

T-110.5121 Mobile Cloud Computing

Introduction, Basics and Assignment 1

12.09.2012

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Introduction

Outline

- **Targets**
- **Requirements**
- **Grading**
- **Plagiarism**
- **Lecture schedule**
- **Assignment schedule**
- **Tools**
- **Reading material**
- **Related courses**



Targets

- “You have a clear view of the advantages of distributed computing technologies, such as cloud computing, in the mobile space. You understand the core properties as well as the strengths and limitations of mobile cloud computing. You have a vision how clouds will change the mobile ecosystem, reviewed both from technology and business angles.”
- (Mobile) Disruption
- Neutral, scientific and critical view, over the hype
- Technology, Business, Theoretical and Practical approach

Requirements

- **5 ECTS: 24 + 0 (2 + 0), not applicable to post graduate studies**
 - Lectures 24 h, Lecture preparation 24 h, Assignments 48 h, Exam preparation 36 h, Exam 3 h
 - Lectures are not obligatory but highly recommended
- **Exam**
 - Tue 18.12.2012, 9-12, Tue 08.01.2013, 9-12 or Tue 28.05.2013, 9-12 (remember to register in Oodi)
 - Structure:
 - 1 obligatory question: 6 definitions
 - 3 questions, 2 must be answered
 - 1 obligatory essay
 - 6 points from each: 0-11=0, 12-13=1, 14-15=2, 16-18=3, 19-21=4, 22-24=5
- **Assignments in pairs (possible alone with good reasons)**
- **Course feedback**



Grading

- **Exam 50% + Both assignments together 50%**
- **Both assignments have the same weight, e.g. 25%**
- **Exam and assignments evaluated 0-5**
- **To pass the whole course, each component must be passed at least with grade 1**
- **Example:**
 - Exam: 3
 - Assignment 1: 3
 - Assignment 2: 5
 - Total: $50\% \times 3 + 25\% \times 3 + 25\% \times 5 = 3.5 = \text{grade 4 (rounded to closest integer)}$

Plagiarism

- Copying is strictly prohibited, including assignments (code, text)
- All assignments will be checked against that
- If you are stuck with the assignment, ask course assistant first
- In your report you may extract text or pictures, but the source must be always defined and shown
- Discussion with other students is encouraged but you are not allowed to give full solutions to others
- If fraud is detected, Dean will be informed and in the worst case you are expelled for one year

Lecture schedule

- 12.09 Introduction, Basics & Assignment 1, Yrjö Raivio and Eetu Jalonen**
- 19.09 Mobile Networks, Jukka K. Nurminen**
- 26.09 Programming on open APIs, Olli Rinne/Apps4Finland**
- 03.10 Mobile Cloud Business, Antero Juntunen**
- 10.10 Scalable Cloud Computing, Keijo Heljanko**
- 17.10 Mobile Cloud, Yrjö Raivio and HTML5, Eetu Jalonen**
- 24.10 No lecture, exam week**
- 31.10 Green Cloud Computing, Tommi Mäkelä & Assignment 2, Yrjö Raivio**
- 07.11 Cloud Computing in Data Centres, NN/CSC**
- 16.11 Cloud Security, NN/Ericsson**
- 21.11 Industry keynote, Markku Lepistö/NSN**
- 28.11 Dynamic Resource Management, Ramasivakarthish Mallavarapu**
- 05.12 Summary, Yrjö Raivio (tbc)**



Assignment schedule

- **Assignments in pairs, inform your pair to assistant by 26.09**
- **1. Assignment, Open APIs**
 - Period: 12.09-28.10
 - Target is to learn how open APIs can be utilized for innovating a novel mashup and business idea
- **2. Assignment, Proof of Concept -report**
 - Period: 31.10-16.12
 - Design a proof of concept for a mobile cloud computing service, define a multi-tier architecture, make a business plan with an optimal cost structure, identify risks and carbon foot print, output as a report

Tools

- **Obligatory registering both to course and exams: Oodi, course deadline by 24.9, exam registering opens a few weeks before the exam date**
- **Information sharing, also lecture presentations (behind Aalto password) and News to your email: Noppa**
- **Assignments returned to course email**
- **Contact course staff: Email to t-110.5121(at)tkk.fi or visit A121/122 (best available 10-16 or before/after lecture)**

Reading material (updates in Noppa)

1. Doug Terry, Technology in the Cloud – Plus some Challenges and Opportunities, Virtual keynote, June 1, 2011, available from <http://techpack.acm.org/cloud/>
2. Armbrust, Michael, Fox, Armando, Griffith, Rean, Joseph, Anthony D., Above the Clouds: A Berkeley View of Cloud Computing, Feb. 10, 2009. Available at: <http://www.eecs.berkeley.edu/Pubs/TechRpts/2009/EECS-2009-28.pdf>
3. Lee Badger, Tim Grance, Robert Patt-Corner and Jeff Voas: Draft Cloud Computing Synopsis and Recommendations, Recommendations of the National Institute of Standards and Technology, May 2011, available at: <http://csrc.nist.gov/publications/drafts/800-146/Draft-NIST-SP800-146.pdf>
4. Rolf Harms and Michael Yamartino: The Economics of the Cloud, Nov. 2010, available at: <http://www.microsoft.com/presspass/presskits/cloud/docs/The-Economics-of-the-Cloud.pdf>
5. Lutz Schaubert and Keith Jeffery: Research in Future Cloud Computing, May 2012, available at: <http://cordis.europa.eu/fp7/ict/ssai/docs/future-cc-2may-finalreport-experts.pdf>
6. Greenberg, Albert, Hamilton, James, Maltz, David A., Patel, Parveen (2009) The cost of a cloud: research problems in data center networks, SIGCOMM Comput. Commun. Rev., Vol. 39, No. 1, pp. 68-73.
7. Cloud Security Alliance: Security Guidance for Critical Areas of Focus in Cloud Computing, v.2.1, Dec 2009, available from <https://cloudsecurityalliance.org/>

Related and recommended courses

- **Autumn**

- T-110.5150 Applications and Services in Internet P (5 ECTS), Zhonghong Ou
- T-110.5241 Network Security (5 ECTS), Tuomas Aura
- T-110.6130 Systems Engineering in Data Communications Software P (2-10 ECTS), Andrey Lukyanenko
- T-79.5308 Scalable Cloud Computing P (5 ECTS), Keijo Heljanko

- **Spring**

- T-110.5130 Mobile Systems Programming (5 ECTS), Sakari Luukkainen
- T-110.5140 Network Application Frameworks P (5 ECTS), Jukka K. Nurminen
- T-110.7111 Internet Technologies for Mobile Computing P (2-10 ECTS), Sasu Tarkoma



Basics

Outline

- **Motivation**
- **Definition**
- **Fixed vs. mobile**
- **Deployment and service models**
- **Key benefits**
- **Key technologies (detailed presentations later)**

IT problems are common

Technology & Economy

HUS hundreds of millions of self-reform remained on the table

Health care giant IT project abbot not yet nytkähtänyt forward in political machinations.

Health care giant IT project abbot not yet nytkähtänyt forward in political machinations. Helsinki Health Board meeting yesterday left the abbot on the table.

