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T-110.5120 Next Generation Wireless Networks Introduction
03.11.2010

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Outline

- **Practical issues**
- **Long Term Evolution**
- **Cloud Computing**
- **Mobile Cloud**

Practical issues

11/4/2010

Targets

- **4 ECTS (P)**
- **Simulate a short paper and poster session in a conference**
- **Full papers on T-110.5190 (IWork) and T-110.5290 (NetSec)**
- **Main themes this year**
  - Long Term Evolution (LTE) – focus in the network
  - (Mobile) Cloud Computing
- **Motivation**
- **Disruption**
- **Neutral, scientific and critical view, over the hype**
- **Technology**
- **Business**

Requirements

- **In pairs**
  - Poster (posters at niksula.hut.fi)
    - Prepare a poster on a chosen topic
    - Present and discuss during poster session
  - Extended abstract (Optima)
    - Four-page extended abstract on the poster topic
    - IEEE proceedings format: double column, 10pt font
- **Individually**
  - Learning diary (Optima)
    - Submit after each lecture and poster session, max half page long
  - Must be present during all lectures and poster sessions
    - Absence must be compensated with extra work, 2 page lecture or poster summary in IEEE format to Optima
    - Will circulate participation list during each lecture and poster session
  - No exam

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Grading

- **Mainly based on your Extended abstract and Poster presentation**
- **How well have you summarized the topic, analyzed it, and explained it to others**
- **Pairs are equally graded, both by teacher and other students**
- **Learning diaries may have an impact (+/-1)**
- **Remember to give course feedback!**
- **Dropping from the course**
  - Please, notify me immediately

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Poster and Extended abstract topics

- **List of proposed topics in <u>Noppa</u>**
- **Topics are quite high level, you may also focus only on certain subtopic**
- **Topic selection process**
  1. Select your pair's preferences OR your own topic (email to me)
  2. Register your pair's preferences OR your own topic in <u>Doodle</u> only once
     - Rank the topics (the first, the second and the third choice)
     - Deadline Sunday **07.11. 2010 at 23.59**
  3. I will allocate topics based on your choices
     - Try to match preferences as well as possible
     - First-come, First-served

LTE topics

1. LTE overview (motivation, technology, business)
2. LTE performance and cost analysis
3. Evolved Packet Core (EPC)
4. LTE deployment scenarios
5. Voice over LTE
6. IP Multimedia Subsystem (IMS)
7. Self-Organizing Networks (SON)
8. Cognitive radio

Cloud computing topics

9. Cloud computing overview (motivation, technology, business)
10. IaaS, PaaS and SaaS
11. Amazon EC2/Google App Engine/Microsoft Azure
12. Open source SW IaaS alternatives
13. Hybrid (private and public) cloud
14. Hybrid (mobile and fixed) cloud
15. MapReduce
16. NoSQL databases

Mobile computing topics

17. **Open APIs (telecom, public sector, Internet)**
18. **Open Source Software in mobile computing**
19. **Mobile Linux, Meego**
20. **Qt development environment**
21. **Django/Ruby on Rails development environment**
22. **iPhone, Android vs. Symbian**
23. **App Store, Android market vs. OVI**
24. **Mobile cloud frameworks**

Poster instructions

- **Process**
    - Content of session's posters are first presented in T2, 10 min each pair, and then we move to hall where the posters are shown and presented as a bazaar
    - One presents, the other one visits other posters and vv.
- **Layout**
    - Template available in Optima
    - A1 size
    - Do not mix too many fonts or font sizes
    - Font size should be at least 30..40.
    - B/W looks often more scientific than colour
    - Do not use PPT cloud symbol, our printer cannot print it properly!
    - Save ink, do not use background pictures or colours
- **Printing**
    - Send your poster, with your surnames in file name, in PDF format to 'posters at niksula.hut.fi' at least 2 days before your session
    - Store your PDF file also to Optima

Extended abstract instructions

- **IEEE format, 4 pages**
  - Title and names
  - Abstract (~150 words)
  - Keywords
  - I Introduction
  - II Background
  - III Main content
  - IV Discussion
  - V Conclusions
  - References
- **Submit in PDF format to Optima including your surnames in file name**

Schedule

03.11 Introduction, Yrjö Raivio

07.11 Topics selected

09.11 Topics assigned

10.11 LTE System Architecture Evolution, Risto Mononen

17.11 Mobile Computing, Juha-Matti Liukkonen

24.11 Poster Session 1 - LTE

- **Posters 1-8**

01.12 Poster Session 2 – Cloud computing

- **Posters 8-16**

08.12 Poster Session 3 – Mobile computing

- **Posters 17-24**

10.12 Deadline for Extended abstracts, Learning diaries and possible Absence essays

17.12 Results published

Further material

LTE:

1. **Magnus Olsson, Lars Frid, Catherine Mulligan, Shabnam Sultana and Stefan Rommer, "SAE and the Evolved Packet Core: Driving the Mobile Broadband Revolution: Evolved Packet Core for LTE, Fixed and other Wireless Accesses", 2010, ISBN: 978-0-12-374826-3**

2. **http://www.eventhelix.com/lte/lte-tutorials.htm**

Cloud and Mobile Computing:

1. **Syed A. Ahson and Mohammad Ilyas, "Cloud Computing and Software Services", 2011, ISBN: 978-1-4398-0315-8**

2. **https://noppa.tkk.fi/noppa/kurssi/t-110.5120/materiaali**

Questions?

