests:
 - Software-Defined, Reliable Networked Systems
 - Cloud Computing
 - See also: <http://perso.uclouvain.be/marco.canini/>



Have you used 'the cloud' before?



The cloud in your pocket and beyond



Why should I care?

- Understand what's underneath the Cloud
 - How does it work? What are its strengths? Its shortcomings?
 - Technologies: virtualization, MapReduce, key-value store, NoSQL, Ajax, ...
- Understand the underlying principles
 - How do you build something that is so scalable, robust, etc.?
 - Lots of clever algorithms needed - very different environment!
- Be able to use the right approach when designing new protocols and web systems
 - How would you go about building the next Facebook?
 - Need to scale, be efficient, avoid failures, prevent intrusions,...

Why should I care? (continued)

- Gain practical experience with cloud technologies
 - Often, the best way to understand it is to build one yourself
 - In this course, you will build on top of Amazon Web Services and Apache Hadoop
- Understand the impact on society
 - Vulnerabilities, privacy concerns, data survivability, ...
 - Need to understand the current state of the technology!
- Anticipate what's possible in the future

How big is Facebook?

Key Facts - Facebook's latest news, announcements and media resources - Mozilla Firefox

File Edit View History Bookmarks Tools Help

newsroom.fb.com/Key-Facts

Platform

- Engineering
- Advertising
- Safety and Privacy
- Photos and B-Roll
- Investor Relations

Fact Check

Contact Info

press@fb.com

Search

Statistics

819 million monthly active users who used Facebook mobile products as of June 30, 2013.

699 million daily active users on average in June 2013.

Approximately 80% of our daily active users are outside the U.S. and Canada.

1.15 billion monthly active users as of June 2013.

Board Members

Mark Zuckerberg, Founder, Chairman and CEO, Facebook

Marc Andreessen, Co-founder and General Partner, Andreessen Horowitz

Susan Desmond-Hellmann, chancellor of the University of California, San Francisco (UCSF)

Donald E. Graham, Chairman and CEO, The Washington Post Company

Reed Hastings, Chairman and CEO, Netflix

Erskine Bowles, President Emeritus, the University of North Carolina

Peter Thiel, Partner, Founders Fund

Sheryl Sandberg, COO, Facebook

Yahoo says uploaded to the wake of popular mobile apps like Instagram, but also social networks like Facebook, which sees more than 300 million photos uploaded each day, making it the most popular photo uploading service on the Internet.

ComScore's estimates are based on its "global measurement panel" of two million Internet users, similar to how Nielsen measures television ratings. ComScore refines the estimates with "page view" data that it receives from more than 90 of the 100 publishers of Web content, but