The abbot means HUS-range customer and patient information systems renewal. It is one of Finland's biggest-ever IT project, it is estimated to cost at least EUR 500 million.

Besides price, the politicians are wondering, the fact that such a system deliveries that are capable of companies in Finland is limited. In general, large public sector IT projects have been carried out either information, Accenture and Logica.

Rail ticket woes continue

VR ticket machines shut down, ticket sales slow

Malfunctions plaguing the Finnish passenger rail services are continuing. Failures in the new ticketing system of the national rail company VR has led to a situation in which passengers have been able to travel for free.

Automatic ticket machines at railway stations had to be shut down on Monday, and ticket sales at stations and on board trains have experienced problems.

Million phones muted fault repaired

publication 05.02. at 10:24, Updated 06.02. 15:46 pm



Image: YLE

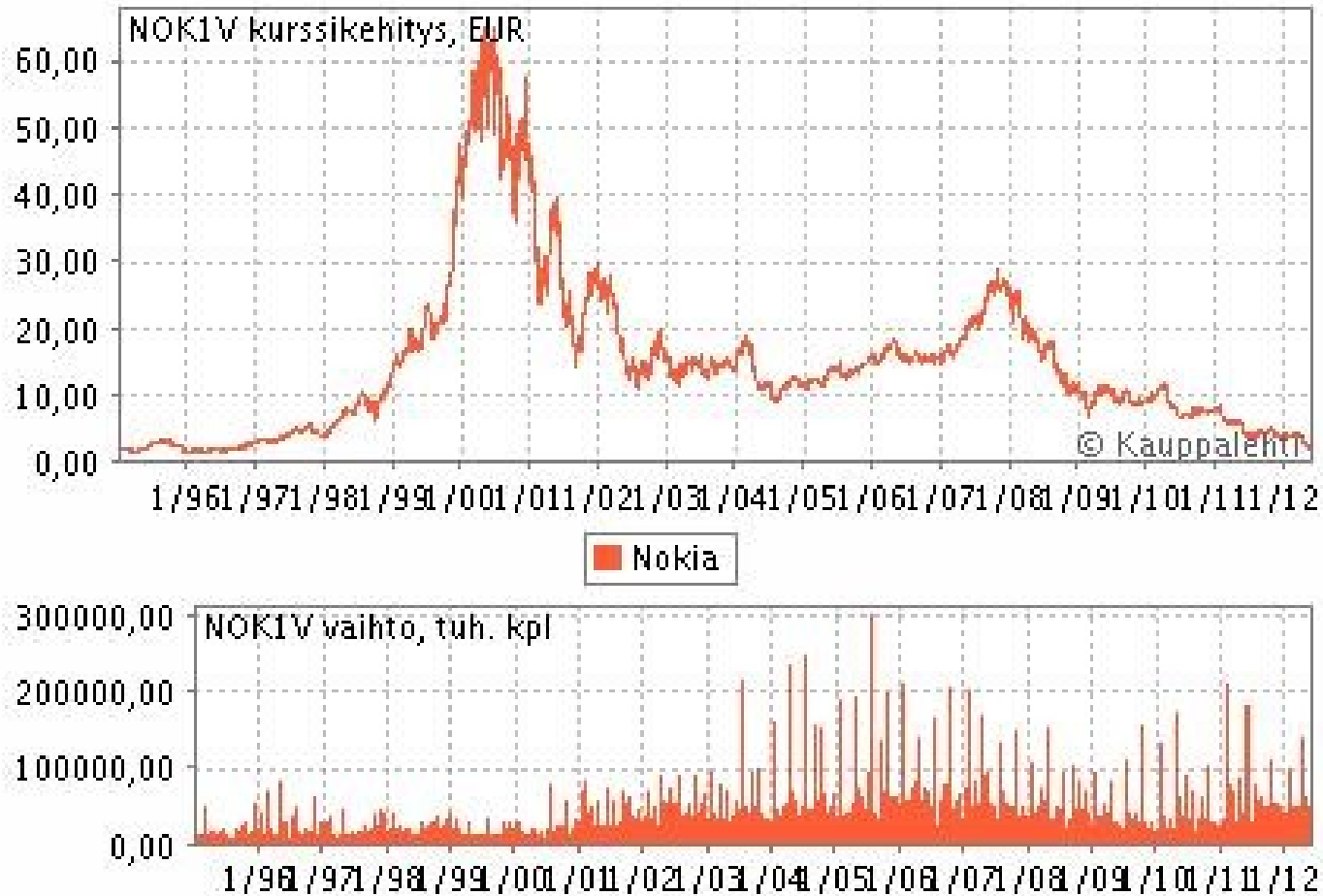
Elisa's mobile network had a large disturbance is corrected. Tampere, an electrical fault occurred in mute one million mobile phone Mikkeli, Vaasa, north of a line for several hours on Saturday. Elisa, all mobile phones are normally operated on that date.

Dysfunction related to 2G and 3G mobile network in the north of Tampere. Southern Finland and the West Coast had not been for the inconvenience.

At 7 o'clock in the morning revealed the fault was corrected at the time of 10.30. Most of the phones to operate normally, shortly after noon and all.

Elisa's broadband service was in Tampere, Kihniön Parkanon areas and problems. Elisa, Sauna and Columbus in the Gulf has a total of about three million mobile phone subscriptions.

Load varies



Massive data volumes

	WAN bandwidth/mo.	CPU hours (all cores)	disk storage
Item in 2003	1 Mbps WAN link	2 GHz CPU, 2 GB DRAM	200 GB disk, 50 Mb/s transfer rate
Cost in 2003	\$100/mo.	\$2000	\$200
\$1 buys in 2003	1 GB	8 CPU hours	1 GB
Item in 2008	100 Mbps WAN link	2 GHz, 2 sockets, 4 cores/socket, 4 GB DRAM	1 TB disk, 115 MB/s sustained transfer
Cost in 2008	\$3600/mo.	\$1000	\$100
\$1 buys in 2008	2.7 GB	128 CPU hours	10 GB
cost/performance improvement	2.7x	16x	10x
Cost to rent \$1 worth on AWS in 2008	\$0.27–\$0.40 (\$0.10–\$0.15/GB × 3 GB)	\$2.56 (128 × 2 VM's @ \$0.10 each)	\$1.20–\$1.50 (\$0.12–\$0.15/GB-month × 10 GB)

Bottleneck: Bandwidth

Example: Facebook 1 PB totally, 2-3 TB added each day
1 TB drive, 1 Gbit/s I/O = 2 h 13 min

$$T = 10^{12}$$

$$P = 10^{15}$$

Source: Ambrust et al, Above the Clouds: A Berkeley View of Cloud Computing, 2009

