T-110.5121 Mobile Cloud Computing
Summary
30.11.2011
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Outline

- Course targets
- Requirements, course feedback
- Grading
- Exam reading material
- Lecture schedule
- Summary of key issues
- 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 recommendable
• Exam
  • Tue 13.12.2011, 9-12, Tue 03.01.2012, 9-12 or Tue 29.05.2012, 9-12
  • Initial structure (all rights reserved!):
    • 3 questions, 2 must be answered (roughly one page together)
    • 1 obligatory question: 6 definitions (one sentence each)
    • 1 obligatory essay (roughly one page)
    • 6 points from each: 0-11=0, 12-13=1, 14-15=2, 16-18=3, 19-21=4, 22-24=5
• 3 Assignments in pairs
Grading

- Exam 50% + Assignments all together 50%
- Each assignment has the same weight, e.g. 1/3
- All parts evaluated 0-5
- To pass the whole course, each component must be passed at least with grade 1
- Example:
  - Exam: 3
  - Assignment 1: 3 = 3/3
  - Assignment 2: 4 = 4/3
  - Assignment 3: 5 = 5/3
  Total: 50% x 3 + 50% x 12/3 = 3.5 = grade 4 (rounded to closest integer)
Reading material to exam


5. Rasmus Paivarinta and Yrjo Raivio: Applicability of NoSQL Databases to Mobile Networks: Case Home Location Register, to be published 2012 (17 pages); Yrjo Raivio and Rushil Dave: Cloud Computing in Mobile Networks – Case MVNO, ICIN2011 (6 pages)

6. Mohammad Hajjat, Xin Sun, Yu-Wei Eric Sung, David Maltz, Sanjay Rao, Kunwadee Sripanidkulchai, and Mohit Tawarmalani, Cloudward Bound: Planning for Beneficial Migration of Enterprise Applications to the Cloud, ACM SIGCOMM’10, (Sections 1-2, 2 pages); Ming Mao and Marty Humphrey, Cloud Auto-scaling with Deadline and Budget Constraints, GRID 2010 (Sections 1-3, 3 pages); Z. Gong, X.Gu and J. Wilkes, “PRESS: Predictive elastic resource scaling for cloud systems”, CNSM 2010 (Sections 1-2, 3 pages)


Lecture schedule

07.09 Introduction, Yrjö R
14.09 Basics, Yrjö R
21.09 Public Cloud, Yrjö R and Karthik M
28.09 Mobile Networks, Jukka K. Nurminen
05.10 Business in a Cloud, Sakari Luukkainen
12.10 Mobile Cloud, Yrjö R
19.10 Private Cloud, Yrjö R and Koushik A
02.11 Mobile Offloading, Matti Kemppainen
09.11 Dynamic Resource Provisioning, Karthik M
16.11 Encapsulated Security in Cloud, Jukka Ylitalo, Ericsson
23.11 Industry keynote, Erkka Ala-Tauriala, NSN
30.11 Summary, Yrjö R
07.12 Spare
Lecture 14.9: Basics & 21.09: Public Cloud

• **Key Benefits**
  • Economies of scale
  • Elasticity
  • Resource planning
  • Pay-as-you-go
  • Always available

• **Technology**
  • Virtualization, Storage, SLA, Provisioning, Energy, Security, Mobility

• **Pros and Cons**

• **Differences between cloud types**
  • Public, Private, Hybrid, Community
  • IaaS, PaaS, SaaS
  • Amazon EC2 main features

“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.”

Traffic load can vary a lot

Lectures 28.09: Mobile Networks & 23.11: Industry Keynote

- What are the key issues in mobile networks/terminals related to cloud computing?
- How to minimize energy consumption in mobile
- GSM, HSPA or LTE – any difference
- IaaS, PaaS or SaaS/private or public cloud
- Regulation and security
- SLA (availability, throughput, latency)

Source: Rasmus Paivarinta and Yrjo Raivio, “Applicability of NoSQL Databases to Mobile Networks: Case Home Location Register”, to be published 2012;


Source: M. Murphy, "Telco Clouds" [presentation], Cloud Asia 2010
Lecture 05.10: Business in a cloud

- Will LTE and cloud computing bring a disruption
- Cost savings
- Energy savings
- Case Amazon – lessons to telecom players?
- Key enablers: ATCA, private cloud, open APIs, market place
- Challenges: installed base, carrier grade SLA, trust

Lecture 02.11: Mobile Offloading

Source: Kumar & Lu, "Cloud Computing for Mobile Users: Can Offloading Computation Save Energy", 2010

Source: Chun and Maniatis, "Augmented Smartphone Applications Through Clone Cloud Execution", 2009
Categories

Figure 1: The five categories of augmented execution.

