Cloud environment

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Agenda

- Cloud fundamentals
- Greening the cloud
- Fog/Edge Computing
- Intercloud
- Network Function Virtualization
- SDN for clouds
- Testing the cloud vs cloud testing
Agenda

• Cloud fundamentals
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Cloud - definition

• It is all about food 😊

• Home meal vs. restaurant

Infrastructure as a Service (IaaS)

- More like self-service
- Take care of all the components
- Flexibility
Platform as a Service (PaaS)

- More like dish from menu
- Integrated components
- Provider-dependent

Software as a Service (PaaS)

- More like invited party menu
- Complete solutions
- Limited choice
Pizza as a Service analogy

http://www.episerver.com/blog/blog-start/fred-bals/pizza-as-a-service/
Services model

IT Tradizionale
- Applications
- Data
- Runtime
- Middleware
- O/S
- Virtualization
- Servers
- Storage
- Networking

IaaS
- Applications
- Data
- Runtime
- Middleware
- O/S
- Virtualization
- Servers
- Storage
- Networking

PaaS
- Applications
- Data
- Runtime
- Middleware
- O/S
- Virtualization
- Servers
- Storage
- Networking

SaaS
- Applications
- Data
- Runtime
- Middleware
- O/S
- Virtualization
- Servers
- Storage
- Networking

http://vinfrastructure.it/2013/07/iaas-vs-paas-vs-saas/
Types of clouds

- Private
- Public
- Hybrid

- Types of clouds vs. service levels?
Pros and cons

• Advantages:
  – Know-how not needed
  – Scalability and pay-as-You-go model
  – Reliability
  – Automation
  – Cost efficiency...

• Disadvantages:
  – Security
  – Law regulations
  – Performance of shared and general purpose hardware
Cloud operators examples

Amazon Web Services

Google Cloud Platform

Microsoft Azure
<table>
<thead>
<tr>
<th>Compute</th>
<th>Storage</th>
<th>Database</th>
<th>Migration</th>
<th>Networking &amp; Content Delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amazon EC2</td>
<td>Amazon EC2 Container Registry</td>
<td>Amazon EC2 Container Service</td>
<td>AWS Batch</td>
<td>Auto Scaling</td>
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<tr>
<td>Virtual Servers in the Cloud</td>
<td>Store and Retrieve Docker Images</td>
<td>Run and Manage Docker Containers</td>
<td>Run Batch Jobs at Any Scale</td>
<td>Automatic Elasticity</td>
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<tr>
<td>Amazon Lightsail</td>
<td>Amazon VPC</td>
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<tr>
<td>Launch and Manage Virtual Private Servers</td>
<td>Isolated Cloud Resources</td>
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<tr>
<td>AWS Elastic Beanstalk</td>
<td>AWS Lambda</td>
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</tr>
<tr>
<td>Run and Manage Web Apps</td>
<td>Run Your Code in Response to Events</td>
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<tr>
<td>Developer Tools</td>
<td>Management Tools</td>
<td>Security, Identity &amp; Compliance</td>
<td>Analytics</td>
<td>Artificial Intelligence</td>
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<tr>
<td>Mobile Services</td>
<td>Application Services</td>
<td>Messaging</td>
<td>Business Productivity</td>
<td>Desktop &amp; App Streaming</td>
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<tr>
<td>Internet of Things</td>
<td>Game Development</td>
<td>See All Products</td>
<td></td>
<td></td>
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</tbody>
</table>
Virtualization vs. Clouds

- Virtualization - definition?
- What to virtualize?
- Why to virtualize?
- Without virtualization cloud will not exist
### Cloud operators examples

<table>
<thead>
<tr>
<th>Cloud Marketplace</th>
<th>AppDirect</th>
<th>APPIRIO</th>
<th>INGRAM MICRO</th>
<th>myGravitant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloud Broker Platform</td>
<td>cloudMatrix</td>
<td>Jamcracker</td>
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<tr>
<td>Cloud Management</td>
<td>apptio</td>
<td>cloudability</td>
<td>CloudSwitch</td>
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<td>SaaS</td>
<td>Google</td>
<td>Netsuite</td>
<td>Salesforce</td>
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<td>enomaly</td>
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<td>Virtualization/software/management</td>
<td>Parallels</td>
<td>Virtuozzo</td>
<td>Xen</td>
<td>CITRIX</td>
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<tr>
<td>Hardware</td>
<td>IBM BladeCenter</td>
<td>DELL PowerEdge Blade Servers</td>
<td>Oracle Sun Blade</td>
<td>HP BladeSystem</td>
</tr>
</tbody>
</table>
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- SDN for clouds
- Testing the cloud vs cloud testing
Greening the cloud

• Definition and motivation?
• Real life examples
• Grow a *greener* Data Center
  – Facility
  – Physical
  – Control and management
• Green network vs green cloud
• DoT contribution:
  – STAR Project
  – GreenTouch
What does it mean to be green?