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Long Term Evolution

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Motivation
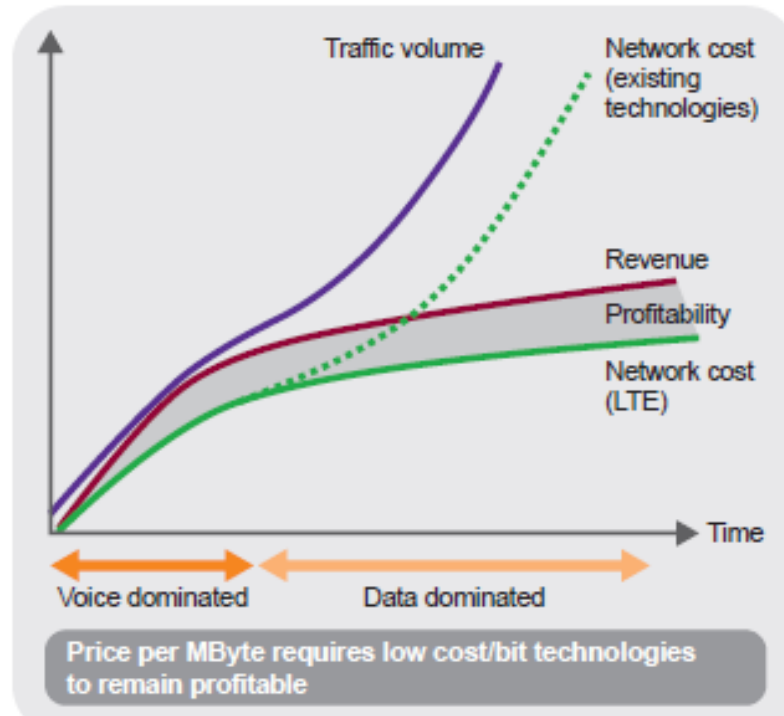
Requirements

- **Increased peak data rates: 100Mbps downlink and 50Mbps uplink.**
- **Reduction of RAN latency to 10ms**
- **Improved spectrum efficiency (two to four times compared with HSPA Release 6)**
- **Cost-effective migration from Release 6 Universal Terrestrial Radio Access (UTRA) radio interface and architecture**
- **Improved broadcasting**
- **IP-optimized (focus on services in the packet switched domain)**
- **Scalable bandwidth of 20MHz, 15MHz, 10MHz, 5MHz, 3MHz and 1.4MHz**
- **Support for both paired and unpaired spectrum**
- **Support for inter-working with existing 3G systems and non-3GPP specified systems**

Source: Ericsson, "LTE – an introduction", White paper, 2009

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Standardization roadmap

	WCDMA (UMTS)	HSPA HSDPA / HSUPA	HSPA+	LTE
Max downlink speed bps	384 k	14 M	28 M	100M
Max uplink speed bps	128 k	5.7 M	11 M	50 M
Latency round trip time approx	150 ms	100 ms	50ms (max)	~10 ms
3GPP releases	Rel 99/4	Rel 5 / 6	Rel 7	Rel 8
Approx years of initial roll out	2003 / 4	2005 / 6 HSDPA 2007 / 8 HSUPA	2008 /9	2009 /10
Access methodology	CDMA	CDMA	CDMA	OFDMA / SC-FDMA

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Evolved Packet Core (EPC)

Services in LTE

- **Data**
  - Anybody can create services
  - LTE enables new service innovations (high bandwidth, low delay - battery lifetime?)
- **Voice**
  - VoLGA, Voice over LTE via GAN
  - CSFB, Circuit Switched Fall Back
  - One Voice / later called Voice over LTE, VoLTE
    - IP Multimedia Subsystem (IMS)
    - NSN: Fast Track Voice over LTE
- **Messaging**
  - Over packet network or via 2G/3G

Self-organizing networks (SON)

- **Automated configuring, operating and optimizing of cellular access network**
- **Introduced in Release 8, but more details in future releases**
- **Interoperability?**
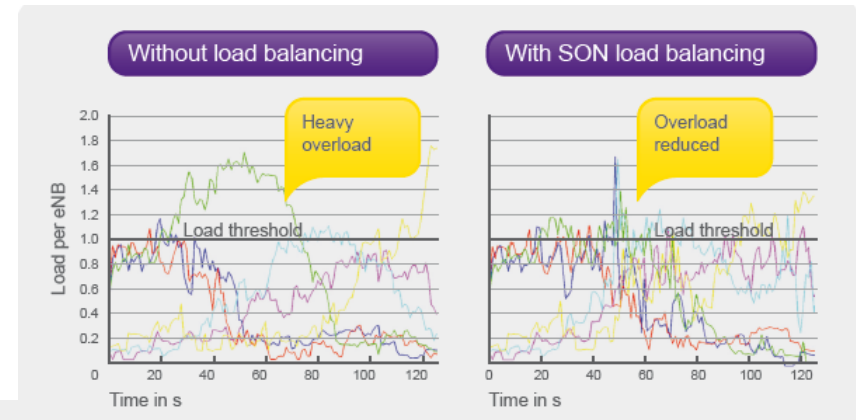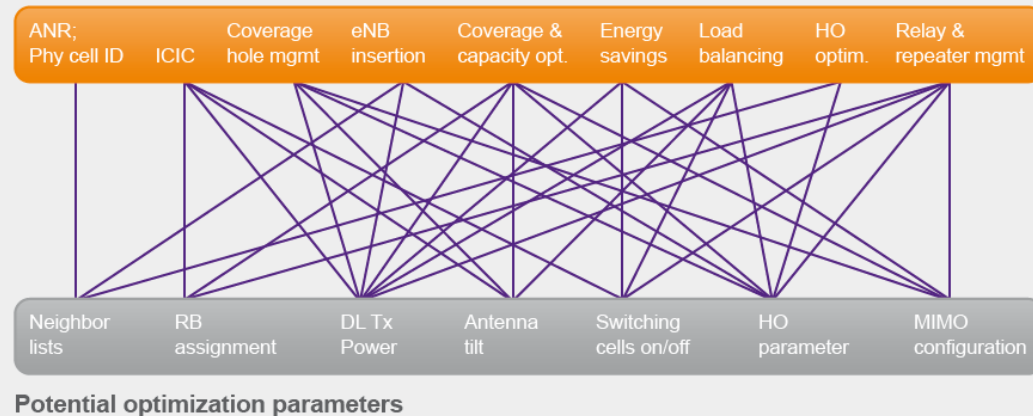
Cognitive radio

