Computer Networks
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Mobile Cloud
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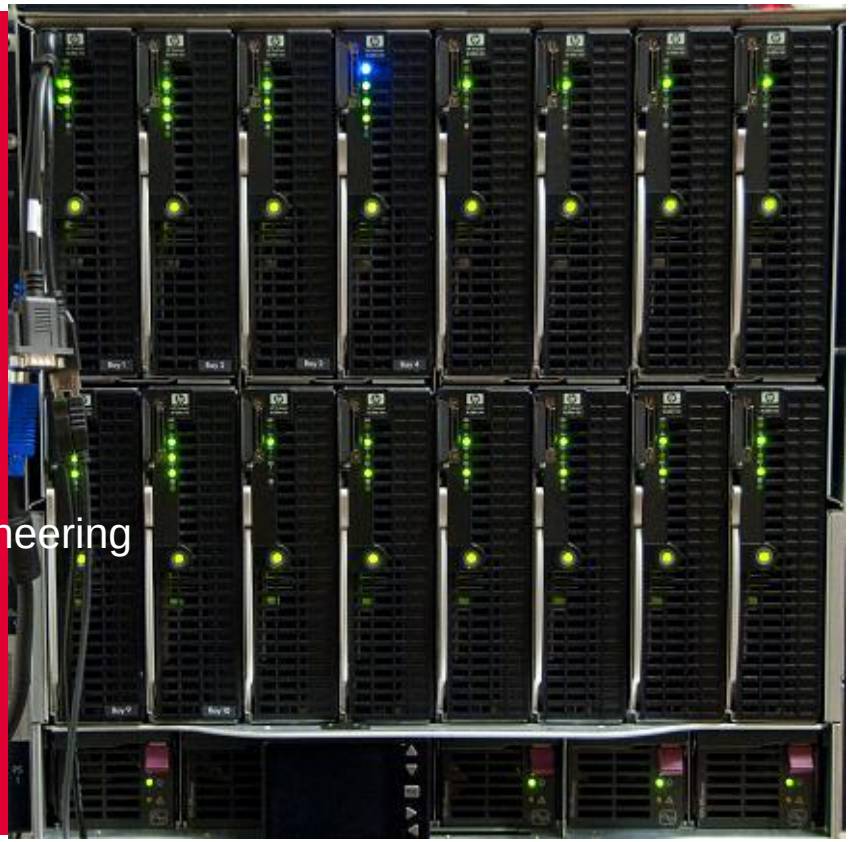


Outline

- Drivers
- Mobile Cloud components
- HLR in Cloud
- SMSC in Cloud
- MVNO in Cloud
- Mobile Offloading
- CrowdCloud
- Conclusions

Server problems are common..

Päivitetty 20.9.2011 10:19, julkaistu 20.9.2011 10:08

IT-firmalla uskomaton selitys VR:n lippukaaoksesta: ”monitoimittajahanke”

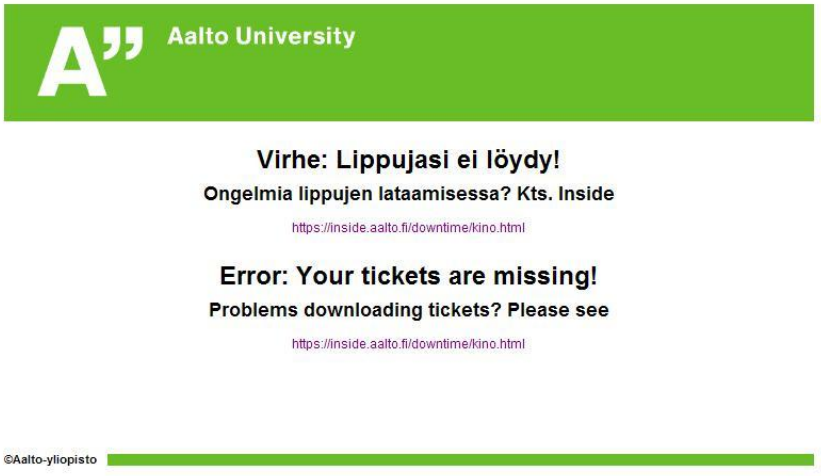
Kuva: Jarkko Mikkonen

Tampereen rautatieaseman lipputoimistossa oli jonkin verran jonoa maanantaina, kun automaatit oli suljettu.

MACHINE ROOM ■ Suvi Korhonen, 08.27.2010, 10:24

One server blacked Logica server room

Logica 's data center in Sweden Bromöllassa downtime attributable to the discovery of a serious fault with servers. Logica announced that customers with problems to hardware failure caused by lightning.



…and also in telecom networks

Wireless End-to-End

Serving Wireless Communications Industry

Another Outage / More Lessons: Geo-redundancy Couldn't Prevent Verizon LTE Service Disruption

by wirelesse2e *on* May 2, 2011

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.

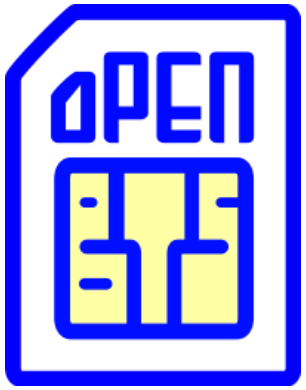
At 7 o'clock in the morning revealed the fault was corrected at the time of 10.30. Most of the phones to operate normally, shortly after noon and all.

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.

Mobile Cloud gains interest

Data

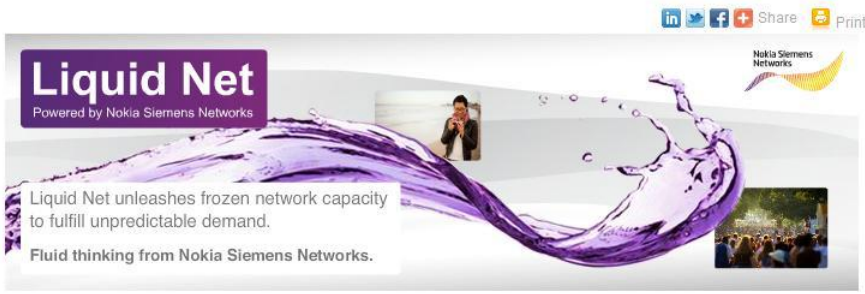
Computation



Introducing Amazon Silk

SEPTEMBER 28, 2011 BY THE AMAZON SILK TEAM 717 COMMENTS

Today in New York, Amazon introduced Silk, an all-new web browser powered by Amazon Web Services (AWS) and available exclusively on the just announced Kindle Fire. You might be asking, "A browser? Do we really need another one?" As you'll see in the video below, Silk isn't just another browser. We sought from the start to tap into the power and capabilities of the AWS infrastructure to overcome the limitations of typical mobile browsers. Instead of a device-siloed software application, Amazon Silk deploys a split-architecture. All of the browser subsystems are present on your Kindle Fire as well as on the AWS cloud computing platform. Each time you load a web page, Silk makes a dynamic decision about which of these subsystems will run locally and which will execute remotely. In short, Amazon Silk extends the boundaries of the browser, coupling the capabilities and interactivity of your local device with the massive computing power, memory, and network connectivity of our cloud.



Liquid Net

We'll help you overcome conventional network limitations and flow spare capacity where it is needed, when it is needed.