• A computing environment that uses resources in a more efficient manner and has less impact upon people and the environment. [1]

• What to measure in Data Center:
  – Energy consumption
  – Carbon dioxide emission
  – Heat emission
  – Water usage

• Metrics: PUE, DCIE, CPE, TCE...

• Certification

[2] Figure: http://www.iglaki24.pl/
Why to be green

• It is fancy
• It is correct
  – Yeah, but why should I pay?
• Money:
  – Yet fashion
  – Energy limits DC expansion
  – Bills
  – Law regulations
  – Financial benefits
• Concerns
Why to be *green*

- 2-3k square meters needs around 20 MW of energy
- Microsoft DC, 45k square meters, 200 MW
- Average reduction of 1000 USD per each 1 $m^2$ results in 2,500,000 USD in 20 year for big DC
Examples

• Vestas Wind Systems
  – Effective turbines in 80% made from recycling materials

• Citigroup
  – DC, 20k m² and 30% need for power

• Cisco
  – 7,5k sensors, reduction of 7,5k MWh per year

• HP

• HSBC

• IBM
Building

http://wikibon.org/blog/7-green-data-centers-just-in-time-for-spring/
Cooling

- Raise temperature
- Reuse heat
- Free-air cooling
- Scalability
- Monitoring
- Hot and cold aisles
Hot and cold aisles

https://www.pinterest.com/pin/496170083921144078/
Cabling and equipment

https://www.pinterest.com/datacenter/data-center-cabling/
http://www.americanis.net/colocation/structured-cabling/
Greening upper layers

- 24 10Gbps cooper cables, 40m length, need around 33kg of cooper
- 48 fibers (similar connectivity), same length, require 56g of glass
- Much less natural resources to produce glass results in huge improvement
- 10 Gbps connection
  - Fiber: 10-20 kW
  - Cooper: 40-80 kW
- Switch, 48-ports, 10Gbps, per year:
  - Fiber: 30,000 kWh
  - Cooper: 126,000 kWh
Greening upper layers

- The aim to run DC is to **earn money** not to be **green**
- IT equipment is a core
- Service-aware infrastructure
- Energy-aware infrastructure
- Mechanisms:
  - Consolidation
  - Virtualization
  - Automation
**Greening upper layers**

- **Consolidation**
  - Potential depends on resource
  - *Green* network vs. *Green* cloud
  - Simplicity
  - Challenges

- **Virtualization:**
  - Coexistence with consolidation
  - Hardware and software-based
  - Resources and services
  - Advantages
  - Challenges
Greening upper layers
Greening upper layers

• Automation (*orchestration*):
  – More logical resources to be managed
  – Opportunities
  – Risks
  – Examples
DoT contribution to the *greening* concept

- **GreenTouch consortium:**
  - Alcatel-Lucent, AT&T, China Mobile, Portugal Telecom, Telefonica, Freescale Semiconductor
  - Reduce energy consumption of ICT

- **SwiTching And tRansmission Project**
  - Green cloud provisioning throughout cooperation of a WDM wide area network and a hybrid power IT infrastructure
  - Dynamic power capping in WAN
  - Testbed
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Fog/Edge computing

• Definition: fog is cloud closer to the ground
  – Fog Computing (Cisco)
  – EdgeComputin (Akamai)
  – Intel’s Intelligent Edge
  – Microsoft’s Cloudnet

• Motivation:
  – Modern applications
  – Location-awareness
  – Geographical distribution

• Relation to the concept of Internet of Things
Fog/Edge computing – Use Cases

- Smart:
  - Grids
  - Cities
  - Buildings
- BigData
- Stream processing
- Monitoring
Fog/Edge computing - challenges

- Heterogenity – need for unification
- Mobility
- Resource outages
- Malicious behaviour
- Battery drain
- Orchestration
- Legal aspects
Fog/Edge – DoT contribution

• SDN-based Fog and Cloud Interplay for Stream Processing
  – INRIA (French Institute for Research in Computer Science and Automation), Ecole Normale Superieure de Lyon, France