- *"Cognitive radios are aware of their surroundings and bandwidth availability and are able to dynamically tune the spectrum usage based on location, nearby radios, time of day and other factors"*
- *"This provides for a more efficient use of the spectrum as well as reducing power consumption, and enabling high priority communications to take precedence if needed"*
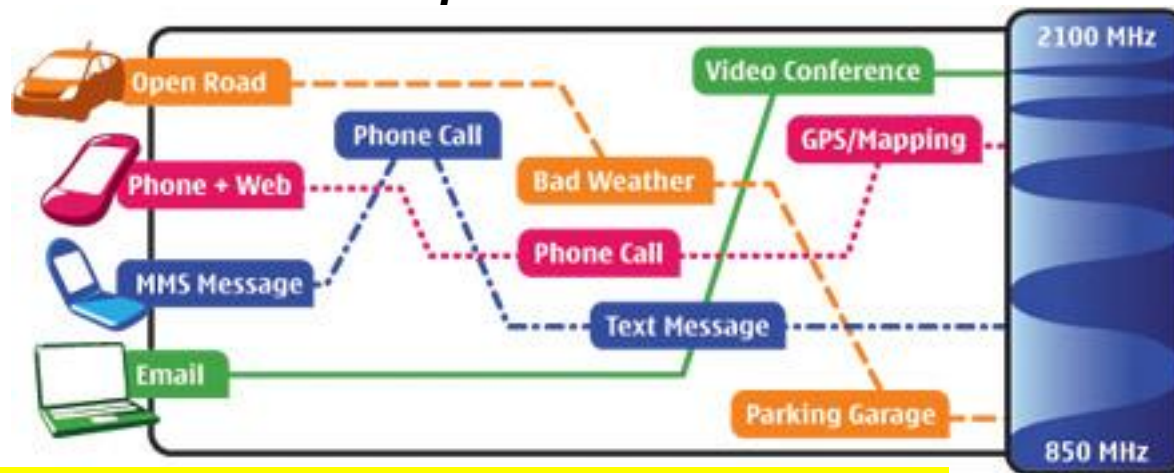
Source: Nokia Research Center, "Cognitive Radio - Liberating Spectrum to Enable New Opportunities", Web page, 2010

Cloud Computing

11/4/2010

Case ticket sales

Definition

- – *"Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable 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."*

Source: P. Mell and T. Grance, "The NIST Definition of Cloud Computing", 2009

What is cloud computing

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
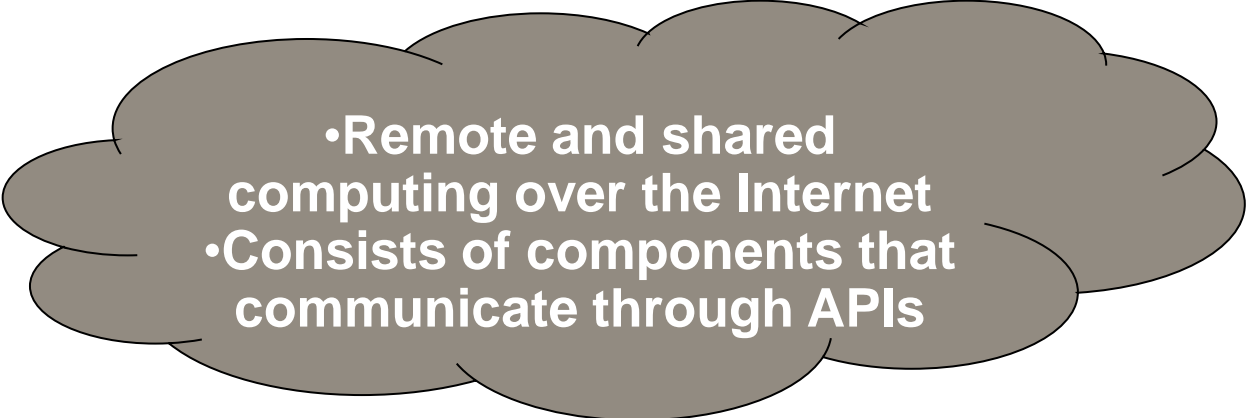
Nothing new?

- *The interesting thing about Cloud Computing is that we've redefined Cloud Computing to include everything that we already do. . . . I don't understand what we would do differently in the light of Cloud Computing other than change the wording of some of our ads.*

  Larry Ellison, quoted in the Wall Street Journal, September 26, 2008

- *It's stupidity. It's worse than stupidity: it's a marketing hype campaign. Somebody is saying this is inevitable — and whenever you hear somebody saying that, it's very likely to be a set of businesses campaigning to make it true.*

  Richard Stallman, quoted in The Guardian, September 29, 2008

Pros and Cons

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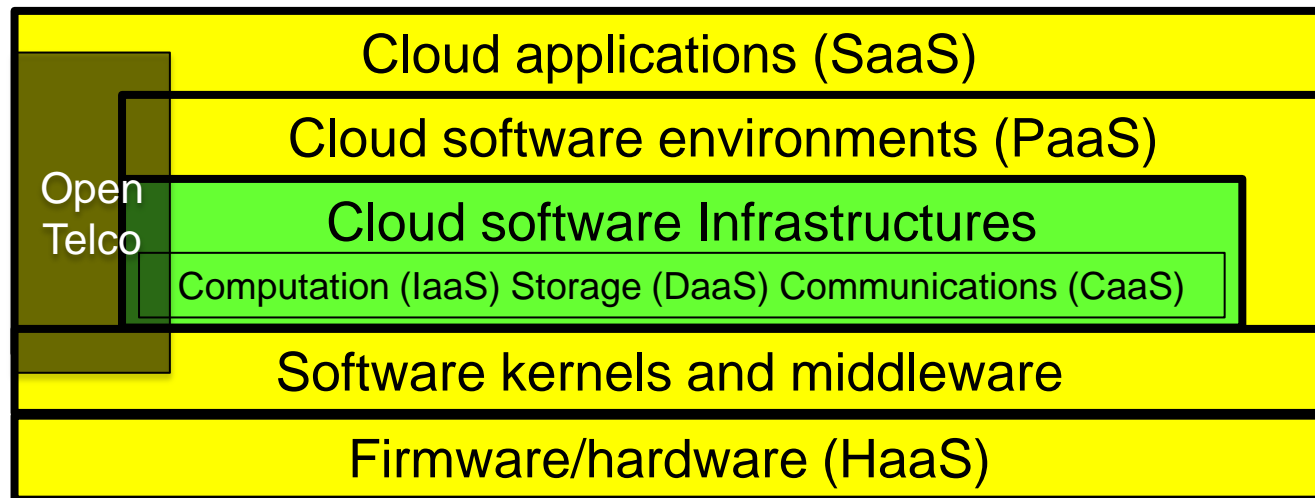•**Consists of components that communicate through APIs**