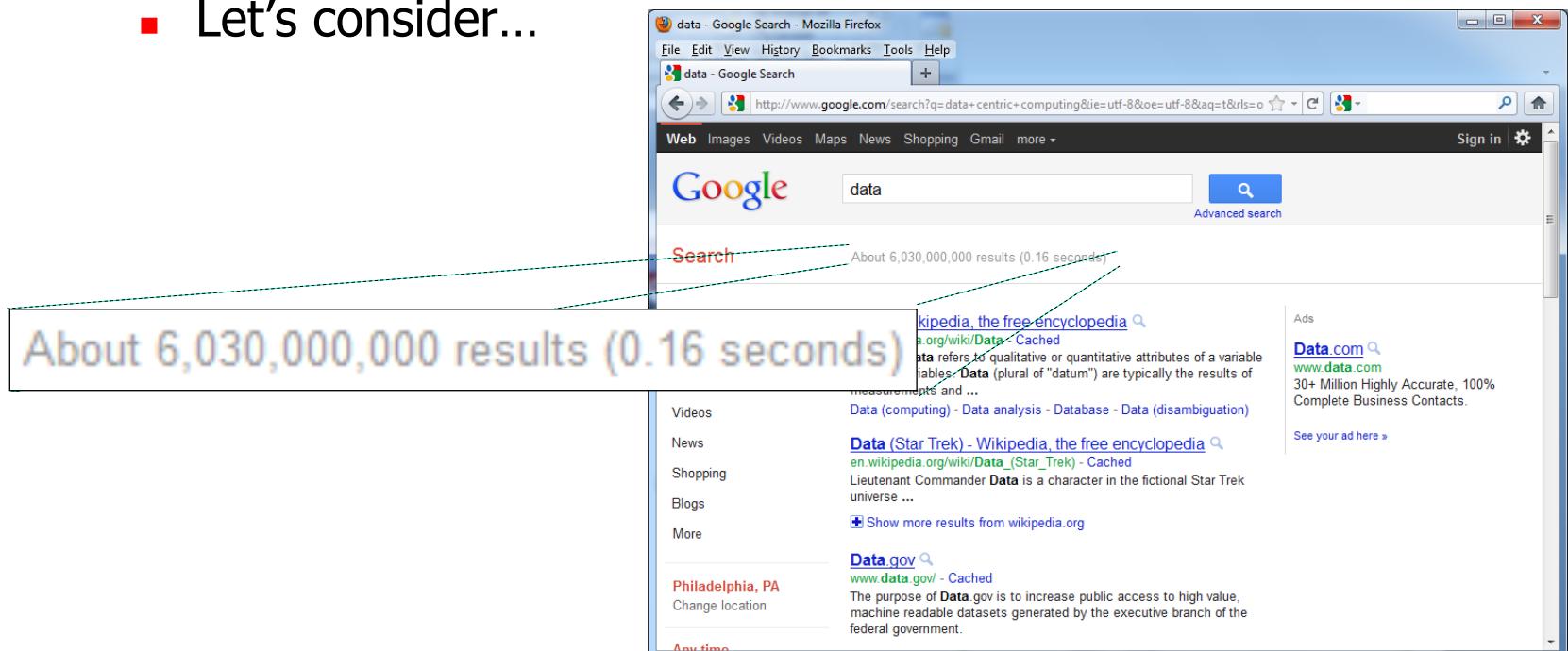
Data-centric computing

- Trend towards **data-centric computing**
 - Two words: "Big data"
- Today's currency on the Internet is data!
 - You "pay" for using Google, Facebook, etc. by letting them record your every action, link, search, etc.
- But data's value is not just economic:
 - It allows us to better answer questions, understand what's important, validate hypotheses about social interactions, ...
 - Example: Online Social Network research