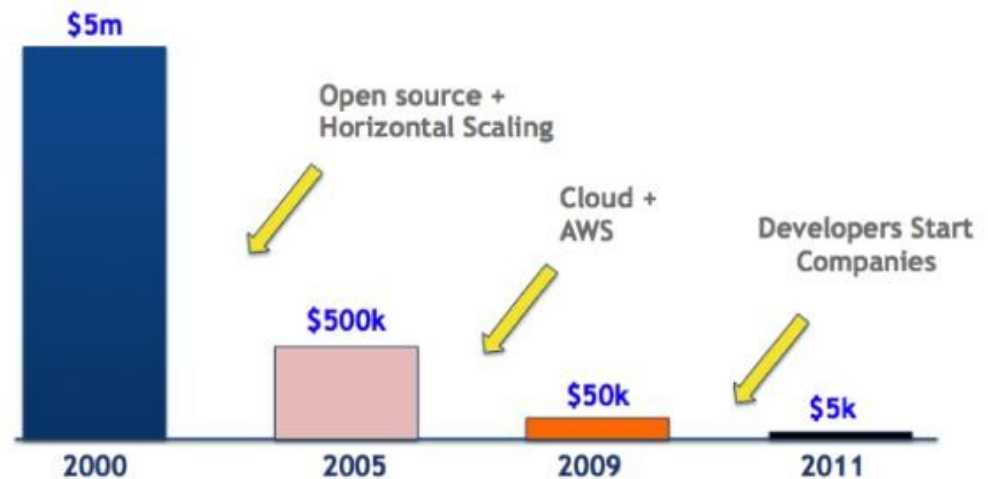


Some numbers

- **Global ICT business size**
 - 2008: \$ 383 B, 4% cloud
 - 2012: \$494 B, 9% cloud
- **Largest growth in storage**
- **SMEs have best opportunities to adapt**
- **Also small countries with good infrastructure**
- **Startup costs for SMEs dropped dramatically**

Source: F. Etro, The Economic Impact of Cloud Computing on Business Creation, Employment and Output in Europe, 2009

Costs to Launch an Internet Tech Startup



Source: M. Suster, It's Morning in Venture Capital, blog, May 23, 2012

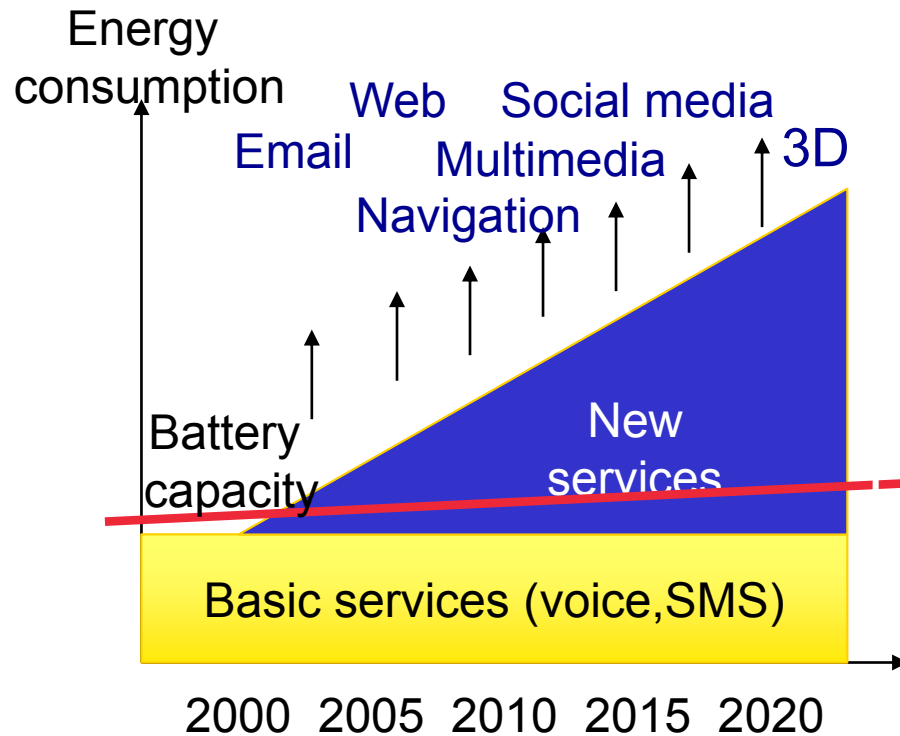
Mobile internet access doubled in a year

Proportion of global Web pageviews from mobile devices, by region, in May 2011 and May 2012							
	Global	Africa	Asia	Europe	North America	Oceania	South America
Mobile pageviews in May 2012	10.1%	12.9%	18.0%	5.1%	8.6%	7.5%	2.8%
Mobile pageviews in May 2011	5.8%	6.7%	8.3%	2.7%	7.8%	4.8%	2.8%
Top mobile operating system for pageviews, by region, in May 2012							
1	Android 23.8%	Symbian 45.6%	Symbian 33.3%	iOS 41.2%	iOS 47.2	iOS 70.5%	Android 24.9%
2	iOS 23.0%	Series 40 23.1%	Series 40 18.8%	Android 33.4%	Android 38.3%	Android 23.7%	Series 40 15.1%
3	Symbian 20.3%	Android 6.8%	Android 15.5%	BlackBerry 11.7%	BlackBerry 6.1%	Symbian 2.0%	iOS 13.6%
4	Series 40 11.8%	Samsung 4.6%	Samsung 12.4%	Symbian 5.63%	Windows 1.0%	Windows 0.8%	Symbian 13.6%
Source: StatCounter (May 2012)					via: mobiThinking		

Source: <http://mobithinking.com/mobile-marketing-tools/latest-mobile-stats/b#mobilepageviews>