!
•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

UCSB-IBM Cloud Computing Classification Model

Cloud applications (SaaS)

Cloud software environments (PaaS)

Cloud software Infrastructures

Computation (IaaS) Storage (DaaS) Communications (CaaS)

Open Telco

Software kernels and middleware

Firmware/hardware (HaaS)

Source: Syed A. Ahson and Mohammad Ilyas, "Cloud Computing and Software Services", 2011

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Everything as a Service

Simplicity Evolution

SaaS (Software as a Service)
- – Ready to deploy application
- – Salesforce, Gmail, SMS, voice

PaaS (Platform as a Service)
- – No system administration
- – Simplified development
- – Scaling is provided by the PaaS framework
- – Google Apps Engine, Microsoft Azure

IaaS (Infrastructure as a Service)
- – Computers owned by the cloud provider
- – No hardware management issues
- – Dynamic scaling of resources through virtualization
- – Billing is calculated by usage only
- – Amazon EC2

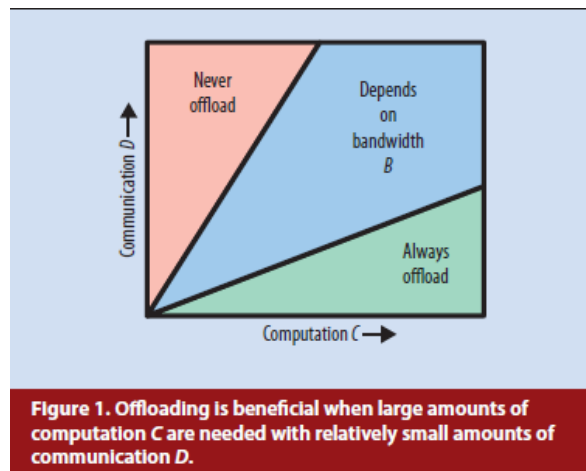**Total market 40 B€ (2011) 70% SaaS&PaaS - 30% IaaS**

Mobile capabilities
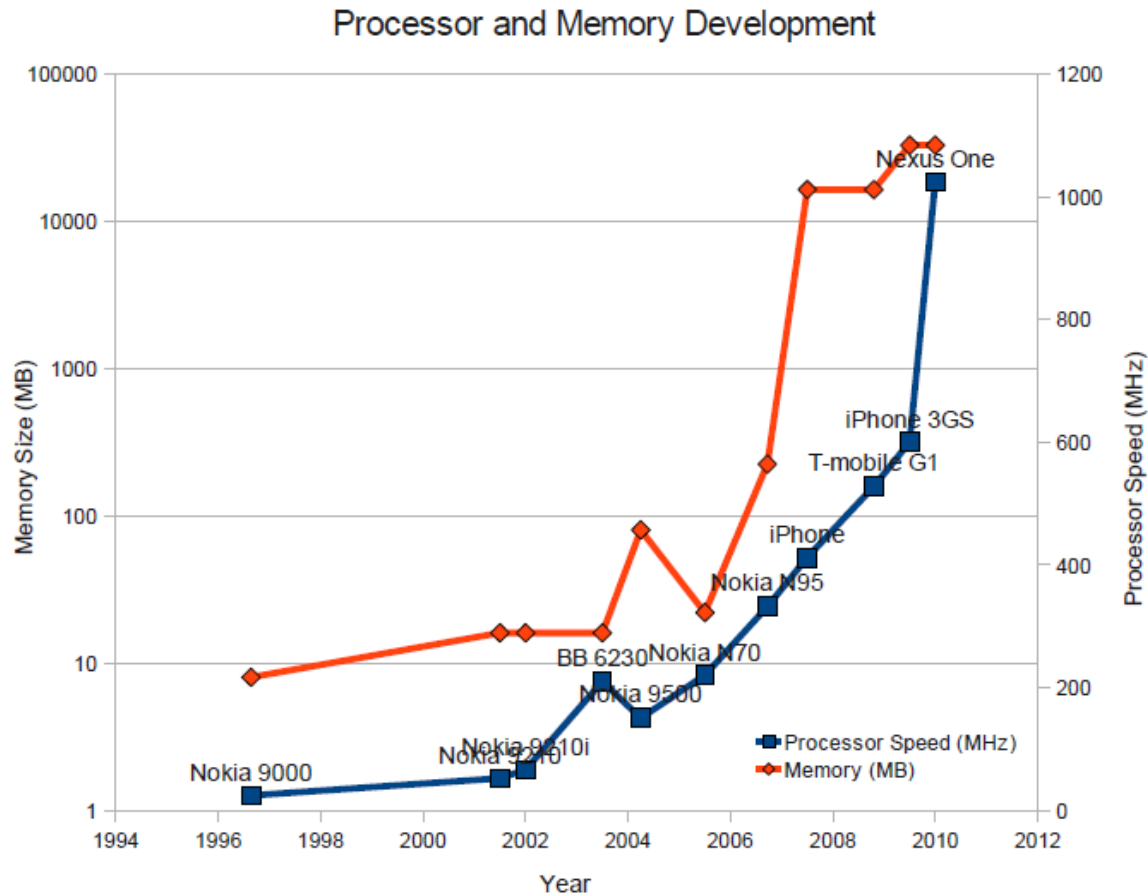
Bottleneck: Battery

Offloading computation

Figure 1. Offloading is beneficial when large amounts of computation C are needed with relatively small amounts of communication D.