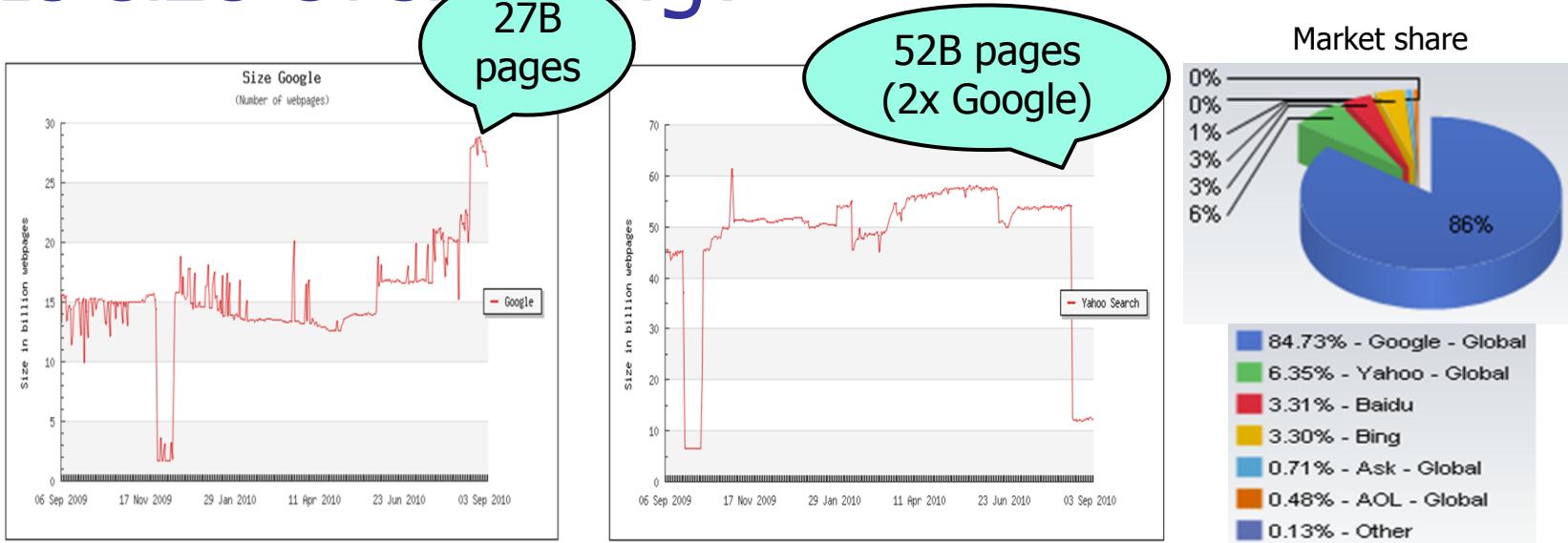


What kinds of data might we use?

- We all know that Google gives good search answers because it has a lot of data...
 - ... but what data, precisely, can it use, and how?
 - Let's consider...



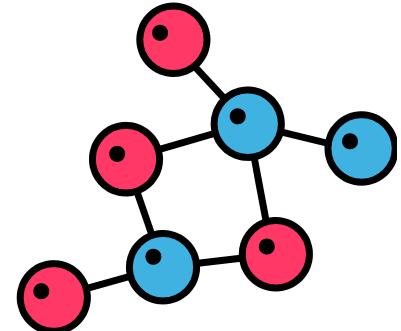
Is size everything?



- Will the search engine with the most data have the best results?
 - Not necessarily - consider the above example from 2010
 - Search engines can crawl different sets of pages, and can rank them differently
 - What does this mean in the long term?

How does it work?

- Google pre-crawls and analyzes millions of images – builds **models**



- Another example: Google & Bing Translate
 - Model how phrases in one language map to phrases in another language, by cross-comparing many, many translated docs

Models are valuable

The image displays three separate web pages side-by-side:

- IMDb Movie Page:** Shows the movie "Inception" (2010) with a poster, plot summary, and a "People who like this also liked" section.
- Amazon Product Page:** Shows the book "Hadoop" by O'Reilly, featuring a large image of an elephant and a "Look Inside" button.
- Google AdWords Landing Page:** Shows a search results page for "beginner yoga classes". The results are highlighted with red boxes:
 - Top Result:** "Laura Yoga Studio" (646) 702-4596
 - Second Result:** "Hot Yoga Classes" (www.yogabears.com/hotyoga)
 - Third Result:** "Yoga for beginners" (www.vinashiyoga.com)
 - Fourth Result:** "Yoga Accessories" (www.yogaccessories.com)
 - Fifth Result:** "Yoga Yoga Denver" (www.yogayogadenver.com)
 - Sixth Result:** "Lilac Yoga Studio" (www.lilacyogadenver.com)

Advertise on Google

Want to grow your business? Put your message in front of potential customers right when they're searching for what you have to offer.

Get started now For free support call: **1-800-919-9922***

Only pay for results
No matter what your budget, you can display your ads on Google and our advertising network. Pay only if people click on your ads and visit your website.
[Learn more](#)

We'll help you get started
We're here to answer all your questions and can even help you create your first campaign. Call us for free setup support at **1-800-919-9922***

How it works

1. People search on Google
2. They see your ad
3. You get more customers

[Learn more](#)

Data-centric computing is pervasive

- Today, Google and Friends aren't the only "Big Data" players
 - Not just Google & friends - banks, financial firms, academia, the government, companies, military, startups, ...
 - All need to store and analyze huge data volumes
- This is being enabled with a new generation of hardware “hosting” services – “the cloud” – and programming models

What is INGI2145 about?

- How do we **build effective data-centric applications**, and serve them to the entire Internet?
 - You've learned procedural programming on a single machine – we'll look at data-centric programming across thousands of machines
 - We'll understand the issues in breaking up problems, global coordination, failures, and so on
 - We'll study many of the systems and algorithms used by real Internet services
- How do we **take advantage of "the cloud"** – the vision of computing as a utility (like the power grid)?
 - You'll understand what lies underneath the cloud computing hype, and how to use the cloud
 - You'll build real Web projects hosted "on the cloud"