Source: Chun and Maniatis, “Augmented Smartphone Applications Through Clone Cloud Execution”, 2009
Mobile capabilities are improving but battery capacity is still a bottleneck

- Less new services
- More frequent charging
- Physically larger battery
- More efficient chips in energy wise
- Radical battery inventions
- Intelligent methods to save energy

Source: professor Jukka K. Nurminen
Lecture 12.10: Mobile Cloud

- Why operators should care about cloud computing?
- Role of Open Innovation
- How operators can cope with Internet APIs
- Location information from terminal or network
- SLA, sustainability
- SaaS: End user intervention
- PaaS: Can be shared with other MVNOs
- IaaS: High computation

Source: Yrjo Raivio and Rushil Dave, "Cloud Computing in Mobile Networks – Case MVNO", ICIN2011
Vision

Load varies in base stations

End users move and use services unpredictable way

End users

Mobile Offloading

Access Cloud

Internet

Open Telco

Telecom Cloud

Operator Cloud

Vendor Cloud

Hybrid Cloud

SaaS

PaaS

IaaS

Load varies in core network elements and between operators
Cloud advantages and disadvantages

• Higher performance and elasticity
• Economies of scale
• Solutions on all IaaS, PaaS and SaaS layers
• Return on Investment (ROI) improved
• Capex to Opex transition, decrease Opex
• Smaller investment risk
• Lower IT administration costs (1$ IT vs. 8$ admin)

• Data security, access and availability are the biggest concerns
• Regulation restricts the transfer of customer sensitive data outside country or region (EU)
• Integration and customization of IT systems may become difficult
• Lack of cloud competences
• Performance of real-time systems like Prepaid, OSS and Network systems
Lecture 19.10: Private Cloud

- Cloud computing management software
  - Manage infrastructure (private and public)
  - Launch VMs into a cloud
- Resource scheduler
- Controls Life-cycle of VMs with the help of Hypervisors
  - Storage management
  - Network management
  - Admin and user interfaces (API/CLI/GUI)
- Provide Image repository/marketplace
- Load balancer
- Accounting/Billing
Virtualization

1) Cost Savings
2) Better Resource Utilization
3) Better Memory Management
4) Increased Availability
5) Better Resource Provisioning
6) Energy Saving

Lecture 09.11: Dynamic Resource Provisioning

1. **Reactive resource controller**
   - Detect changes in workload pattern and react to changes after the event occurs
   - Suitable for services with predictable workload patterns
   - Unreliable for QoS critical services

2. **Proactive resource controller (Predictive)**
   - Predict/forecast changes in workload based on a recent history and react before the event occurs
   - Can cater to variable and unpredictable workloads
   - Efficiency largely depends on the prediction algorithm

Source: Ming Mao and Marty Humphrey, Cloud Auto-scaling with Deadline and Budget Constraints, GRID 2010 (Sections 1-3, 3 pages)
Predictive model

- Model the incoming workload pattern
- Based on a recent history of workload data, predict (forecast) the future workload
- Scale resources based on the predicted workload values well in advance
- Resources are scaled before occurrence of the event
- Suitable for performance/latency critical services
- Most useful for variable incoming traffic and unpredictable workload patterns
- Example use cases: Telecom components, online ticketing services, e-commerce applications etc.

Lecture 16.11: Security

• Top threats
  • Abuse and Nefarious Use of Cloud Computing
  • Insecure Application Programming Interfaces
  • Malicious Insiders
  • Shared Technology Vulnerabilities
  • Data Loss/Leakage
  • Account, Service & Traffic Hijacking
  • Unknown Risk Profile

Source: Cloud Security Alliance, “Top Threats to Cloud Computing V1.0”, March 2010
Critical areas of focus

Domain 1: Cloud Computing Architectural Framework ......................................................... 13
Domain 2: Governance and Enterprise Risk Management.................................................. 31
Domain 3: Legal and Electronic Discovery....................................................................... 35
Domain 4: Compliance and Audit .................................................................................... 37
Domain 5: Information Lifecycle Management ................................................................... 40
Domain 6: Portability and Interoperability....................................................................... 46
Domain 7: Traditional Security, Business Continuity, and Disaster Recovery.............. 50
Domain 8: Data Center Operations................................................................................... 52
Domain 9: Incident Response, Notification, and Remediation ....................................... 54
Domain 10: Application Security .................................................................................... 57
Domain 11: Encryption and Key Management ................................................................. 60
Domain 12: Identity and Access Management .................................................................. 63

Data Lifecycle Management

Data Security Lifecycle

- **Create**
  - Classify
  - Assign Rights

- **Store**
  - Access Controls
  - Encryption
  - Rights Management
  - Content Discovery

- **Use**
  - Activity Monitoring and Enforcement
  - Rights Management
  - Logical Controls
  - Application Security

- **Share**
  - CMP (DLP)
  - Encryption
  - Logical Controls
  - Application Security

- **Archive**
  - Encryption
  - Asset Management

- **Destroy**
  - Crypto-Shredding
  - Secure Deletion
  - Content Discovery

Related and recommended courses

- **T-110.5130** Mobile Systems Programming (5 cr), Spring III-IV, Sakari Luukkainen
- **T-110.5140** Network Application Frameworks P (5 cr), Spring III-IV, Jukka K. Nurminen
- **T-110.5191** Seminar on Internetworking P (5 cr), Spring IV, Antti Ylä-Jääski
- **T-110.7111** Internet Technologies for Mobile Computing P (3-5 cr), Spring IV, Sasu Tarkoma
Questions?

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