Mobile capabilities are improving but battery capacity is still a bottleneck

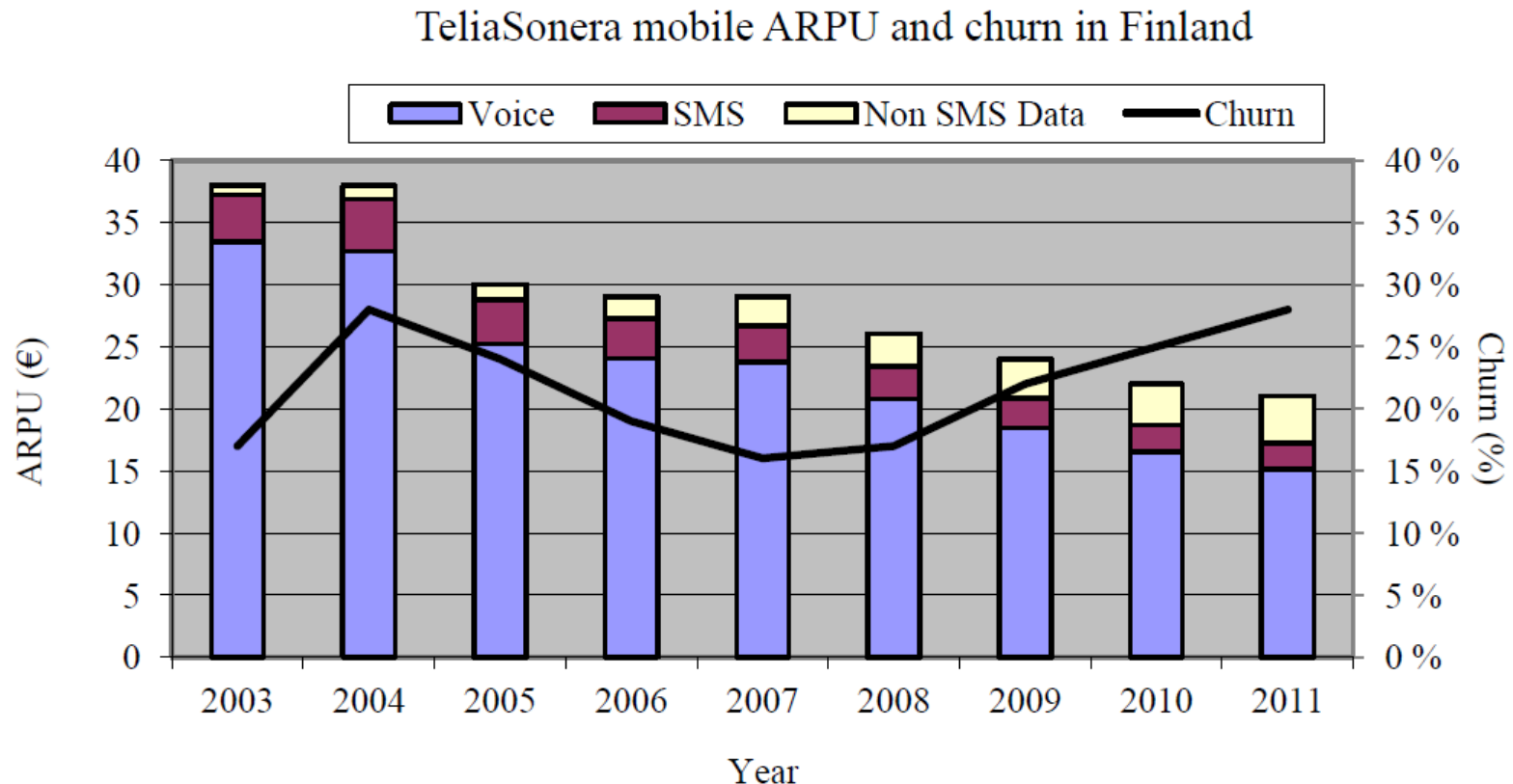


- Less new services
- More frequent charging
- Physically larger battery
- More energy efficient chips
- Intelligent methods
- Radical battery inventions
- HTML5

NOK
NOK
NOK
OK
OK
?
?

Source: professor Jukka K. Nurminen

Operators have challenges ahead: decreasing ARPU and increasing churn



What is Cloud Computing

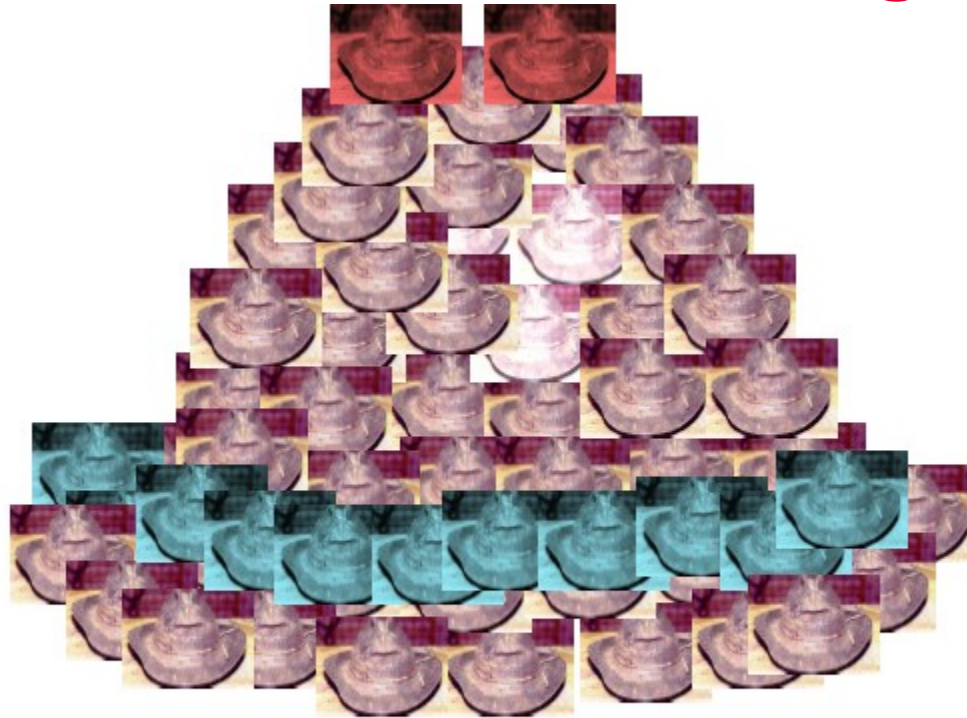


Isn't it just old hat?

Source: Giles Hogben, ENISA



New hat with new business models and clever resource distribution algorithms



To make **NEW Hat**

(Mobile) Cloud Computing

*“**Mobile** Cloud computing is a model for enabling convenient, on-demand **mobile** network access to a shared pool of configurable **mobile** computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.”*

Adapted from: P. Mell and T. Grance, The NIST Definition of Cloud Computing, 2009



Definition 2

1. The illusion of ***infinite computing resources*** available ***on demand***, thereby ***eliminating*** the need for Cloud Computing users to plan ***far ahead*** for provisioning.
2. The ***elimination*** of an ***up-front*** commitment by Cloud users, thereby allowing companies to start ***small*** and increase hardware resources only when there is an ***increase*** in their needs.
3. The ability to ***pay for use*** of computing resources on a short-term basis as needed (e.g., processors by the hour and storage by the day) and ***release*** them as needed, thereby rewarding conservation by letting machines and storage go when they are no longer useful.

Source: Ambrust et al, Above the Clouds: A Berkeley View of Cloud Computing, 2009



Fixed vs. Mobile

- **Cloud performance**
 - Processing time at the data center
 - Processing time on the device
 - Network latency
 - Data transport time
- **Mobile challenges**
 - Variable reliability, less throughput, longer latency
 - Energy
 - Limited resources, example Dell Desktop vs. iPhone 4
 - 3 times less processing power
 - 8 times less memory
 - 5 times less storage capacity
 - 10 times less network bandwidth
- **But mobiles are always with you and provide context data (location, sensor data, camera)**

Source: <http://www2.alcatel-lucent.com/blogs/techzine/2010/mobile-cloud-computing-challenges/>



What is Mobile Cloud Computing (MCC)