Towards understanding a larger trend

- Internet services are increasingly integrated into the fabric of our society
 - Communication – Twitter, Facebook, Skype, IM, ...
 - Media – iTunes, Spotify, Netflix, ...
 - Markets – Amazon, eBay, stock exchanges, advertising
 - Utilities, commodities – smart power grids, exch. markets
- Cloud computing likely to have profound implications on economical, social, ethical and legal matters
 - Data-centric, quantitative methods are revolutionizing advertising, sales but also science

Plan for today

- Introduction ✓
- Course logistics ← NEXT
- Overview

Course Staff



- Marco Canini
 - Réaumur A-049, x7-4832



- Nicolas Laurent (TA)
 - Réaumur A-057



- Waleed Reda (TA)
 - Réaumur A-058

Course website

<https://sites.google.com/site/uclngi2145/>

- All official communication is there

The screenshot shows a web browser window displaying the course schedule for INGI2145: CLOUD COMPUTING (Fall 2014) at the Université catholique de Louvain (UCL). The page has a header with the UCL logo and the course title. A search bar and a navigation menu are also present. The main content area shows a weekly schedule with lectures and lab sessions. Some of the time slots for lab sessions are highlighted in green.

Week	Date	Time	Activity	Description
Week 1	18 Sep	14:00-16:00	Lecture 1	Introduction Administrivia
Week 2	25 Sep	14:00-16:00	Lecture 2	The Cloud
	26 Sep	8:30-10:30	Lab 1	
Week 3	2 Oct	14:00-16:00	Lecture 3	Design for large scale
Week 4	9 Oct	14:00-16:00	Lecture 4	Cloud basics
	10 Oct	8:30-10:30	Lab 2	
Week 5	16 Oct	14:00-16:00	Lecture 5	MapReduce (NOTE: Class in SUD 04)
	17 Oct	8:30-10:30	Lab 3	

Language

- This course – including all supports (lectures, exercises, exam) – is in English
- Please use English
 - only use French if you must

Prerequisites

- Necessary skills:
- Good Java programming skills
 - LSINF1121 or equiv.; familiarity with Java
 - If you don't have a lot of programming experience yet, you should be willing to invest the necessary time
- Some familiarity with Linux command line
- Background in computer networks (LINGI1341) and OS (LSINF1252)
- A willingness to “push the envelope”
 - Example: We'll be using Node.js + Bootstrap this year, so you'll need to learn a bit of CSS and JavaScript

Course discussion group

- We will be using piazza for discussions related to this course
 - Examples: Questions about homework assignments
 - The TAs and I will read the posts and respond to questions
- Piazza will also be used for
 - Announcements, e.g., cancelled classes (if necessary)
 - Supplemental materials, e.g., links to relevant papers
 - Corrections/clarifications, e.g., bugs in homework handouts
 - Please check the group frequently!
- Please sign up at
 - <https://piazza.com/uclouvain.be/fall2014/ingi2145>

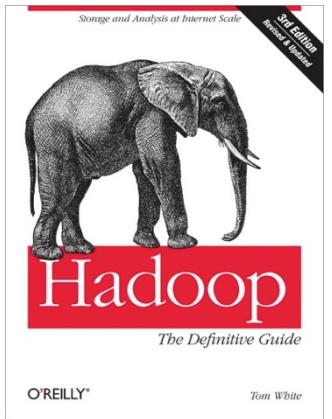
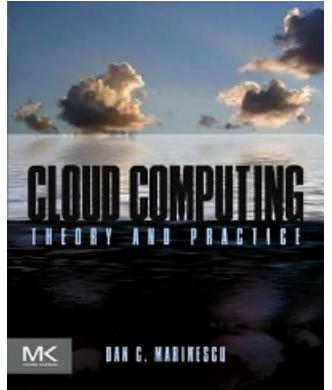
TODO

Lectures

- Regularly Thursdays 14:00 to 16:00, BARB 00
 - Could exceptionally be on Fridays 8:30 to 10:30, BARB 21
 - Check online schedule often
 - Be on time!
 - No lecture notes but reference books
-
- **Participation** to class counts towards grade
 - Will keep a presence sheet but just presence is not sufficient
 - Engage in discussion, make insightful questions or comments
 - May organize in-class quizzes on material covered in prior classes

Readings

- This field is too recent, and too fast-moving to truly have a good textbook yet
- Two reference books:
 - "Cloud Computing: Theory and Practice" by Dan C. Marinescu (Morgan Kaufmann)
 - "Hadoop: The Definitive Guide, 3rd edition" by Tom White (O'Reilly)
- Supplementary handouts and Web references
 - Refer to course website
 - Handouts, slides, example code, ..., will be published there