• Energy-aware fog and cloud interplay supported by wide area software defined networking, IEEE International Conference on Communications : 22–27 May 2016, Kuala Lumpur, Malaysia
Energy-Aware Fog and Cloud Interplay
Supported by Wide Area SDN
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Intercloud

• Intercloud – one seamless interface to all clouds

• Motivation
  – Resilience
  – Geographical distribution
  – Optimization – latency awareness
  – Cost efficiency (vendor lock-in problem)
  – Law regulations
Intercloud

- Emerging concept … really?
  - IaaS is almost seamless – big advantage
  - PaaS and SaaS are not, definitely
- Financial challenges
  - Why should anyone cooperate?
  - We offer different services
  - Who should be the cloud broker?
- Technical challenges
  - Different architectures
  - Different service levels
  - Different interfaces
Intercloud

- Libcloud - Python library for interacting with many of the popular cloud service providers using a unified API
  - One interface to rule them all
  - Only selected, basic features
  - Amazon, Google, Windows, Vmware, OpenStack-based, ...
Intercloud

- OpenStack - Open source software for creating private and public clouds
  - Easy to install
  - Hard to configure
  - 6 core services
  - 13 optional services
  - Cern, ChinaMobile, AT&T, Walmart, Bloomberg,
  - Valuable skill at labor market
Intercloud

NOVA
Compute
Manages the lifecycle of compute instances in an OpenStack environment. Responsibilities include spawning, scheduling and decommissioning of machines on demand.

- **95%** Adoption
- **8 of 8** Maturity
- **7 yrs** Age

MORE DETAILS

NEUTRON
Networking
Enables network connectivity as a service for other OpenStack services, such as OpenStack Compute. Provides an API for users to define networks and the attachments into them. Has a pluggable architecture that supports many popular networking vendors and technologies.

- **93%** Adoption
- **8 of 8** Maturity
- **5 yrs** Age

MORE DETAILS

SWIFT
Object Storage
Stores and retrieves arbitrary unstructured data objects via a RESTful, HTTP based API. It is highly fault tolerant with its data replication and scale out architecture. Its implementation is not like a file server with mountable directories.

- **52%** Adoption
- **7 of 8** Maturity
- **7 yrs** Age

MORE DETAILS

CINDER
Block Storage
Provides persistent block storage to running instances. Its pluggable driver architecture facilitates the creation and management of block storage devices.

- **88%** Adoption
- **8 of 8** Maturity
- **5 yrs** Age

MORE DETAILS

KEYSTONE
Identity
Provides an authentication and authorization service for other OpenStack services. Provides a catalog of endpoints for all OpenStack services.

- **96%** Adoption
- **7 of 8** Maturity
- **5 yrs** Age

MORE DETAILS

GLANCE
Image Service
Stores and retrieves virtual machine disk images. OpenStack Compute makes use of this during instance provisioning.

- **95%** Adoption
- **6 of 8** Maturity
- **7 yrs** Age

MORE DETAILS
**Intercloud**

- OpenStack - Open source software for creating private and public clouds
  - Easy to install
  - Hard to configure
  - 6 core services
  - 13 optional services
  - Cern, ChinaMobile, AT&T, Walmart, Bloomberg, ...
  - Valuable skill at labor market

- Kubernetes – Open source by Google
Intercloud – DoT contribution

- Cloud testing using infrastructure of heterogenous cloud providers
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Network Function Virtualization

- General concept
  NFV: principle of separating network functions from the hardware they run on by using virtual hardware abstraction [1].

- Where to deploy: cloud? Fog?

- DoT contribution will be presented in the context of testing the cloud

[1] ETSI GS NFV 003 V1.2.1
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- **SDN for clouds**
- Testing the cloud vs cloud testing
SDN for clouds

• What is SDN?

• SDN vs. Cloud

• Why SDN and clouds are complementary
  – Virtualization
  – NFV
  – Cloud automation
  – Network automation
  – Application oriented architecture
SDN for clouds

- Seperation of *control plane* and *data plane*
- Central controller
- Complete knowledge about topology and network state
- Programability and *softwareization*
  - Northbound interface
  - Eastbound and Westbound interfaces
- Threats
SDN for clouds

Attractive and promising future network architecture

Or maybe...