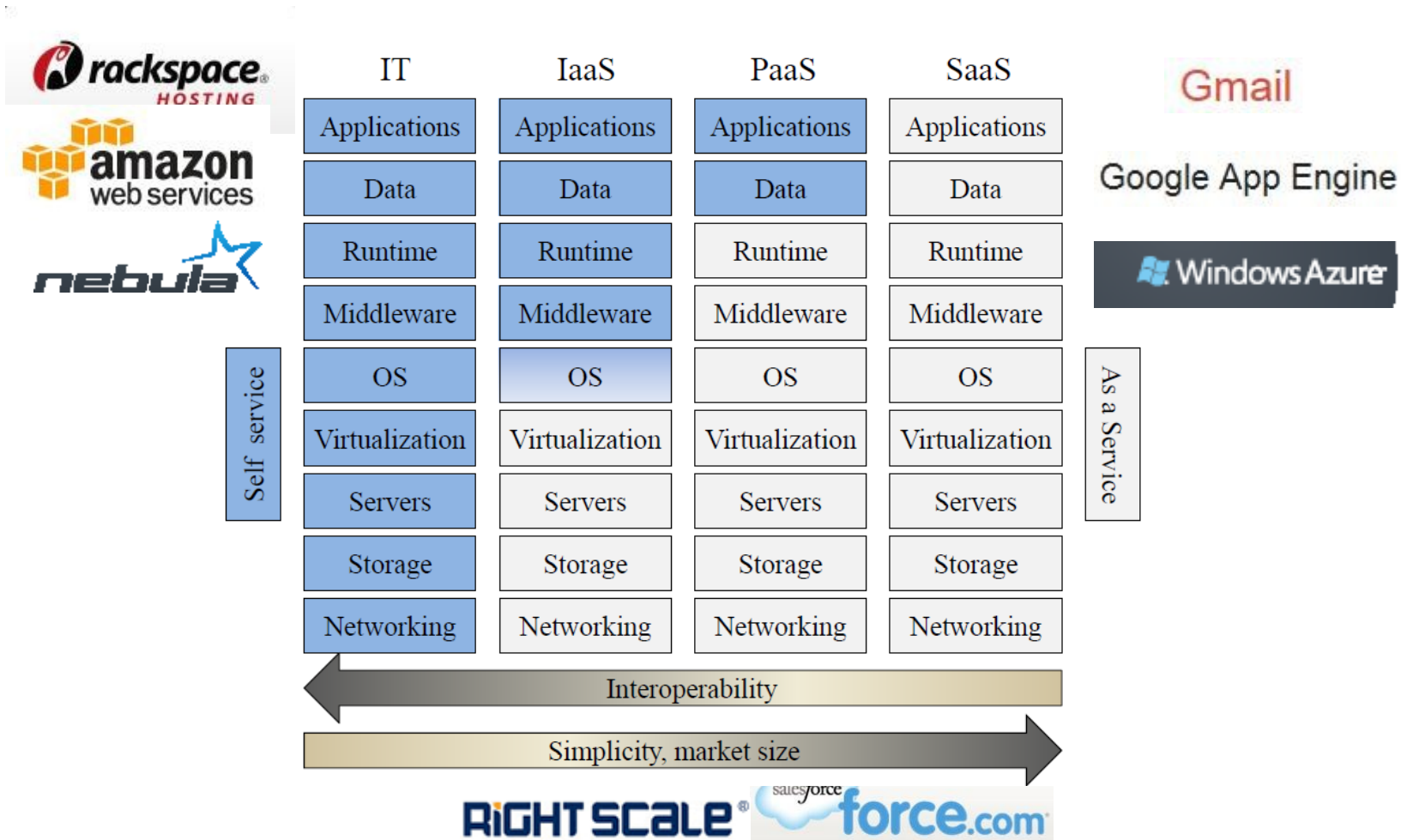
- **Mobile Cloud Computing:** mobile apps are processed and data stored in a cloud rather than on the native handset, referred as *Mobile Computing*
- **Mobile Offloading:** moving data, code block or virtual machine from mobile to cloud or vv.
- Using mobile context to enhance cloud based services
- Cloud within mobile (Hyrax, Cuckoo, ThinkAir, MAUI, CloneCloud..)



Deployment models

- **Public cloud**
 - Resources made available to the general public via the Internet
 - Scalable
 - Pay for what you use
- **Private cloud**
 - Host own resources
 - Provide to internal customers only
 - Provision with cloud interfaces
- **Hybrid cloud**
 - Some resources provided internally and some outsourced
- **Community cloud**
 - Address special needs of a community

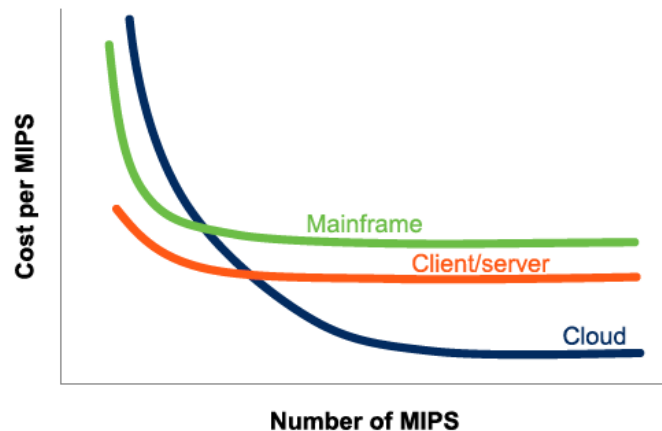
Main benefits - Service models



Economies of scale

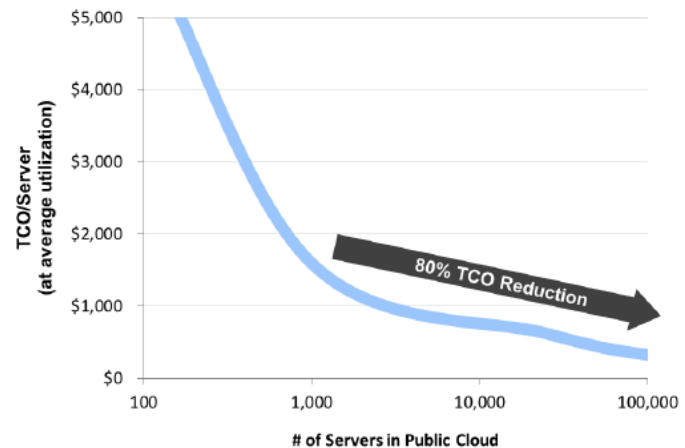
- Cheaper MIPS (5-7 times)
- Better utilization of computing resources (5-10% to 60-80%)
- Multi-tenancy: one instance can serve several customers
- Less admin people per server (from 1:100 up to 1:10 000)
- Worth 1\$ IT requires 8\$ admin costs

FIG. 4: ECONOMIES OF SCALE (ILLUSTRATIVE)



Source: Microsoft.

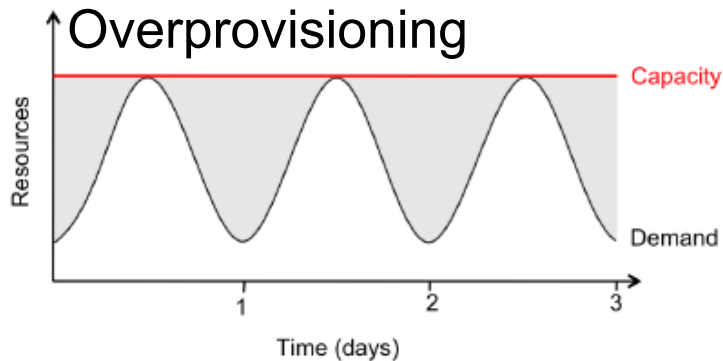
FIG. 15: ECONOMIES OF SCALE IN THE CLOUD



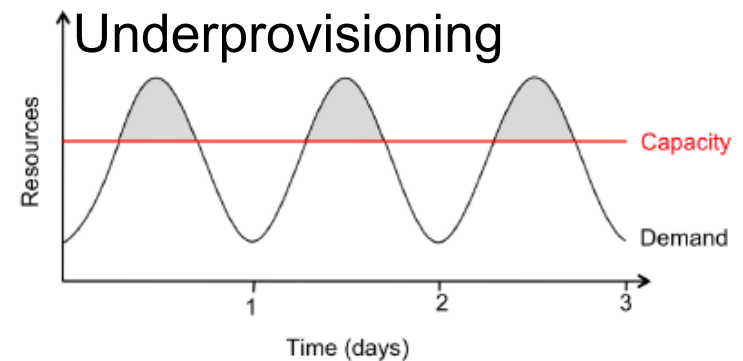
Source: Microsoft.