(a) Single-machine computation

(b) Distributed computation
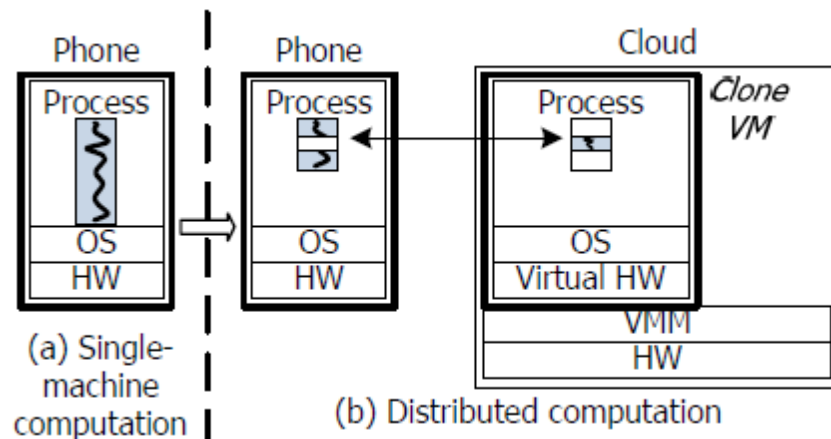
- **Application examples (by Kemp et al):**
  - Image processing
  - Audio processing
  - Text processing
  - Artificial intelligence for games
  - 3D rendering
  - Security

Cost of Bandwidth, CPU and Storage

	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)

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

Bottleneck: Bandwidth
Example: 1 TB drive, 1 Gbit/s I/O = 2 h 13 min

MapReduce

- **Numbers:**
  - Facebook with 10 billion photos (x4: 40 billion files), one PB in total; 2-3 TB are added every day
  - The Web: 100 billion web pages -> 400-500 TB compressed (duplicated across several clusters)
  - eBay has 6.5 PB of user data + 50 TB/day bytes are added every day
- **Bottleneck in data transfer speeds (reads/writes from/to disks)**
- **Unlike disk capacity, improves linearly**
- **Solution: read parallel from multiple disks**
- **Google introduced MapReduce year 2003/2004**
- **Hides from a programmer complexity of parallelization, fault-tolerance, data distribution and load-balancing**

Source: Denis Shestakov, Cloud Computing seminar 24.9.2010

Amazon Elastic Compute Cloud (EC2) pricing parameters

- **Zones**
- **Instance size**
- **Storage size**
- **Reserved instances**
- **Spot instances**
- **Data transfer**
- **Elastic IP address**
- **Monitoring services**
- **Elastic load balancing**
- **VPN**

Source: http://aws.amazon.com/ec2/pricing/

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Challenges and opportunities

#	Challenge	Opportunity
1	Availability of Service	Use Multiple Cloud Providers
2	Data Lock-In	API standardization
3	Data Confidentiality and Auditability	Deploy Encryption, VLANs, and Firewalls
4	Data Transfer Bottlenecks	Higher Bandwidth LAN Switches
5	Performance Unpredictability	Flash Memory
6	Scalable Storage	Invent Scalable Store
7	Bugs in Large-Scale Distributed Systems	Invent Debugger that relies on Distributed VMs
8	Scaling Quickly	Invent Auto-Scaler
9	Reputation Fate Sharing	Offer reputation-guarding services
10	Software Licensing	Pay-for-use licenses

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

Top Security Risks

Threat	Description	Target
Abuse and Nefarious Use of Cloud Computing	Abusing anonymity for spamming, malicous code launch etc.	IaaS, PaaS
Insecure Interfaces and APIs	Anonymous logging, miuse of resources	All
Malicious Insiders	Misuse of internal information	All
Shared Technology Issues	Misuse of computation resources	IaaS
Data Loss or Leakage	Misuse of data	All
Account or Service Hijacking	Eavesdrop business	All
Unknown Risk Profile	Lack of control	All

Mobile Cloud

What is Mobile Cloud

Tekes Signal Session 11.5.2010:
1. Mobile access to fixed cloud
2. Enabler for new services utilizing the benefits of mobiles and clouds
3. Adhoc cloud based on mobiles

Telecom Forum, Pekka Markkula (TeliaSonera) 21.9.2010:
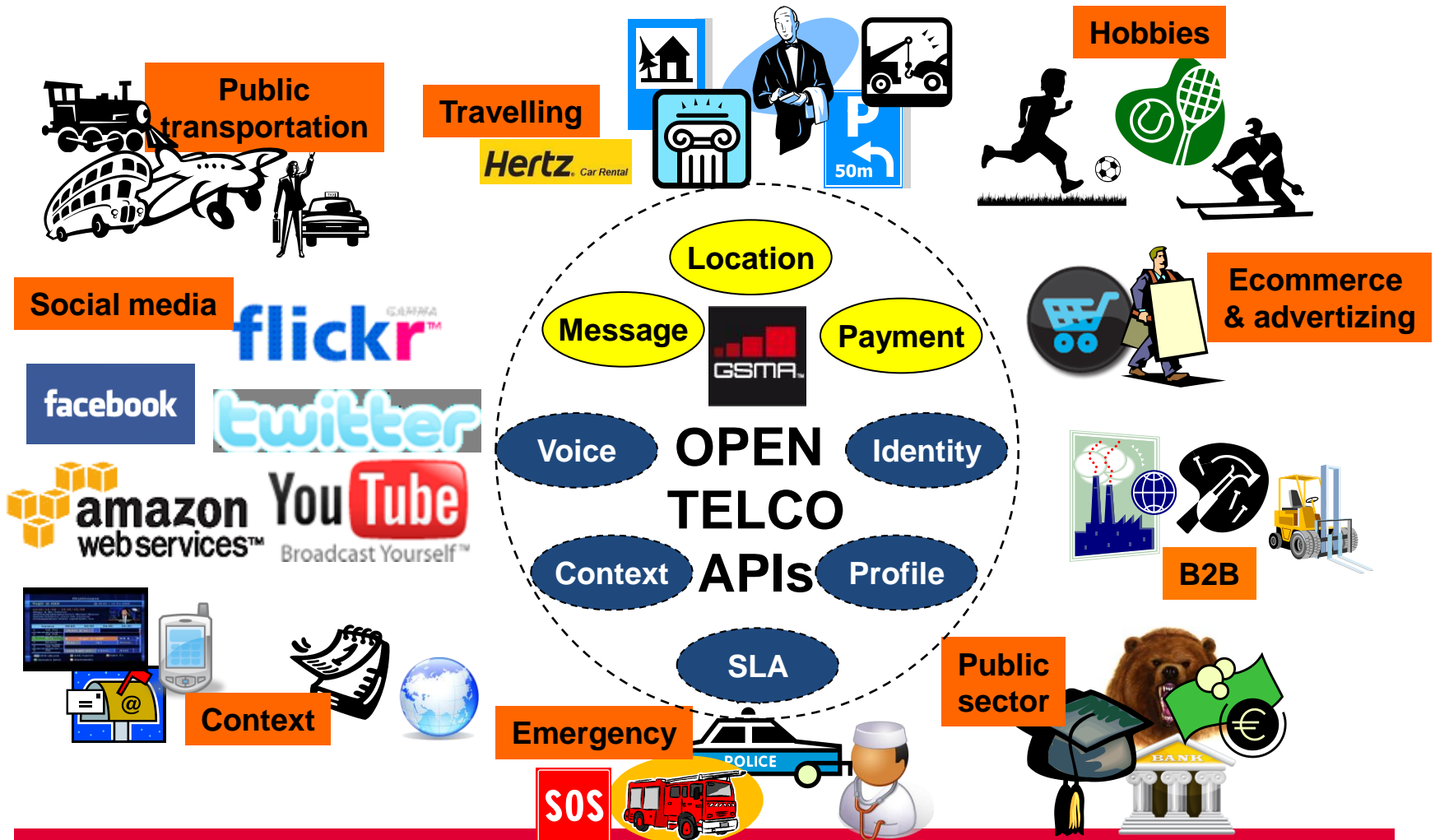- Mobility
- E2E Security
- Context awareness