Vulnerable and not realistic concept.
OpenFlow protocol

- OpenFlow != SDN
  - Stanford university
  - ONF
New flow handling
SDN forwarding tables

- The most important part of the SDN switch
- Managed by controller
- Matching against: port, MAC, IP, TCP, priorities, ...
- Possible actions: CONTROLLER, port, table_id, drop, ...
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- SDN for clouds
  - Anycast for cloud services
  - Traffic engineering for clouds
  - SDN Switch Tester

- Testing the cloud vs cloud testing
SDN for clouds – DoT contribution

• Threefold contribution:
  – Anycast strategies
  – Schemas fitting strategies to cloud services
  – Cooperation models between cloud and SDN

SDN for clouds – DoT contribution
Cooperation models

• **overlay**
  Lack of cooperation between cloud provider and network operator

• **augmented**
  Basic cooperation – exclude DCs without required resources

• **peer**
  Extended cooperation — cloud provider expresses preferences
Cooperation models: CO$_2$ emission

Brown kW per 1 Gb/s of DC requests

- overlay
- augmented
- peer

Offered DC load
Cooperation models: blocking probability

Total blocking probability

Offered DC load

overlay
augmented
peer
Cooperation models: main conclusions

• Models differ in terms of information being exchanged between operators

• Final conclusions
  – augmented i peer models
    • The lowest CO$_2$ emission when associated with proper fitting schema
  – peer
    • The lowest blocking probability
Publications


- P. Boryło, A. Lasoń, J. Rząsa, A. Szymański, A. Jajszczyk. *Fitting green anycast strategies to cloud services in WDM hybrid power networks*. *GLOBECOM 2014*, Austin, TX, USA.


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SDN for clouds – DoT contribution

- Contribution in terms of traffic engineering in SDN networks
- Application oriented traffic engineering
- Cloud is one of the applications

- **SDNRoute**: integrated system supporting routing in Software Defined Networks
- National Research and Development Center – Lider VII Programme
The aim and features of the project

• Develop, investigate and implement SDNRoute system – routing support tool designed for SDN

• SDNRoute features:
  – Proactive
  – Application-oriented
  – Static and dynamic optimization in one tool
  – Validation through emulation

• The result is designed for network operators of all scale willing to introduce SDN concept
Use cases

- Measurements inform that one of the nodes is overloaded
- Load consolidation and reduction of energy consumption
- Prepare network for expected congestion
  - Prediction
  - Information from applications, e.g. cloud
Final results

• Integration with SDN controller
• Integration with applications, e.g. cloud
• Demonstrator
• Competitors:
  – Google – B4 Network
  – NEC
  – Tata
  – Packet Design - SDN Management and Orchestration (MANO) Platform
  – Cisco - Wide Area Network Automation Engine (WAE)
  – Brocade - Flow Optimizer
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SDN for clouds – DoT contribution

• OpenFlow Switch Compliance Tester
  – For vendors
  – For customers

• Implements over 350 tests from ONF Conformance Test Specification for OpenFlow Switch Specification from 29 categories

• Implements 129 original tests in 7 categories including selected features from OpenFlow protocol ver. 1.4 and 1.5
<table>
<thead>
<tr>
<th>Functionality</th>
<th>NetResearch NVCT</th>
<th>Spirent Test Center</th>
<th>Ixia IxANVL (SDN bundle)</th>
<th>Veryx ATTEST CTS</th>
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<tbody>
<tr>
<td>Controller test</td>
<td>—</td>
<td>✓</td>
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<tr>
<td>Switch test</td>
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<tr>
<td>OpenFlow 1.0</td>
<td>—</td>
<td>✓</td>
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<td>Multiple forwarding table pipeline</td>
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Testing the cloud vs cloud testing

Cloud computing

https://en.wikipedia.org/wiki/Cloud_computing
Testing the cloud

• Need for testing the cloud:
  – Virtualization
  – NFV
  – Not so concrete SLA, is provider honest

• What can we test:
  – Computing performance: instructions, operations, tasks, architecture-dependent
  – Memory access: read and write throughput, latency
  – Storage: read and write throughput, iops capacity

• Requirements depend on VM application
Cloud testing

• Advantages of cloud testing:
  – Geographical coverage
  – Automation
  – User experience monitoring

• DoT contribution:
  – Intercloud
  – Stressing the cloud (NFV)
  – Stressing using cloud
  – Virtual Universal Testing Platform
Virtual Universal Testing Platform

- Emerging product being delivered

- Competitors:
  - Spirent
  - IXIA
  - SpeedTest...
  - ...

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Thank You for attention!

Q&A?