Source: Rolf Harms and Michael Yamartino: The Economics of the Cloud, Nov. 2010.

Elasticity – pay-as-you-go

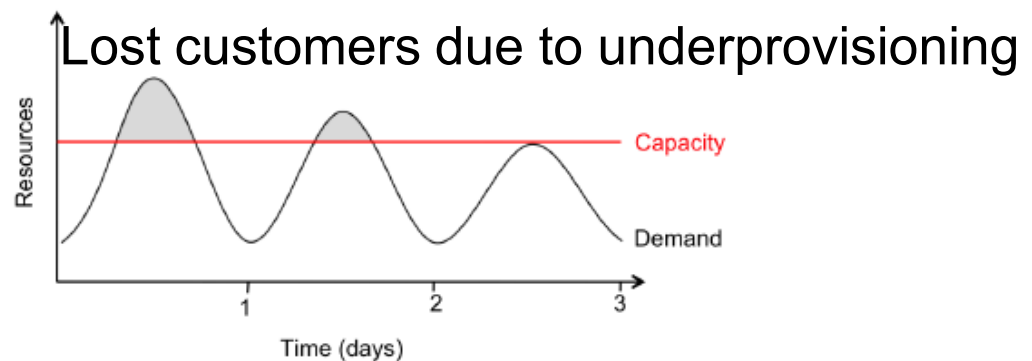


(a) Provisioning for peak load



(b) Underprovisioning 1

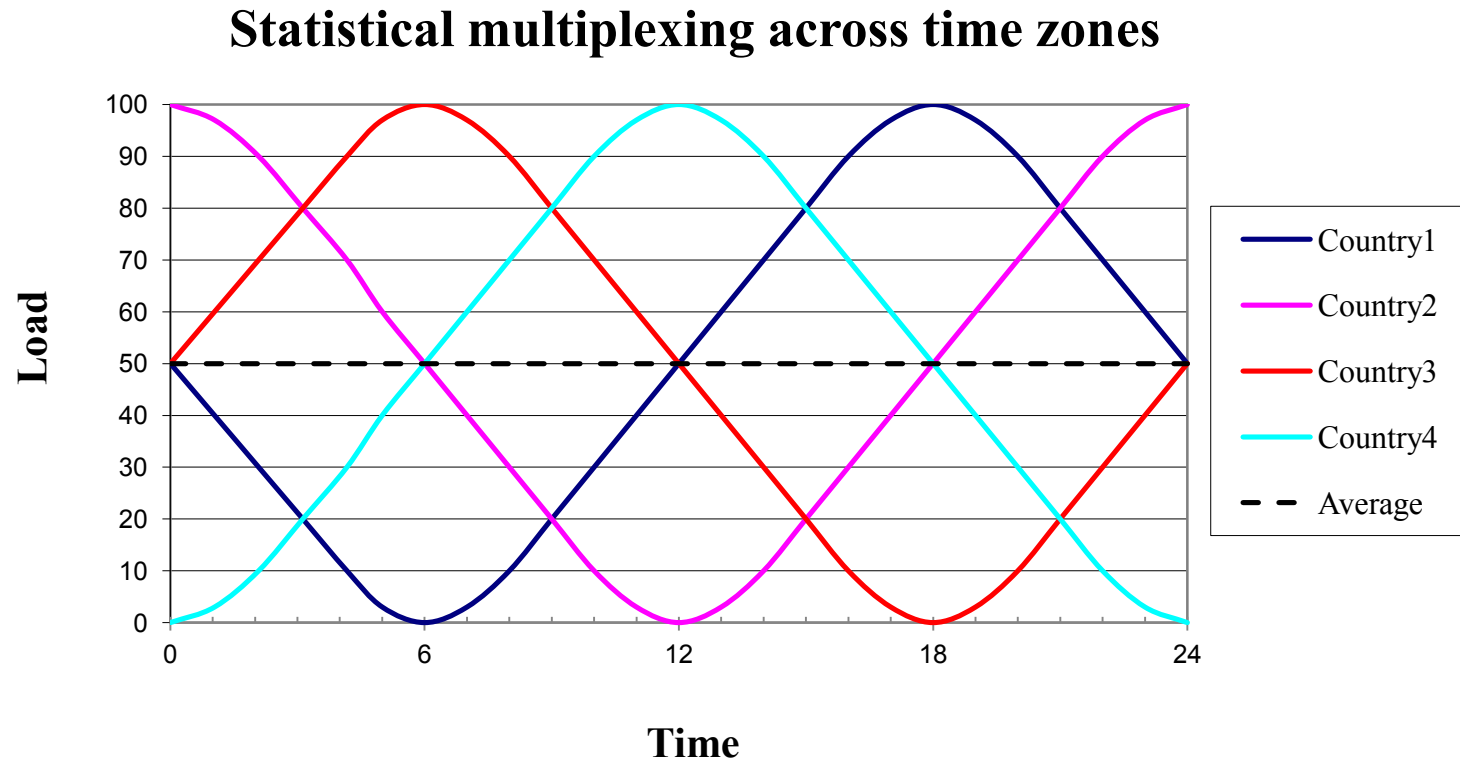
- **Avoid high upfront investment, avoid risk**
- **Adapt to changing business**
- **Buy or lease**
- **Amortizise value to investment period**



(c) Underprovisioning 2

Source: Ambrust et al, Above the Clouds: A Berkeley View of Cloud Computing, Feb 2009

Statistical multiplexing



Always available

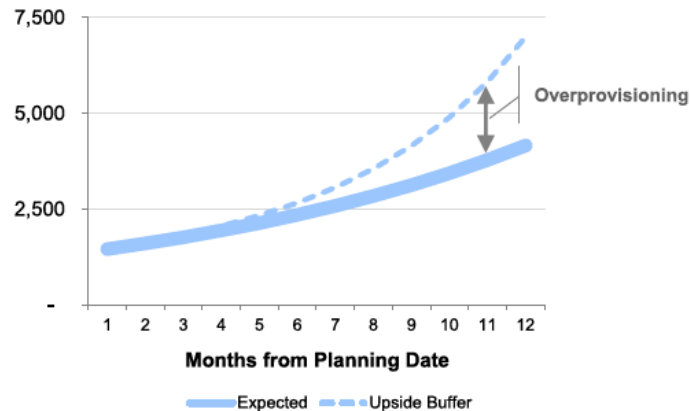
- **Anyone, anytime, anywhere**
- **High availability?**
- **Typical public cloud SLA promise**
 - 99.95% = max 4 h 23 min down time per year
- **Telecom**
 - 99.999% = 5 min
- **Availability Zone, fully (?) independent computing systems**
- **Using two Availability Zones**