<http://shop.oreilly.com/product/0636920021773.do>

<http://secure-eecsdu.elsevier.com/covers/80/Tango2/large/9780124046276.jpg>

Additional readings (optional)

- The Datacenter as a Computer:
An Introduction to the Design of Warehouse-Scale Machines, Second edition
 - Luiz André Barroso, Jimmy Clidaras, Urs Hözle
 - <http://www.morganclaypool.com/doi/abs/10.2200/S00516ED2V01Y201306CAC024>
- Above the Clouds: A Berkeley View of Cloud Computing
 - Michael Armbrust, Armando Fox, Rean Griffith, Anthony D. Joseph, Randy Katz, Andy Konwinski, Gunho Lee, David Patterson, Ariel Rabkin, Ion Stoica, and Matei Zaharia
 - <http://www.eecs.berkeley.edu/Pubs/TechRpts/2009/EECS-2009-28.pdf>

Lab sessions

- We will organize ~6-7 lab sessions
- Complement the lectures with more practical information and hands-on exercises
- A sketch solution of the exercises will be presented during the session
- Labs on Fridays 8:30 to 10:30, BARB 21
 - Conflicts? Propose a slot that works for all and we will try to move lab sessions
- Attendance is optional but **highly encouraged**

Homework assignments

- We will organize 2-3 homework assignments
 - They are all mandatory
- No extensions granted
 - Automatic lateness penalty applies: 10% deducted on the assignment grade for each day late or fraction thereof
 - If an assignment is 1 minute late, it is one day late
- Start to work on them early
 - Do not wait until the last day before homework is due
- Deploy and run code on Amazon EC2
 - But credit is limited. Don't blow it up!
- We will offer a standardized development system that is based on a virtual machine

The INGI2145 Virtual Machine

- We will provide a **virtual machine** with the necessary software
 - Linux, Hadoop, Amazon CLI, ...
- Use with VMware Player, VirtualBox, etc.
 - Safe to experiment with
 - Standardized environment makes it easier to support
 - We will not support custom environments
- First lab session
 - Demonstrate how to provision the virtual machine through Vagrant and Puppet
 - Getting setup with Amazon Web Services (AWS)

Grading

- Final exam: **60%**
- Homework: **30%**
- In-class participation: **10%**
- Note: Homework grade and participation grade carry to the second examination session (September) as they cannot be repeated
- Grading policy is the same for first and second examination session

Policies: Collaboration

- All assignments must be done **individually**
 - All the code you submit has to be your own
 - Only exception: Code we have provided or explicitly authorized
 - UCL's regulations applies
 - No cheating, plagiarism, fabrication, multiple submissions, gaining an unfair advantage, or facilitating (!) academic dishonesty
 - It's not worth it!! Penalties can be severe:
<http://www.uclouvain.be/enseignement-reglements.html>
- **Zero tolerance policy** to ensure fairness
 - We will use various tools to actively look for cheating

Policies: Collaboration

- Can we work on assignments together? Yes No
- Can I discuss the assignment with others (in general terms)? Yes No
- Can I use code I copied from the web? Yes No
- Can I ask questions about the assignments on Piazza? Yes No
- I just happened to leave my password on my table, and XYZ just happened to find it. Will I be penalized for this? Yes No

Expected 'payoff'

- You will acquire a set of skills that is in very high demand right now
 - At Google, Facebook, and at many other places
- You will gain interesting insights
- You will have a good basis for other courses

A disclaimer...

- This is a “bleeding edge” course!
 - UCL is one of a handful of places offering these topics
 - The subject of this course is still evolving: no established curriculum, no classical textbooks yet
- Some of the material in the course will result in hair loss
 - Debugging distributed code is hard!
- We will be using some immature technology
 - We will do the best we can to smooth over the bugs
- I hope it will be a fun course, though...
... and an interesting one!