Downloads

Everything as a Service

SaaS (Software as a Service)

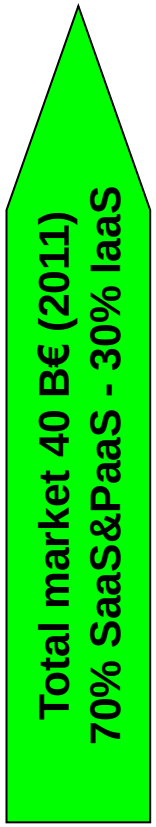
- Ready to deploy application
- Salesforce, Gmail, SMS, voice

PaaS (Platform as a Service)

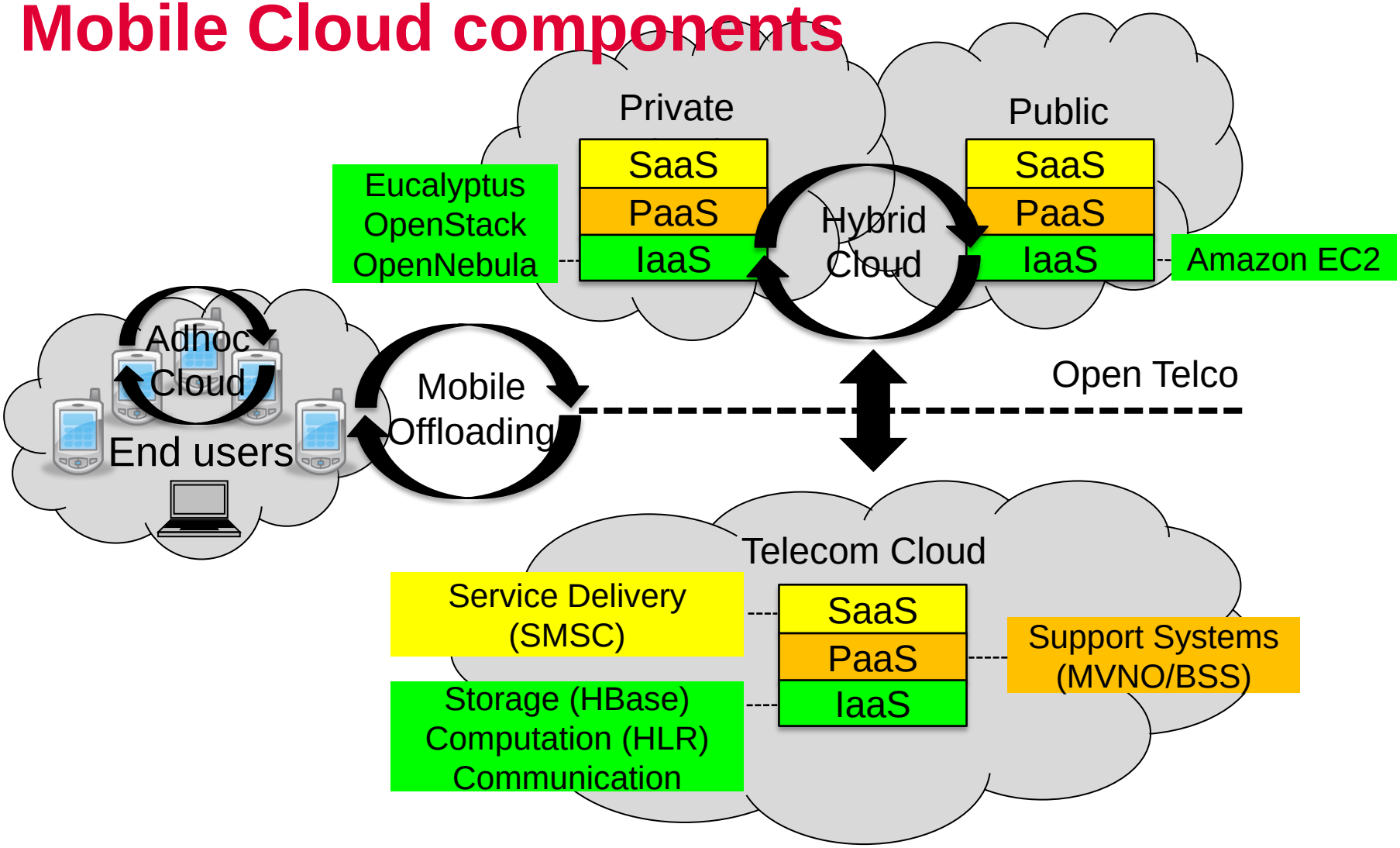
- No system administration
- Simplified development
- Scaling is provided by the PaaS framework
- Google Apps Engine, Microsoft Azure, Force.com

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

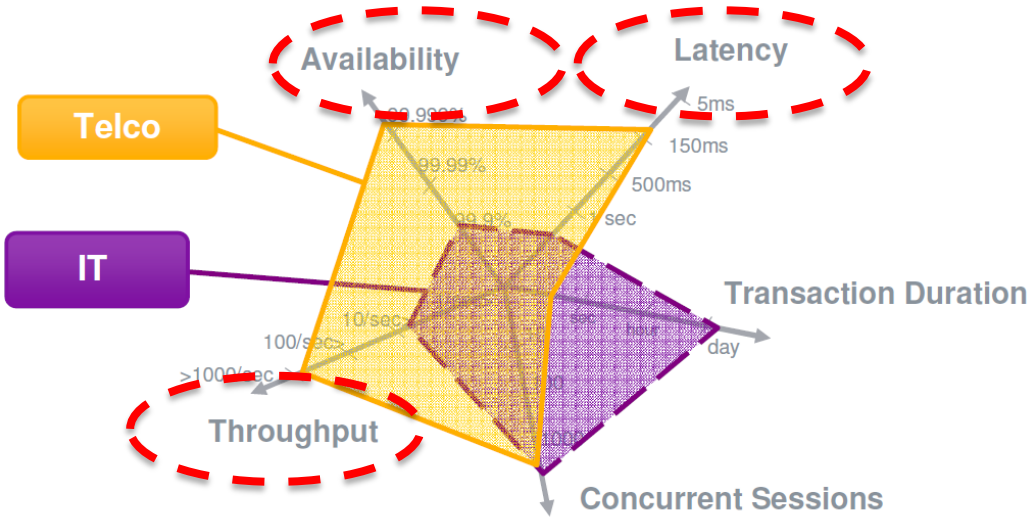


Mobile Cloud components



Service Level Agreement (SLA)

- **Research topics:**
  - Availability
  - Latency
  - Throughput
- **Availability alone not enough**
- **Telecom users require more specific SLAs**
- **Sustainability?**
- **Penalties from violation?**
- **Monitoring tools important**