$$P_P = 1 - P_F^2 = 1 - (1 - A)^2 = 99.9999\%$$

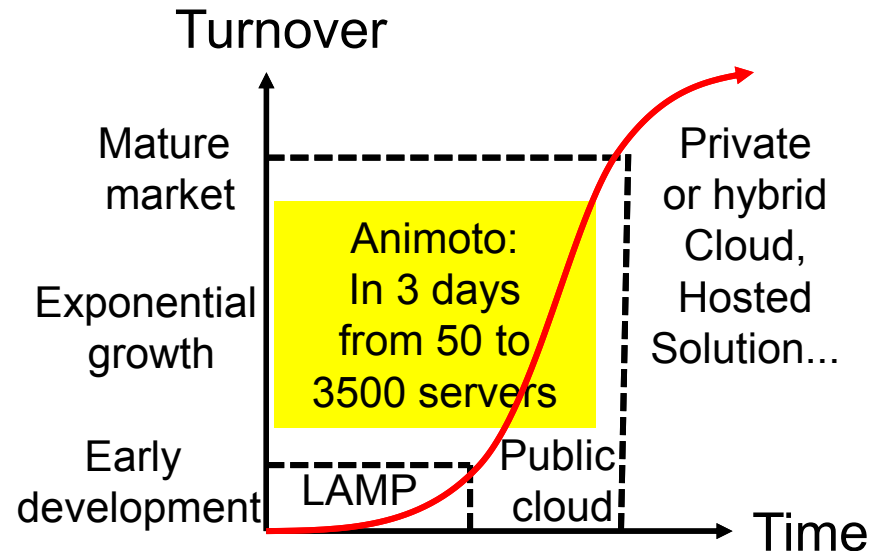
Resource planning

- Resources can be optimized to meet service needs
- Service integration time can be shortened, example Short Message Service Center setup from 2 weeks to 4 minutes

FIG.10: UNCERTAIN GROWTH PATTERNS



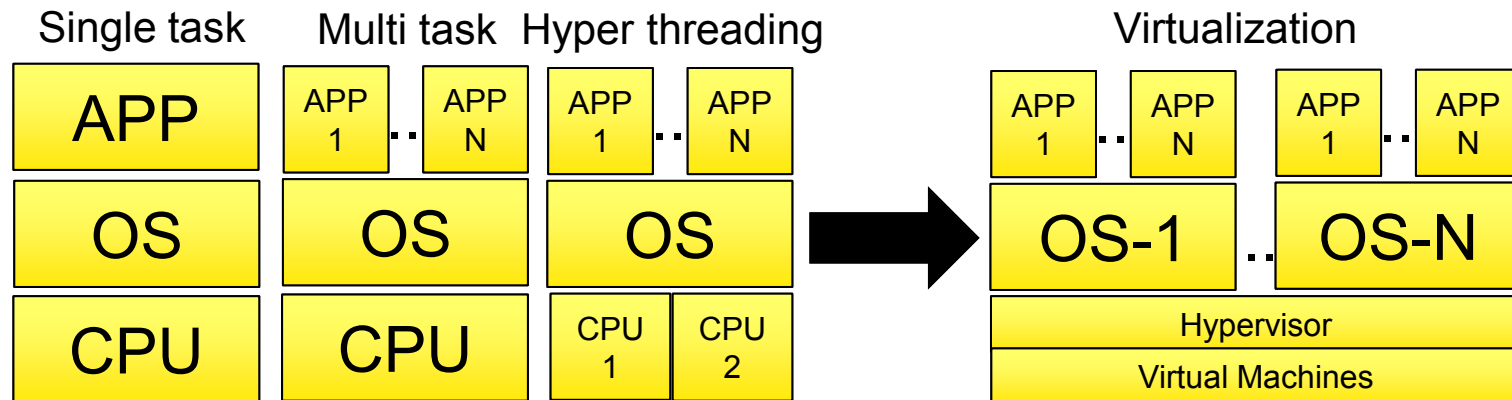
Source: Microsoft.



Source: Rolf Harms and Michael Yamartino: The Economics of the Cloud, Nov. 2010.

Key technologies - Virtualization

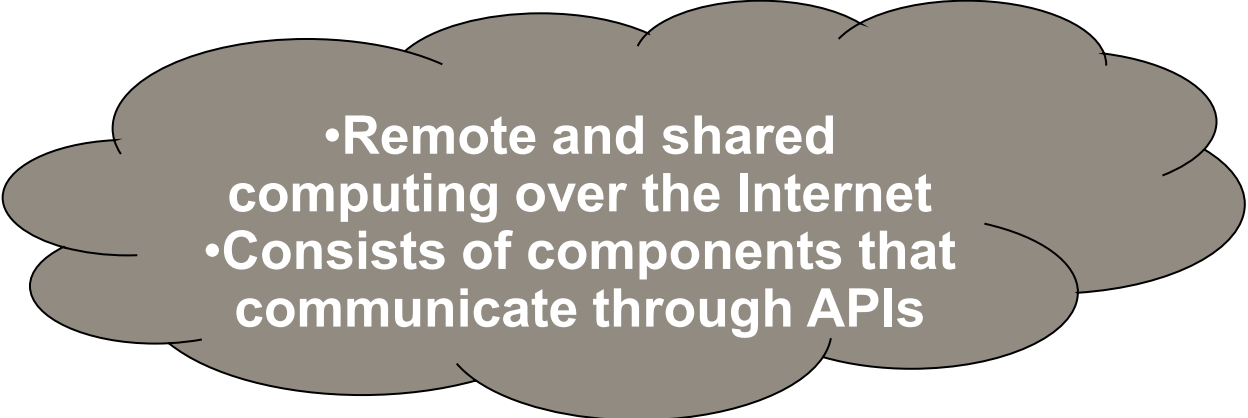
- **Drivers**
 - Better utilization of HW (from 15% to 80%), saves energy and money
 - Reduces system admin work
 - Easier SW installation
- **Hypervisors (VM manager): Xen, KVM (Kernel based VM), VMware**
- **Full (complete HW simulation), Para (interface between OS and HW) and HW-assisted virtualization**



Other key technologies

- **Mobile communication (Jukka K. Nurminen 19.9)**
- **Virtualization, storage and programming models (Keijo Heljanko 10.10)**
- **Mobile Cloud and HTML5 (Eetu Jalonon 17.10)**
- **Energy (Tommi Mäkelä 31.10)**
- **Data Centres (CSC/NN 7.11)**
- **Security (Ericsson/NN 14.11)**
- **Dynamic Resource Provisioning (Karthik 28.11)**

Pros and cons

- 
- Remote and shared computing over the Internet
 - Consists of components that communicate through APIs

!