Mobile Cloud

Open Telco

Cloud

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Mobile Cloud project

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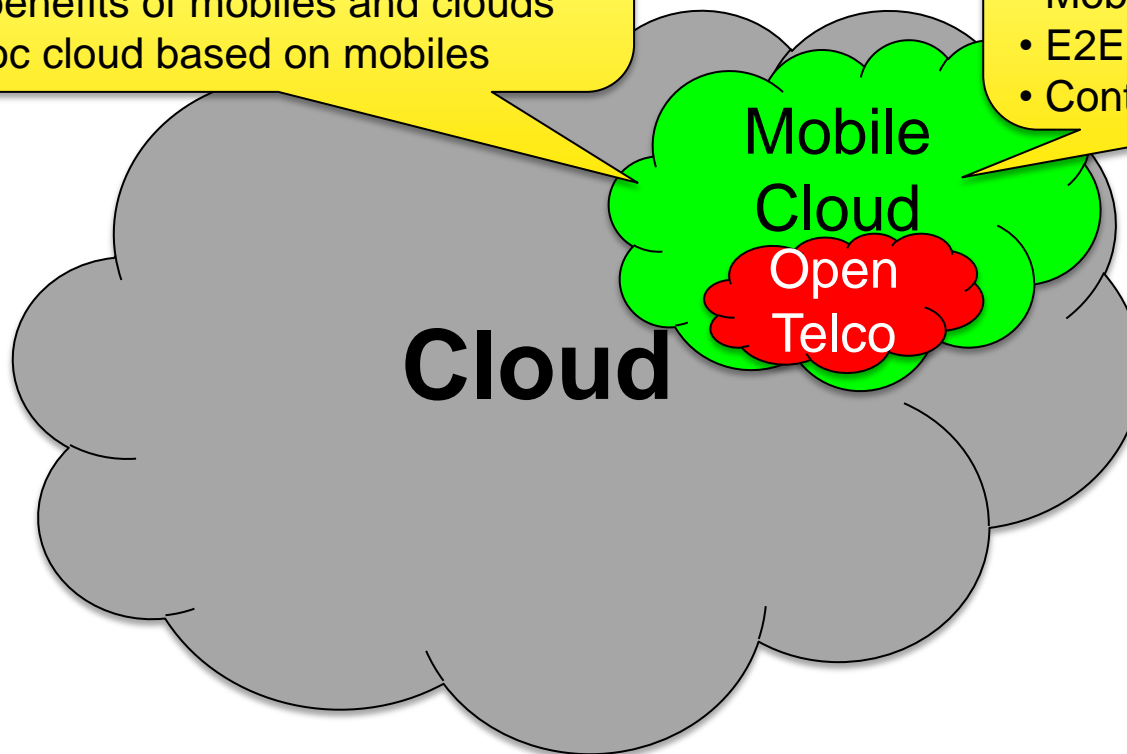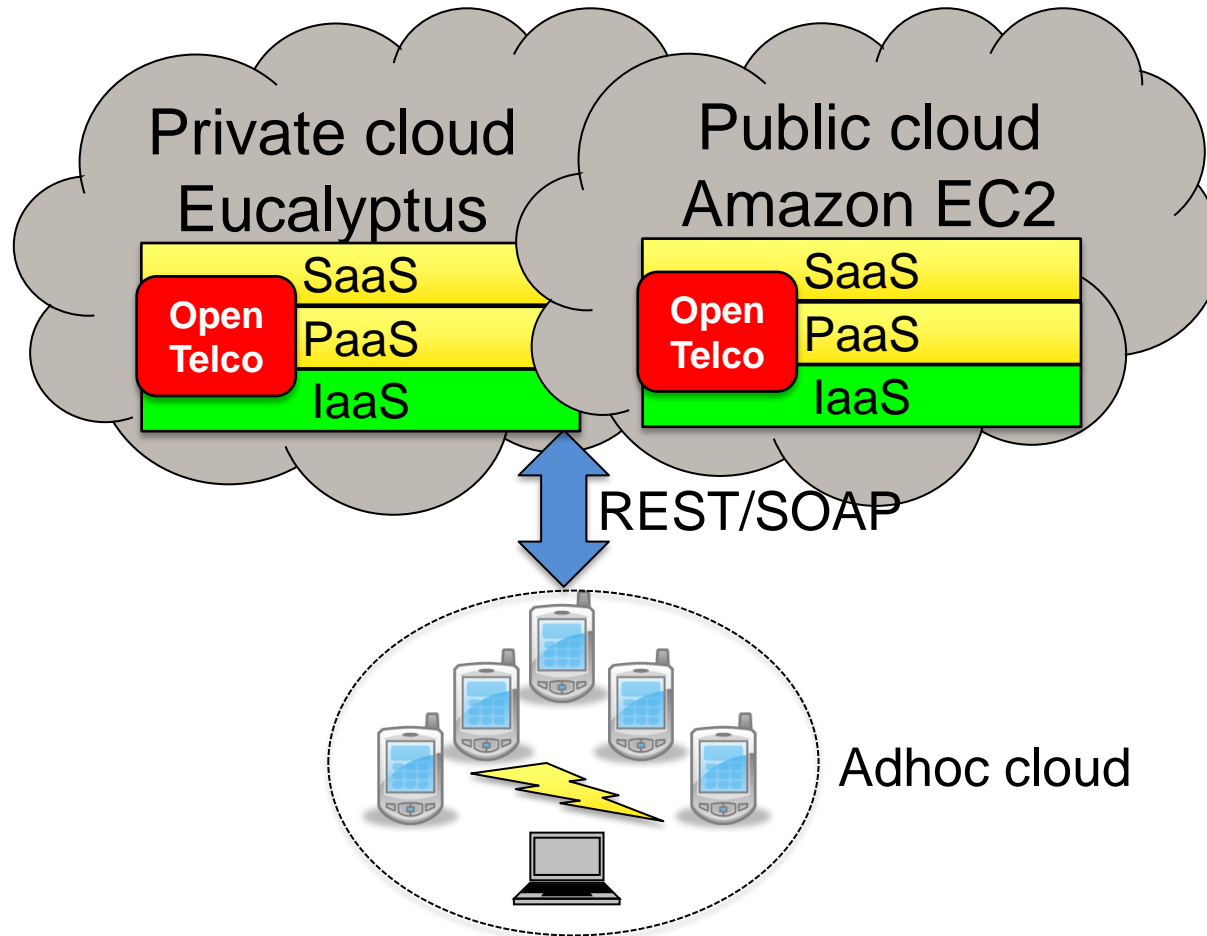
Research goals