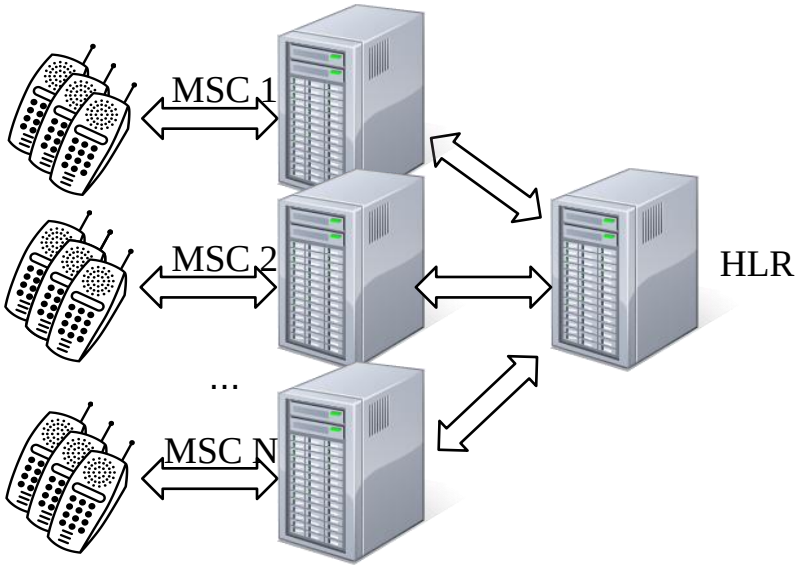


Source: M. Murphy, "Telco Clouds" [presentation], Cloud Asia 2010

SLA	Carrier grade	6 EC2 Large VMs
Availability	99.999 %	99.95 % one zone 99.9999 % two zones
Latency	< 150 ms	< 50 ms (EU zone)
Throughput	> 1000 msg/s	>1000 msg/s

HLR in Cloud

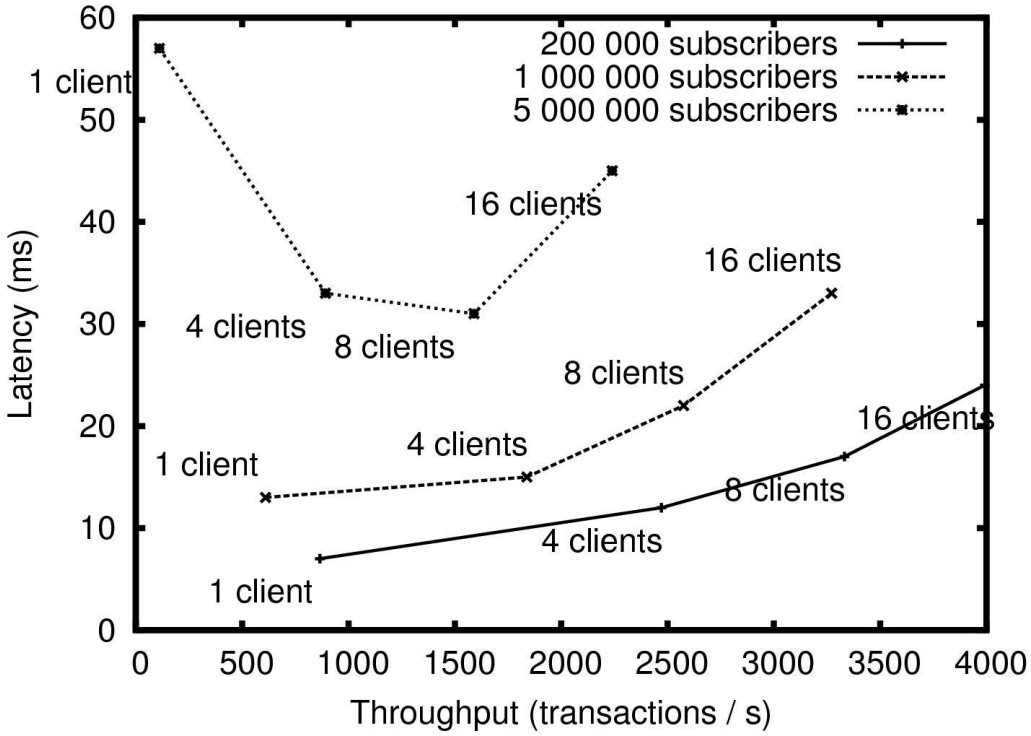
- **TATP (Telecommunication Application Transaction Processing) benchmark originally developed in 2003 to test HLRs based on SQL databases**
- **Simulates load on HLR database**
- **Ported for HBase NoSQL database, four tables denormalised into one adding redundancy**
- **80% reads, 20% writes**



Source: http://tatpbenchmark.sourceforge.net/

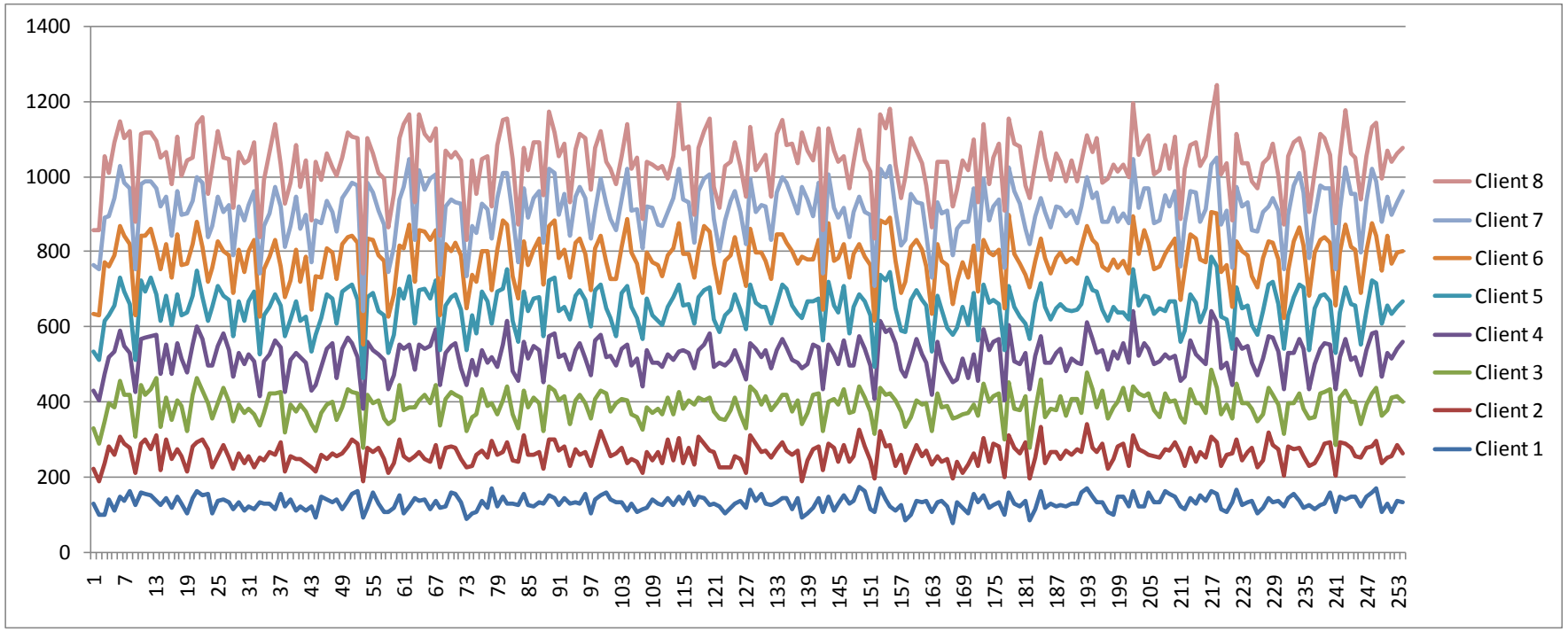
Measurement results - example

- **Latency: the 95th percentile of the worst performing client and heaviest transaction type**
- **Throughput: sum of throughput of all clients**
- **Performance gets worse as database size increases**
- **Even with 5 million subscribers results are still good**
- **One client cannot provide enough load with large database**