- Simple architecture
- Efficient usage of CPU (>50%)
 - Scalability
 - Load balancing
 - Low capex
- High availability

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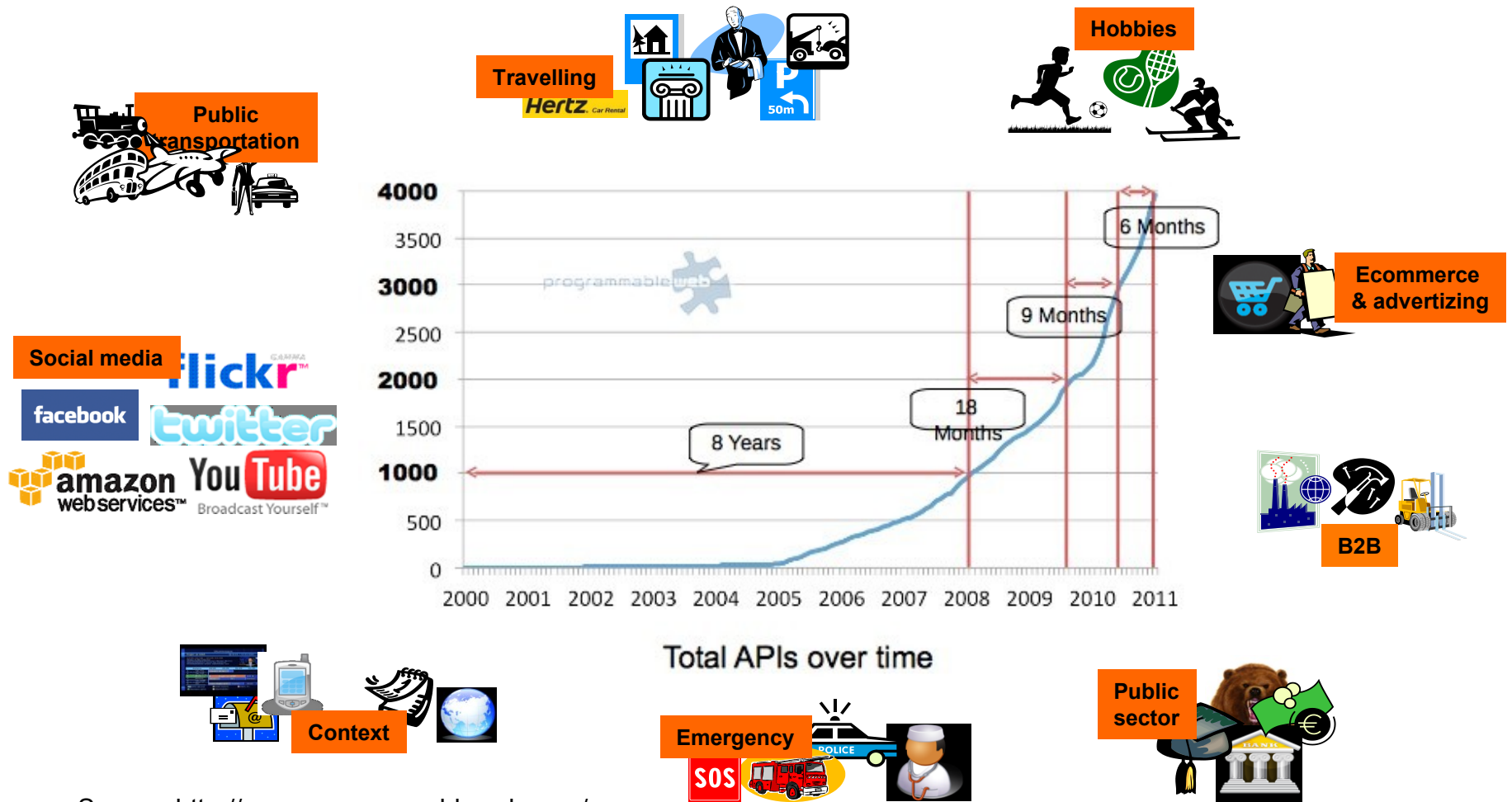
- Security & Privacy
- High usage of certain CPUs
- Interoperability
- Vendor lock-in
 - High opex
- SLA critical

Conclusions

- **Cloud computing is a new business model**
- **Great tool to startups**
- **Biggest challenge: (lack of) trust**
- **Next target: utility computing (similarly to water, electricity, gas and telephony)**
- **Future research topics**
 - Energy efficiency in data centers
 - Cloud interoperability
 - HTML5
 - Dynamic resource provisioning algorithms
 - Security

Assignment 1

Open APIs exist everywhere



Source: <http://www.programmableweb.com/>

Targets

- Create an innovative business idea that utilizes open network APIs and data
- Solves a real problem in citizens' every day life
- Role of mobile & cloud
- Implemented in an accessible system, free choice, examples:
 - PaaS: Google AppEngine, Windows Azure
 - IaaS: Amazon EC2..
- Deadline 28.10
- Bonus target Apps4Finland competition
- More information 26.09 by Olli Rinne, Apps4Finland project manager

Requirements and grading

- **Describe your idea, use case and APIs used**
- **Business plan**
- **Demo that can be accessed over network**
- **Document all parts shortly (max 4 pages), and return to course email**
- **Grading each component 0, 1, 3, 5**
 - Idea: 25%
 - Business plan: 25%
 - Implementation: 25%
 - Documentation: 25%
- **Final assignment grade weighted result of all components, rounded to the closest integer**
- **Best works encouraged to be submitted to Apps4Finland, contact staff before submission**
- **Next: find a pair by 26.09; if not found, contact staff & familiarize with examples, start innovating**



Example services

Maps	<u>www.maanmittauslaitos.fi/kartat/karttapaikka</u>
Restaurant directory	<u>www.eat.fi</u>
Real estate	<u>www.trulia.com</u> , <u>www.jokakoti.fi</u>
Region data	<u>www.infopankki.fi/helsinkiregion</u>
Communal services	<u>www.hel.fi/palvelukartta</u> , <u>open311.org/</u>
Statistics	<u>www.stat.fi/index.html</u> , <u>www.thl.fi/fi_FI/web/fi/tilastot</u>
Commutation	<u>www.matka.fi</u> , <u>www.reittiopas.fi</u> , <u>http://mak.hsl.fi/</u>
User generated data	<u>www.foursquare.com</u>
Air pollution	<u>www.ilmanlaatu.fi/</u>
Weather	<u>www.ilmatieteenlaitos.fi/</u>
Area political view	<u>www.vaalikone.fi/eduskuntavaalit2011/tulos/</u>
Location of Base St.	<u>www.opensignalmaps.com/</u>

Example APIs

<http://developer.reittiopas.fi/pages/en/home.php>

http://www.hel.fi/palvelukarttaws/rest/index_en.html

http://www.hel.fi/palvelukarttaws/rest/ver2_en.html

<http://www.hri.fi/en/>

<http://www.hel.fi/palvelukartta/?lang=en>

<http://www.korja.us/>

<http://www.floapps.com/lab/tieke/> (Only in Finnish)

http://cloudns.ci.fi/wiki/demos/traffic_accidents_in_Helsinki_heatmap.html

<http://busbus.nypon.fi/>

<http://mak.hsl.fi/>



Questions?

Contacts:

Teacher: Yrjo Raivio, A122

Assistant: Eetu Jalonen A121

Course staff: [t-110.5121\(at\)tkk.fi](mailto:t-110.5121(at)tkk.fi)