- **HBase NoSQL cloud storage in Telecom environment, measured with <u>TATP benchmark</u> tool**
- **Earlier thesis about Cassandra NoSQL DB**
- **Hybrid (mobile-fixed) cloud**
  - Adhoc cloud
  - Hadoop/MapReduce in N900
- **Hybrid (private-public) cloud**
  - Software development process for SME
  - Peak load management
- **REST interface**
- **Security and privacy challenges**

NoSQL databases

- **No SQL, Not only SQL**
- **A family of databases for implementing storage in the cloud**
- **Google BigTable, Amazon SimpleDB, LinkedIn Voldemort**
- **Good for web-scale data and analytics, not so great for transaction processing**
- **Data model not relational, rather a key-value store**
- **Scalable by nature**
- **ACID (Atomicity, Consistency, Isolation, Durability) relaxed in favor of BASE (Basically Available, Soft state, Eventually consistent)**
- **Easier scalability, partition tolerances**

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Open APIs exist everywhere

Public transportation

Travelling
Hertz Car Rental

Hobbies

Social media
flickr
facebook
twitter
amazon web services™
You Tube Broadcast Yourself™

Ecommerce & advertizing

Location

Message

Payment

Voice

OPEN TELCO APIs

Identity

Context

Profile

SLA

B2B

Context

Emergency
SOS

Public sector

Open Telco in a nutshell

- **Provide open and secure interfaces (API's) into telecom network infrastructure**
- **Selected information is made available through these API's for 3rd party developers**
- **3rd party developers can develop innovative new services in mash-up fashion for the benefit of the end-users**
- **Work started in GSMA OneAPI group,Telco 2.0 Forum and OMA**
- **Our core targets**
  - Reviewing theoretical literature and frameworks
  - Report on secure & open APIs and middleware solutions in cloud
  - Analyzing business models and value networks
  - Developing a demonstration system with real APIs in multi-operator & -vendor networks

TeliaSonera developer portal

Service example 1: Location tracing
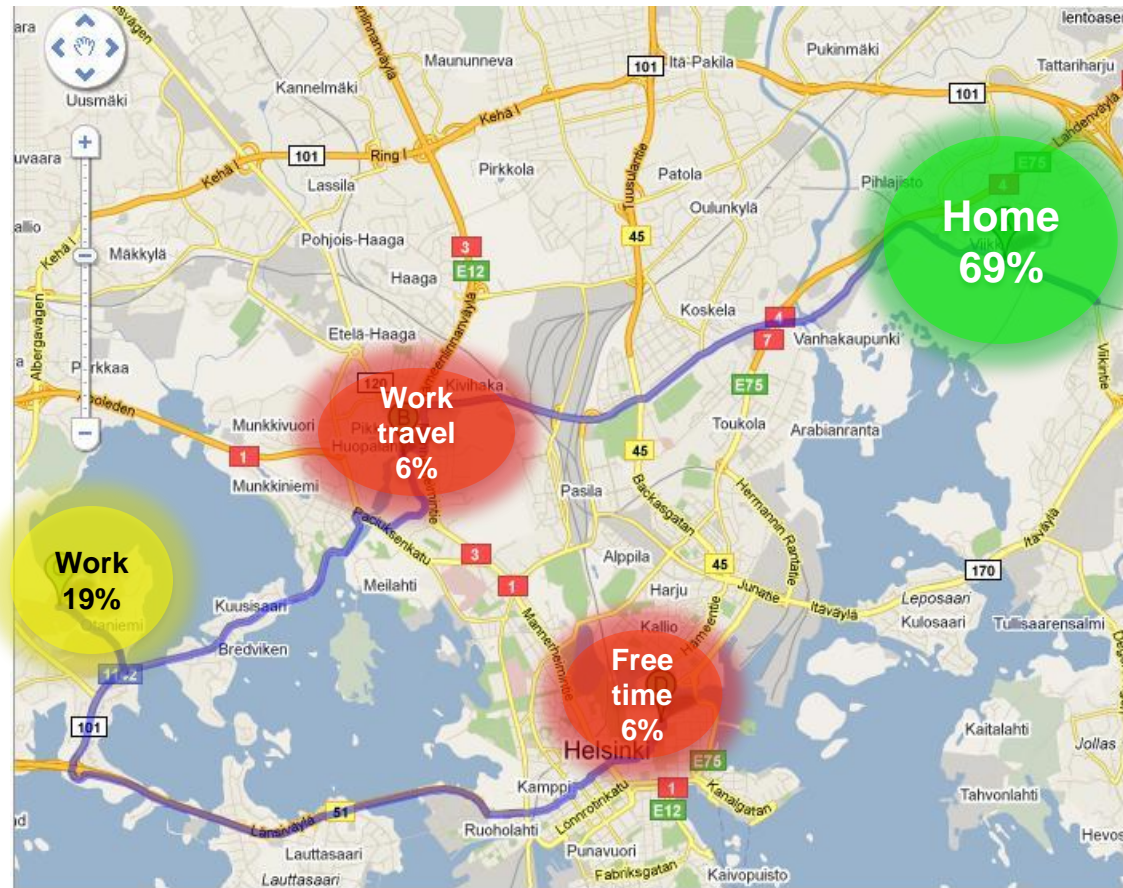
Service example 3: Event Experience