Source: R. Paivarinta and Y. Raivio: Performance Evaluation of NoSQL databases in Mobile Networks, Closer2011

Throughput results with 1 master, 4 slaves and 8 benchmark clients

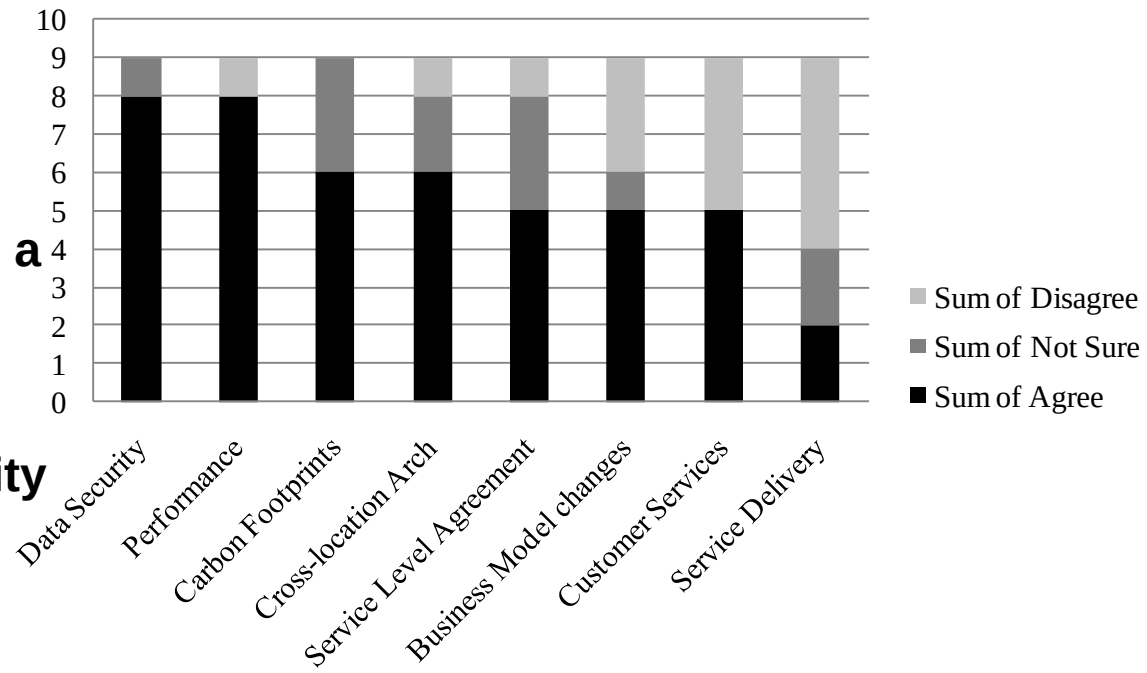


Sum of transactions per second with 200 000 subscribers, 300 s measurement

Source: http://code.google.com/apis/chart/

MVNO in Cloud - Parameter evaluation

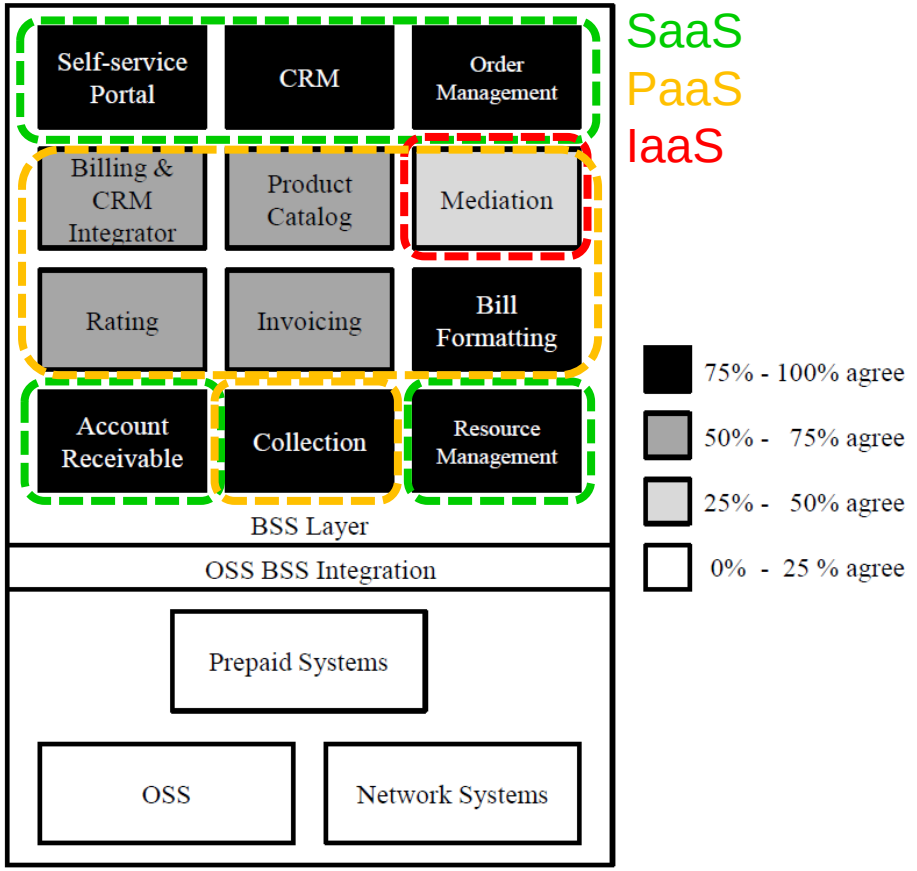
- **Data security important and concerns exist**
- **Cloud performance questioned, but high SLA not required**
- **Cross-location can be a challenge due to integration work**
- **Decrease of carbon footprint an opportunity**
- **Cloud not needed for service delivery**



Source: Y. Raivio and R. Dave, Cloud Computing in Mobile Networks - Case MVNO, ICIN2011, 4.-7.10.2011

MVNO mapping to Cloud

- **Basically all BSS functions except Mediation**
- **Prepaid, OSS or Network Systems not recommended**
- **Cloud computing suits to offline and web access tasks**
- **SaaS: End user intervention**
- **IaaS: High computation**
- **PaaS: Can be shared with other MVNOs**



SMSC in Cloud

- **Compare**
  - Public cloud
  - Hosted private cloud (run from Web hotel)
  - Dynamic hybrid cloud (public & private, own or hosted)
- **Minimize**