Plan for today

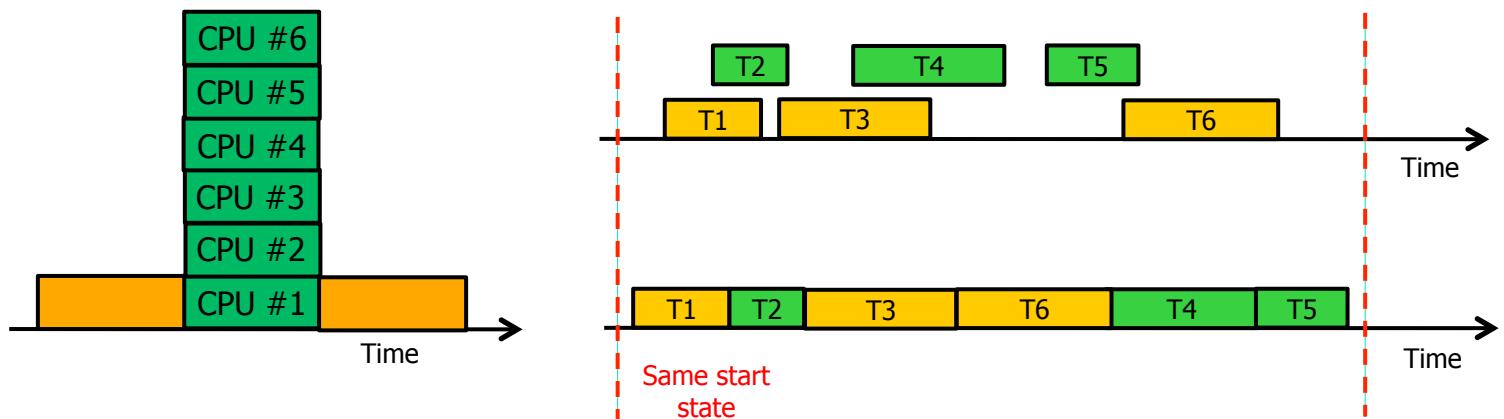
- Introduction ✓
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Cloud basics



- What is 'the cloud'?
 - Types of clouds; xAAS; utility computing
- What kinds of services does it provide?
 - AWS, EC2, EBS, S3, SimpleDB, key-value stores, ...
 - Amazon has donated free AWS usage credits for your homeworks
 - Case studies of cloud-based services

Technical challenges

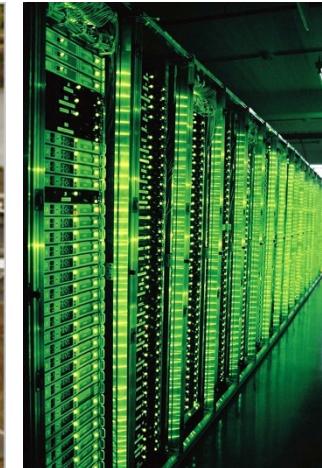


- What are key challenges in cloud computing?
 - Scale, concurrency, consistency, security, availability, ...
 - Speed of light (!), unreliable machines, ...
- What can you do about these challenges?
 - Concurrency control, weak consistency, locking, replication, ...
 - Special types of extremely scalable algorithms

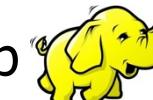
Programming the cloud



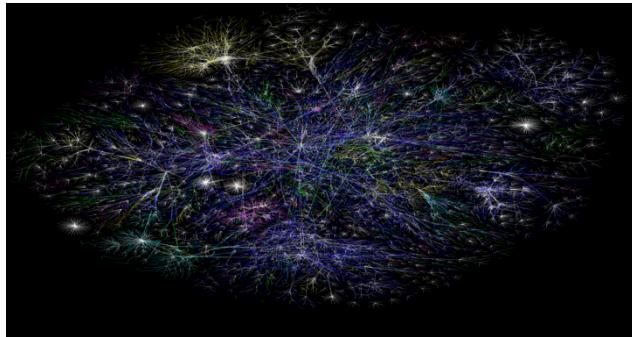
<http://www.nytimes.com/2006/06/14/technology/14search.html>