Tiketti: event tickets

VTT: UX, Upcode matrix code

Google: maps

Event Experience (University of Hki & Aalto)

HSL: timetables, travel tickets

Nokia: Instant Community

Open Telco: location, messaging, payment

Facebook: event, friends, notifications, content sharing, feedback
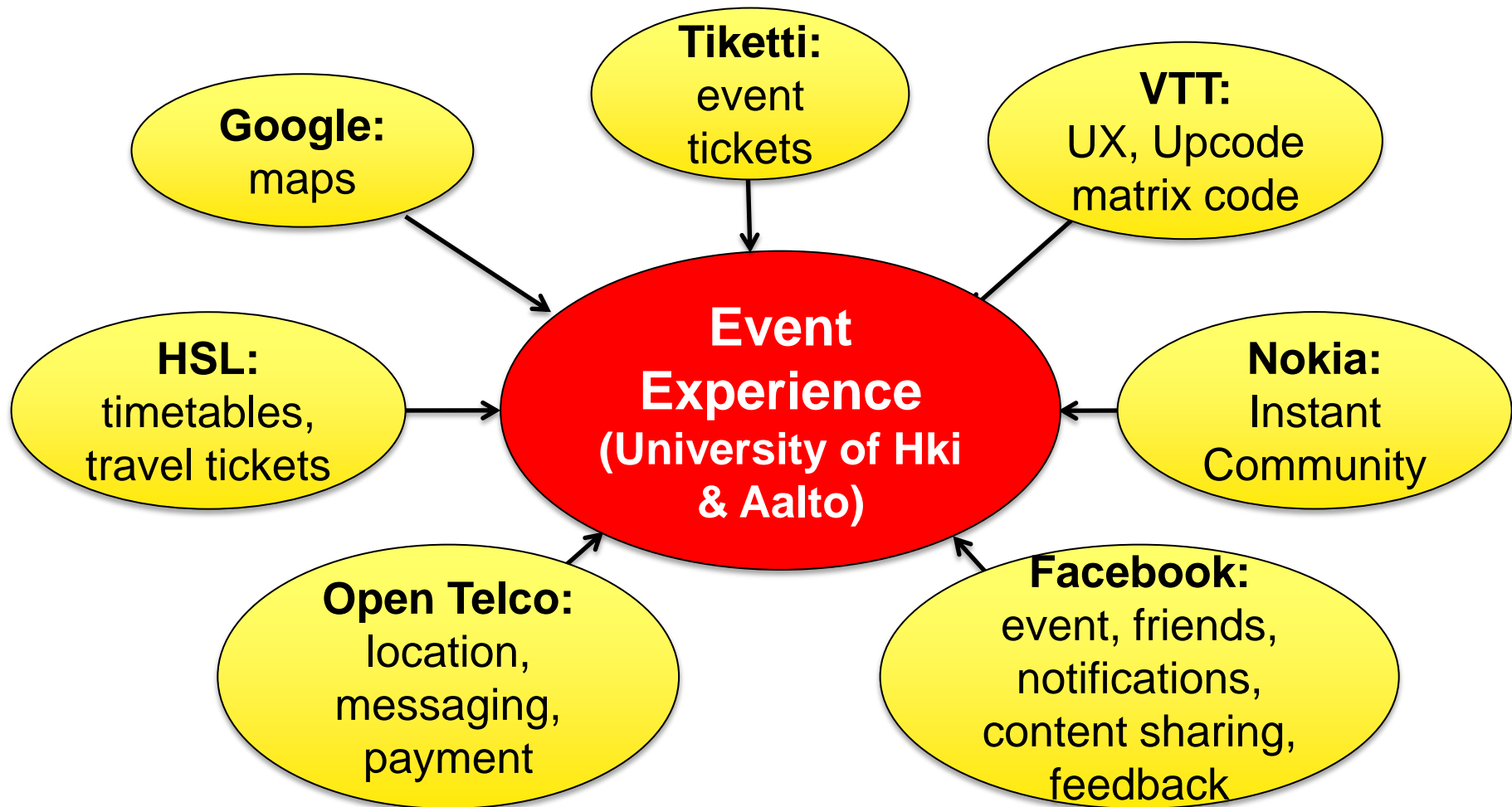
Future research topics

- **OpenNebula, Eucalyptus, Hadoop vs. Amazon EC2**
- **NoSQL in application servers**
- **Hybrid models**
  - Performance, scalability
  - Which components to migrate to cloud
  - Security policies, data compliance, private public cloud (VPN)
  - Load balancing algorithm
  - Business decision – to lease or not to lease
  - Offloading computation from mobile to cloud
- **<u>Security</u> (Data compliance, Location privacy, Hybrid clouds)**
- **LTE and cloud computing**
- **Data mining & Long Tail of Mobile Services**

Thank You!
Any final questions?

Email: yrjo.raivio@tkk.fi
Room: A122

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