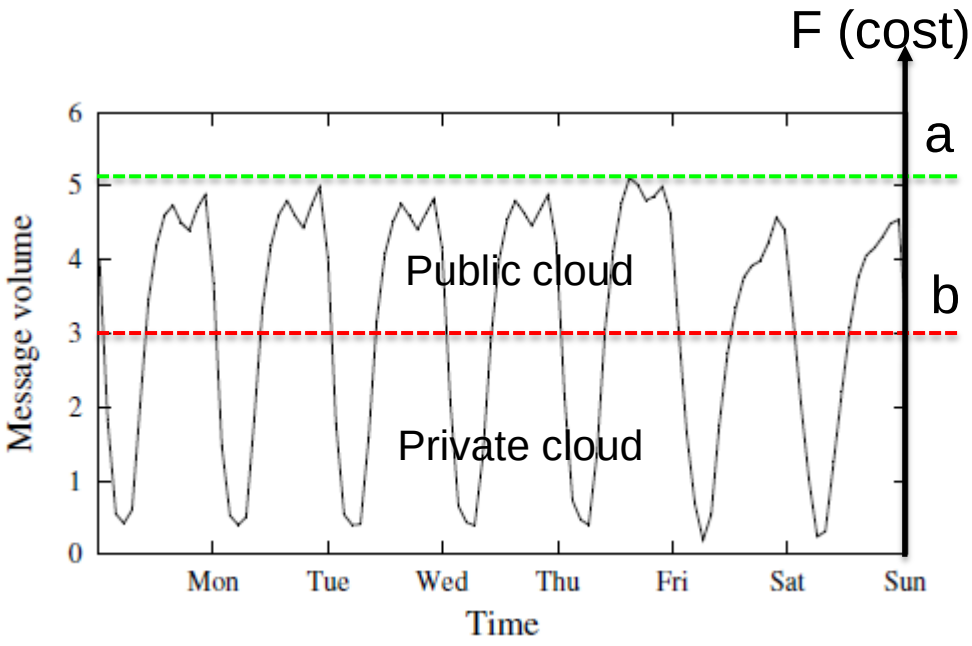
$$F = A \int_{0}^{b} f(y) + B \int_{b}^{a} f(y)\, dt, \text{ where}$$