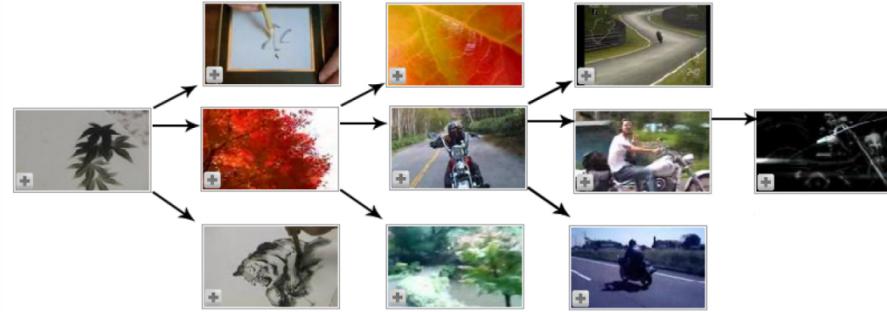
Source: 1&1

- How to program a building-sized computer?
 - MapReduce programming model; Hadoop 
 - Beyond MapReduce: LINQ, Hive, PigLatin, XQuery, ...
- How to store/process petabytes of data?
 - Cloud file systems; HDFS; replication

Working with large data sets



<http://www.opte.org/maps/>

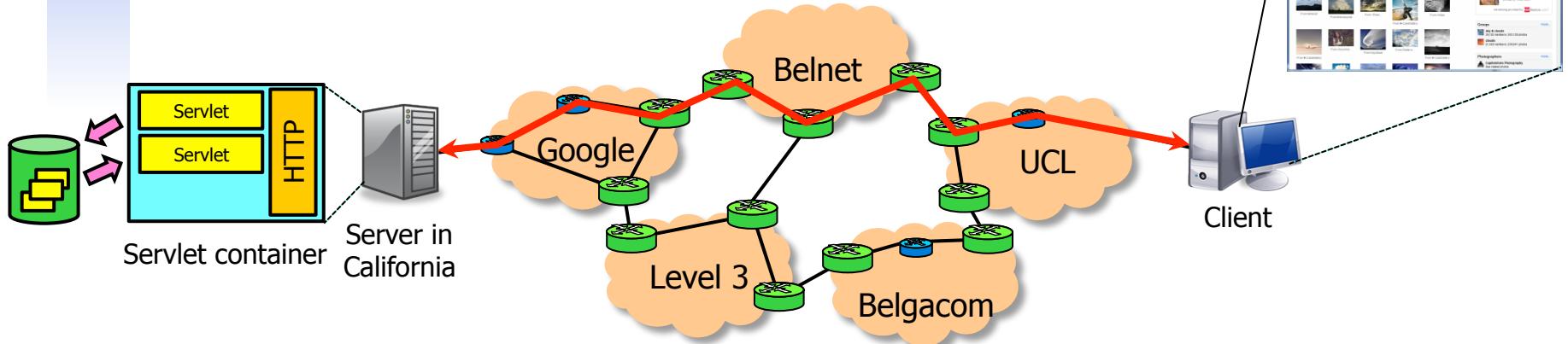


Source: Baluja et al., WWW 2008

■ Useful algorithms:

- How does YouTube recommend movies to you?
- How does Google find the relevant pages for your search?
- How does Goggle recognize images?
- How can you (automatically) tell which emails are spam?
- How does Facebook find out who your friends might be?

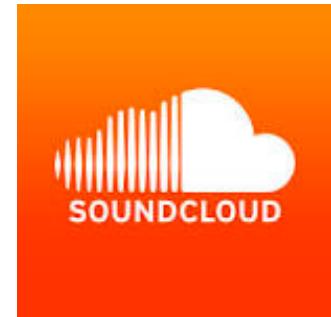
Interacting with the cloud



- How do users interact with the cloud?
 - Internet and web protocols: TCP, DNS, HTTP...
 - How to build a web server; Java servlets
 - Dynamic content: Ajax, Node.js; "Web 2.0"
- How are cloud services interconnected?

Industry perspective

- Cloud Computing for Behavioural Tracking by Sean Braithwaite (SoundCloud)
 - What, Why, How
 - Architectures: validation; transmission; storage...
 - Case studies at SoundCloud and more



Advanced topics (time permitting)

- Advanced cloud services
 - Cloud resource scheduling and allocation
- Cloud networks
 - Data center networking
 - Capacity sharing
- Cloud research at UCL
 - Adaptive distributed systems

Any questions?



Stay tuned



<http://www.flickr.com/photos/10909957@N03/3135455311/>

Next time you will learn about:
Kinds of clouds; utility computing