T-110.5121 Mobile Cloud Computing
Introduction, Basics and Assignment 1
12.09.2012
Teacher: Yrjö Raivio
Assistant: Eetu Jalonen
Aalto University, School of Science
Department of Computer Science and Engineering
Data Communications Software
Email: yrjo.raivio(at)aalto.fi
Course email: t-110.5121(at)tkk.fi
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% x 3 + 25% x 3 + 25% x 5 = 3.5 = 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, Ramasivakarthik Mallavarapu
05.12 Summary, Yrjö Raivio (tbc)
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 footprint, 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/


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.

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

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, Kihniönt Parkonon 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

<table>
<thead>
<tr>
<th>Item in 2003</th>
<th>WAN bandwidth/mo.</th>
<th>CPU hours (all cores)</th>
<th>disk storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost in 2003</td>
<td>1 Mbps WAN link</td>
<td>2 GHz CPU, 2 GB DRAM</td>
<td>200 GB disk, 50 Mb/s transfer rate</td>
</tr>
<tr>
<td>$1 buys in 2003</td>
<td>1 GB</td>
<td>8 CPU hours</td>
<td>$200</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item in 2008</th>
<th>WAN bandwidth/mo.</th>
<th>CPU hours (all cores)</th>
<th>disk storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost in 2008</td>
<td>100 Mbps WAN link</td>
<td>2 GHz, 2 sockets, 4 cores/socket, 4 GB DRAM</td>
<td>1 TB disk, 115 MB/s sustained transfer</td>
</tr>
<tr>
<td>$1 buys in 2008</td>
<td>2.7 GB</td>
<td>128 CPU hours</td>
<td>10 GB</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>cost/performance improvement</th>
<th>2.7x</th>
<th>16x</th>
<th>10x</th>
</tr>
</thead>
</table>

| Cost to rent $1 worth on AWS in 2008 | $0.27–$0.40 \((0.10–0.15/GB \times 3 \text{ GB})\) | $2.56 \((128 \times 2 \text{ VM’s} @ $0.10 \text{ each})\) | $1.20–$1.50 \((0.12–0.15/\text{GB-month} \times 10 \text{ GB})\) |

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

\[ T = 10^{12} \]
\[ P = 10^{15} \]


© Y Raivio
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: M. Suster, It’s Morning in Venture Capital, blog, May 23, 2012
Mobile internet access doubled in a year

<p>| Proportion of global Web pageviews from mobile devices, by region, in May 2011 and May 2012 |
|---------------------------------|--------|--------|--------|--------|--------|--------|--------|</p>
<table>
<thead>
<tr>
<th>Mobile pageviews in May 2012</th>
<th>Global</th>
<th>Africa</th>
<th>Asia</th>
<th>Europe</th>
<th>North America</th>
<th>Oceana</th>
<th>South America</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile pageviews in May 2011</td>
<td>10.1%</td>
<td>12.9%</td>
<td>18.0%</td>
<td>5.1%</td>
<td>8.6%</td>
<td>7.5%</td>
<td>2.8%</td>
</tr>
<tr>
<td>Mobile pageviews in May 2011</td>
<td>5.8%</td>
<td>6.7%</td>
<td>8.3%</td>
<td>2.7%</td>
<td>7.8%</td>
<td>4.8%</td>
<td>2.8%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Top mobile operating system for pageviews, by region, in May 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

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

Source: professor Jukka K. Nurminen
Operators have challenges ahead: decreasing ARPU and increasing churn

TeliaSonera mobile ARPU and churn in Finland

Year

ARPU (£)

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.

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)**

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

Source: Rolf Harms and Michael Yamartino: The Economics of the Cloud, Nov. 2010.
Elasticity – pay-as-you-go

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

Statistical multiplexing across time zones

- Country1
- Country2
- Country3
- Country4
- Average
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

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

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 Jalonen 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

? • 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: www.maanmittauslaitos.fi/kartat/karttapaikka
Restaurant directory: www.eat.fi
Region data: www.infopankki.fi/helsinkiregion
Communal services: www.hel.fi/palvelukartta, open311.org/
User generated data: www.foursquare.com
Air pollution: www.ilmanlaatu.fi/
Weather: www.ilmatieteenlaitos.fi/
Area political view: www.vaalikone.fi/eduskuntavaalit2011/tulos/
Location of Base St.: www.opensignalmaps.com/
Example APIs

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://cloudnsci.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