A = private cloud cost/msg

B = public cloud cost/msg

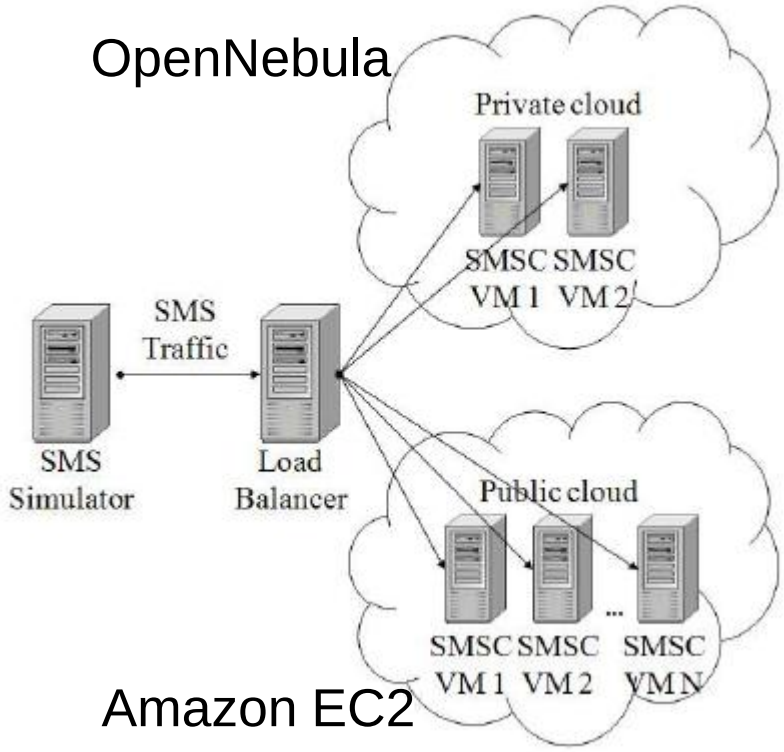
a = peak load

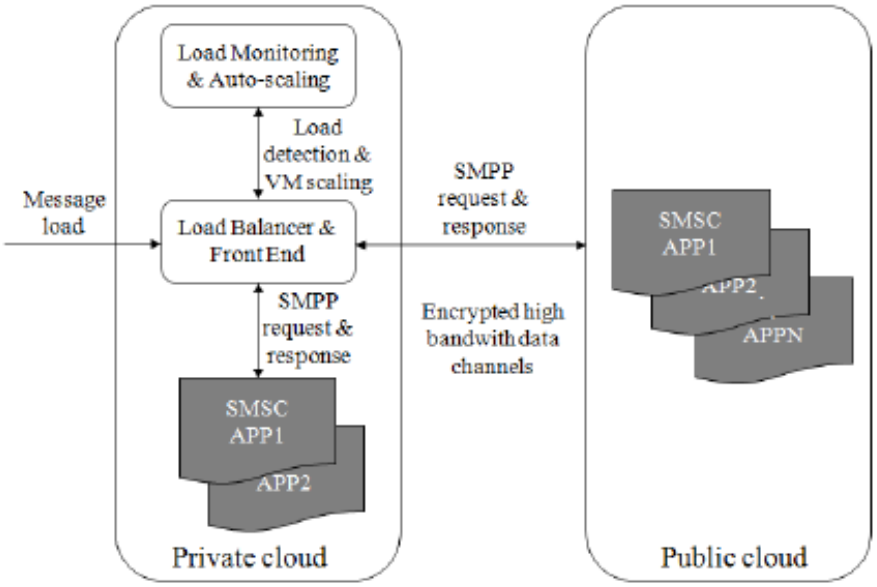
b = private cloud max capacity



Source: TeliaSonera

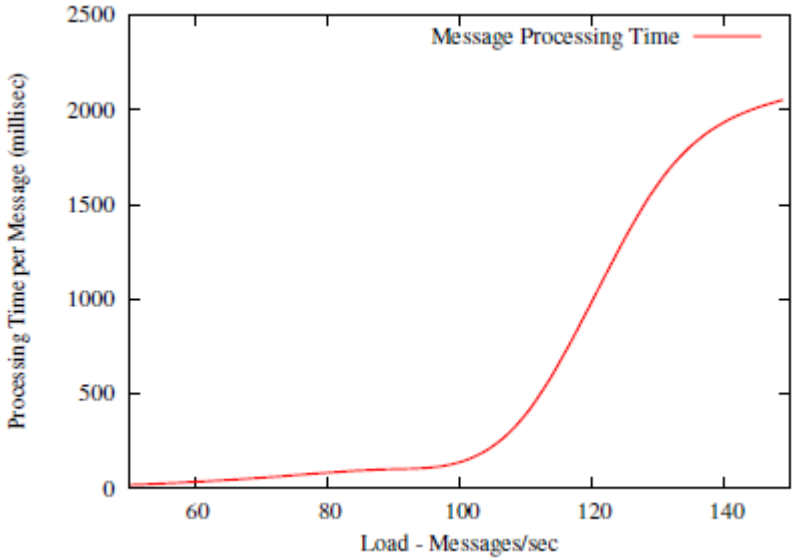
Simulator setup

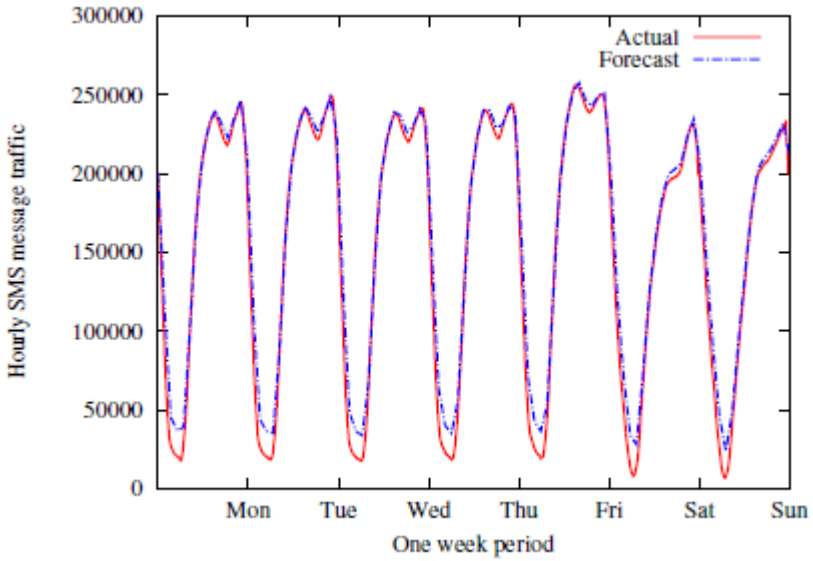




http://www.seleniumsoftware.com/
http://sourceforge.net/projects/smstools/
http://haproxy.1wt.eu/
http://www.frenchfries.net/paul/tcpstat/
http://www.xmlrpc.com/

Measurement & Simulation results





Source: Koushik Annapureddy, Ramasivakarthik Mallavarapu and Yrjo Raivio, Efficient and Dynamic Resource Management of Telecom Components in Hybrid Cloud (STEW2011)

Mobile offloading

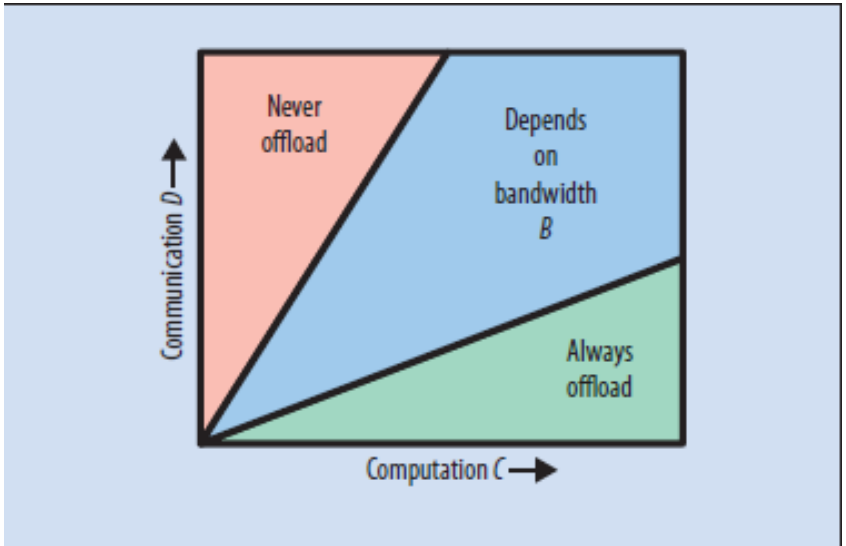
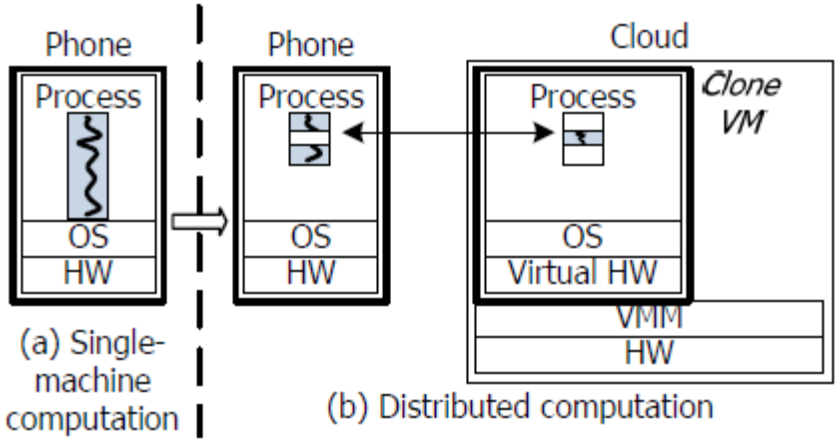


Figure 1. Offloading is beneficial when large amounts of computation *C* are needed with relatively small amounts of communication *D*.

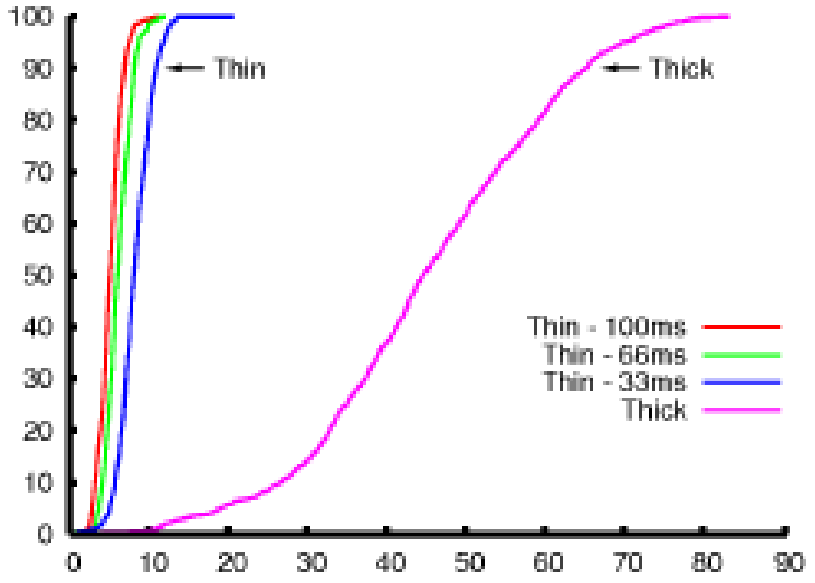


Source: B.-G. Chun and P. Maniatis, ”Augmented Smartphone Applications Through Clone Cloud Execution”, HotOS 2009.

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

Mobile Offloading technology analysis

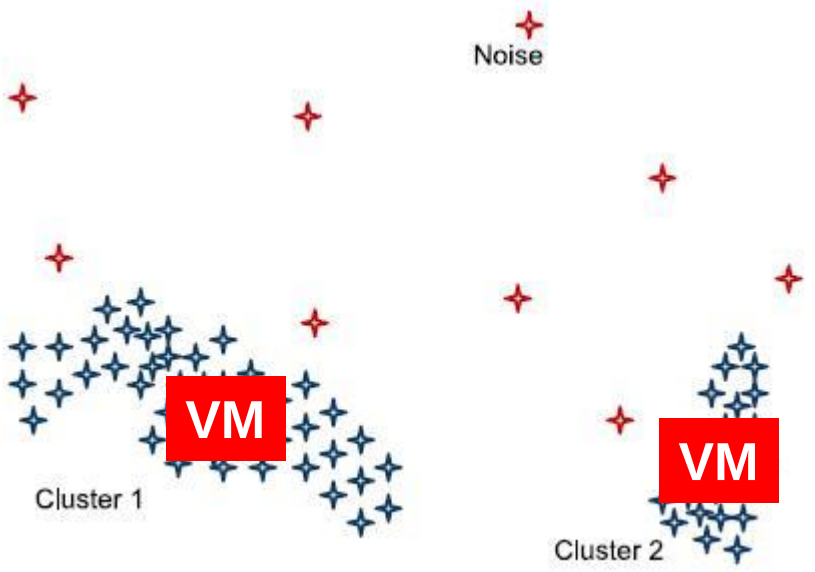
- **Two Android frameworks studied**
  - Cuckoo, Vrije Universiteit
  - ThinkAir, DT Labs/TU Berlin
- **Drivers**
  - Battery power
  - Novel applications
  - Device fragmentation
  - WiFi, LTE
- **Challenges**
  - Security
  - QoS
  - Technology

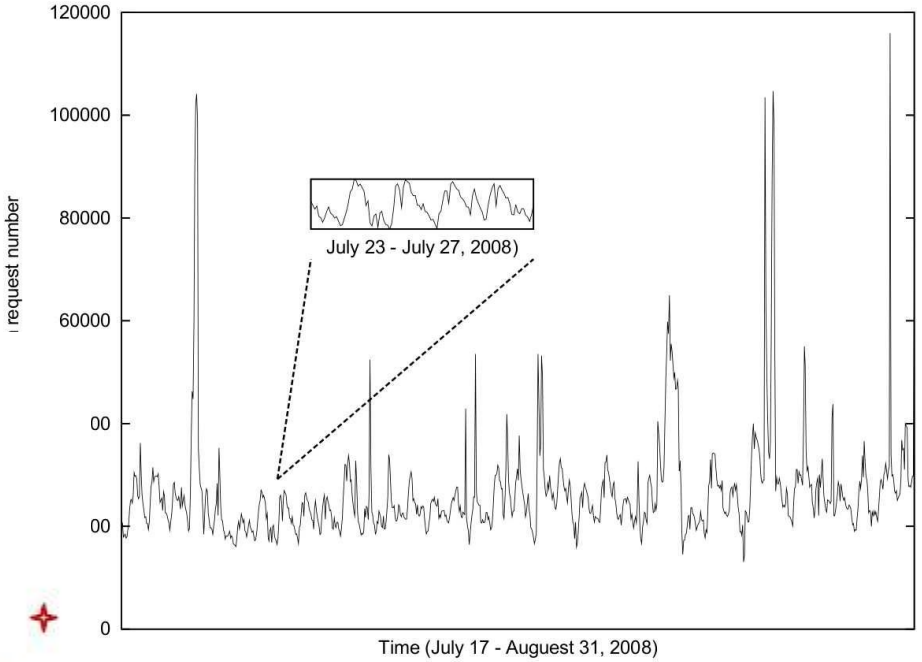


Source: M. Satyanarayanan, V. Bahl, R. Caceres, and N. Davies. The Case for VM-based Cloudlets in Mobile Computing. IEEE Pervasive Computing, vol. 99, no. 1, 2009.

Using clusters to optimise computation

- **Slash-dot effect: during peak similar content accessed**
- **90% of IP addresses within 2 time zones from middle**



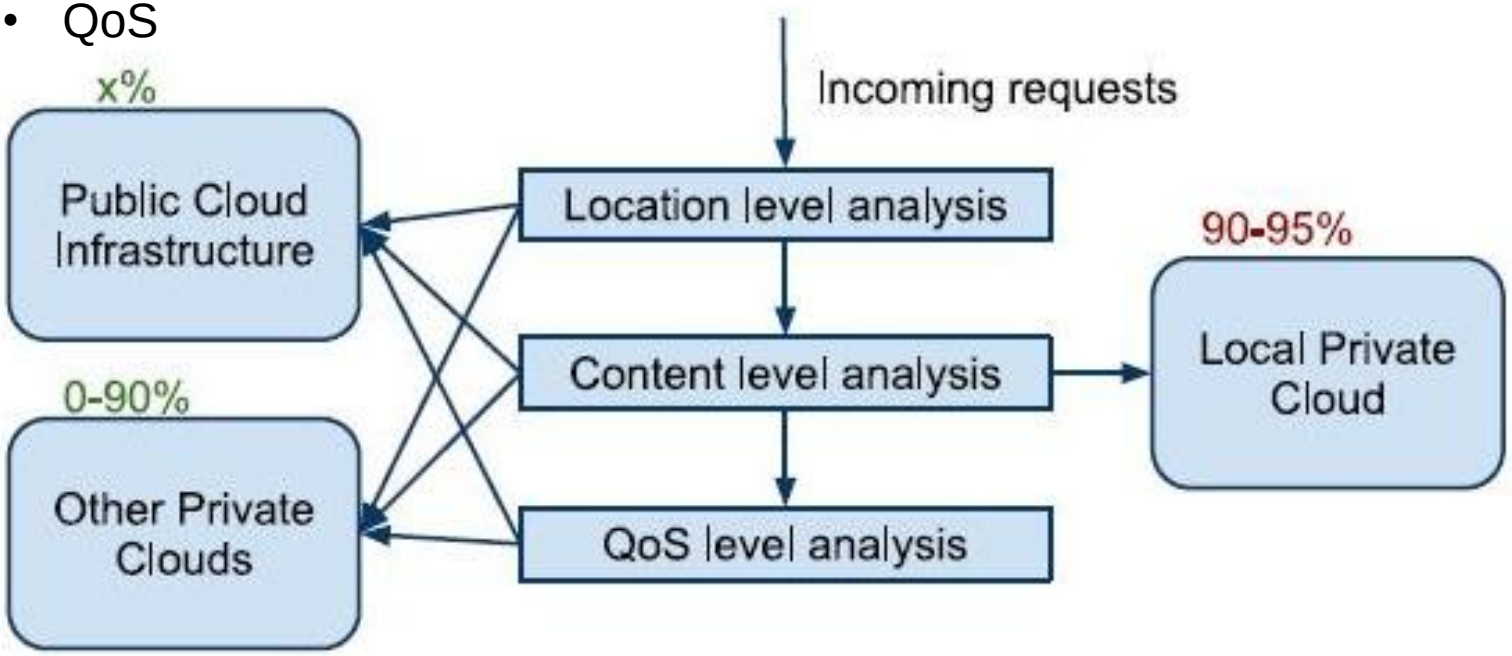


Video stream workload on Yahoo! Video web service

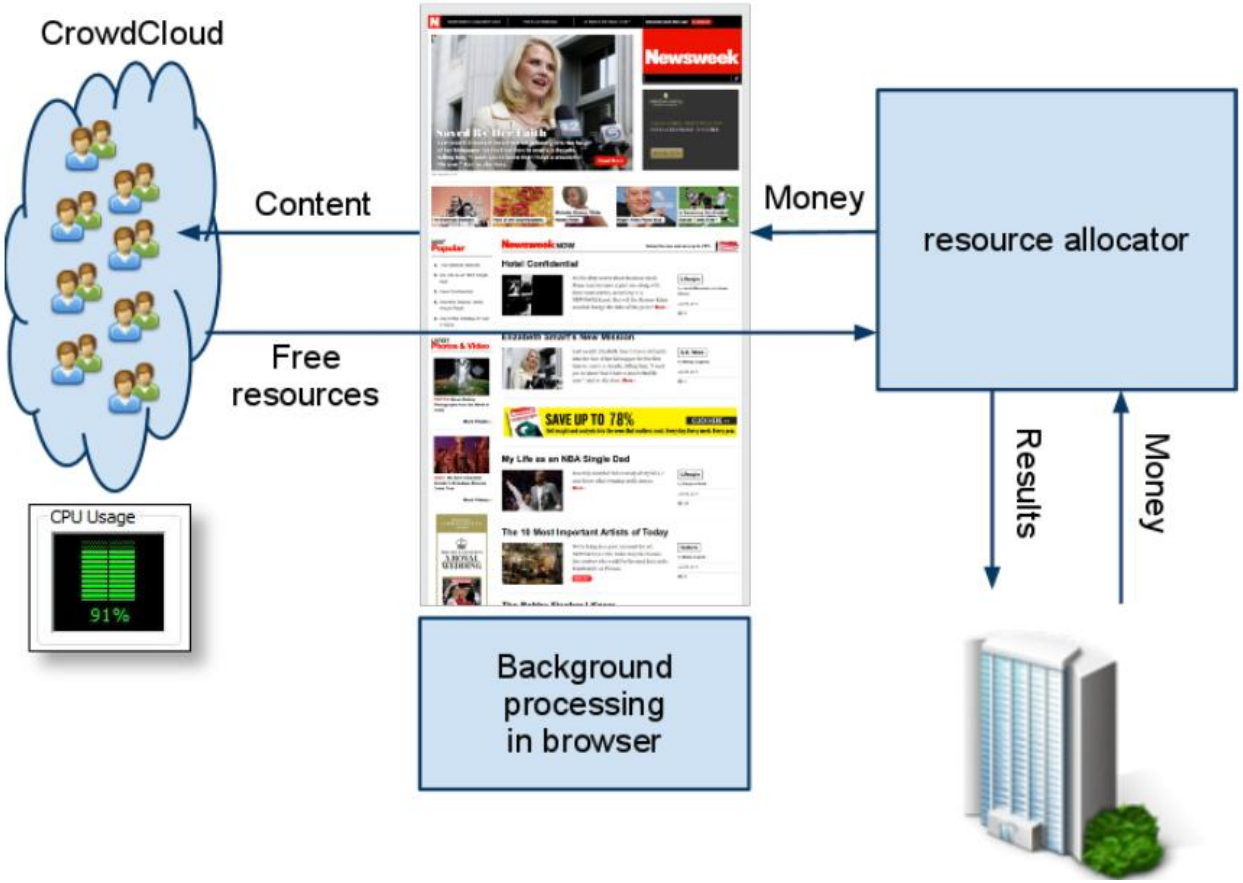
Source: H. Zhang, G. Jiang, K. Yoshihira, H. Chen, and A. Saxena. Intelligent workload factoring for a hybrid cloud computing model. In Proceedings of the 2009 Congress on Services - I, pages 701–708, Washington, DC, USA, 2009. IEEE Computer Society.

Algorithm

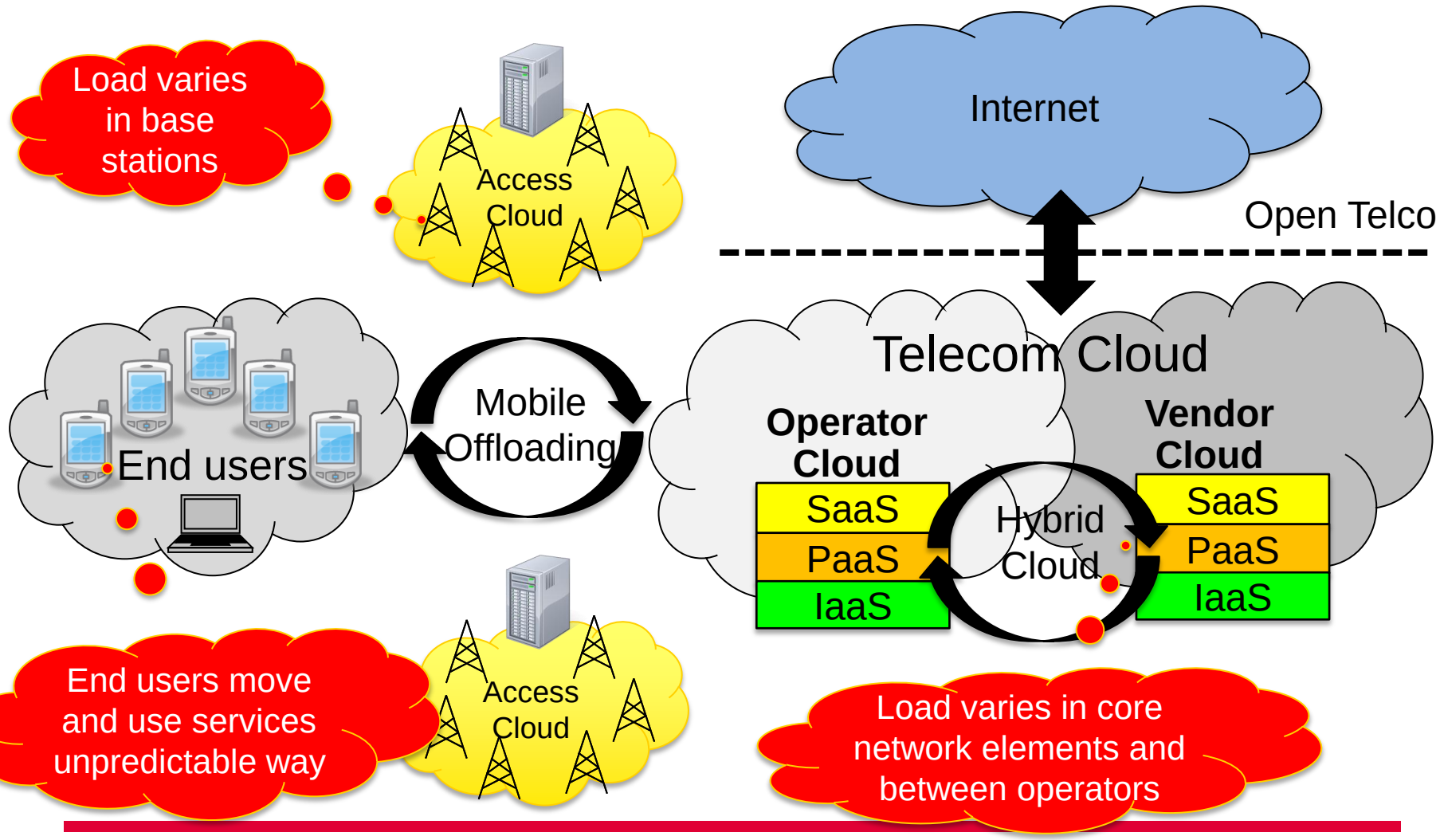
- **Optimise private/private/public cloud load balancing based on**
  - Location
  - Content
  - QoS



CrowdCloud – selling idle browser computing capacity



Vision



Conclusions

- **Virtualization of telecom infrastructure is gaining interest**
- **Generic goal: optimize computation location based on**
  - Load
  - SLA
  - Energy
  - Cost
- **Results can be adopted to other industries, too**
- **Hybrid cloud improves scalability, optimizes cost and solves data regulation challenges**
- **Mobile offloading**
  - From mobile/browser to cloud or vice versa
  - Energy and performance enhancements drive

Questions?

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