InterCloud Architecture Framework (ICAF) for Interoperability and Integration

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Outline

- Cloud Computing Architecture research at SNE group (UvA)
- General use cases for Intercloud Architecture
- Related standardisation initiatives: NIST, OGF, IETF
- Intercloud Architectural Framework (ICA/ICAF) components
  - Multi-layer/Layered Cloud Services Model (CSM)
  - Intercloud Control and Management Plane (ICCMP)
  - Intercloud Federation Framework (ICFF)
  - Intercloud Operations Framework (ICAF)
- Abstract Model for Cloud IaaS Provisioning
- Further research and standardisation contribution
SNE group is primarily a research group but also supports SNE master education

Main research areas
- High speed optical networks
  - Recent testbed achieved sub-40Gbps at Amsterdam-CERN link
  - Information modeling for network description
- Security and generic AAA Authorisation framework (GAAA-AuthZ)
  - Evolving from client/security model to dynamically provisioned services for Cloud and Grids
- Cloud and Intercloud Architecture, Cloud Security, Cloud Services Provisioning

New research area on Big Data Infrastructure services and adoption of Cloud based/powered provisioning technologies and models
- Defining corresponding security models and infrastructure

Long term research cooperation with SURFnet and GigaPort program in NL

Re-building own testbed for optical network technologies, Intercloud infrastructures and AAA/Security

Recent and current projects participation – DataGrid, NextGrid, EGEE, Phosphorus, GEYSERS, GEANT3, NOVI, ENVRI
Yuri Demchenko – Professional Summary

- Graduated from National Technical University of Ukraine “Kiev Polytechnic Institute” (KPI) in Instrumentation and Measurement (aka Industry Automation)
- Candidate of Science (Tech) – Dissertation on System Oriented Precision Generators (1989)
- Professional work in Internet technologies since 1993
  - First publications on Internet technologies and security – 1994
- Work at TERENA (Trans-European R&E Networking Association) – 1998-2002
  - Wide contacts among European and international NREN and research community
- Work at UvA with SNE group – since 2003
  - Main research areas: Cloud Computing, Big Data Infrastructures, Application and Infrastructure Security, Generic AAA&Authorisation, Grid and collaborative systems
  - EU Projects: GEYSERS, GEANT3, Phosphorus, EGEEI-II, Collaboratory.nl
  - Standardisation activity – IETF (1 I-Draft pending, 3 RFC’s published), Open Grid Forum (OGF) – ISOD-RG chairing, NIST Cloud Architecture Collaboration
General use cases for Intercloud Architecture

- Clouds are evolving as a common way of provisioning infrastructure services on-demand
  - In this way, clouds add a new type of services, in addition and on the top of currently existing network based and distributed services
- Intercloud Architecture Framework (ICAF) provides a framework to support provisioning of cloud based project oriented infrastructures on-demand and distributed virtualised applications mobility
  - Hybrid Cloud/Grid e-Science collaborative environment
    - Scientific Data e-Infrastructure for Big Data
  - Enterprise/campus cloud infrastructure evolution and migration/mobility
  - Infrastructure disaster recovery (e.g., Vodafone NL Datacenter Incident – April 2012, Orange multiple DC failures – summer 2012)
    - Data require supporting infrastructure
  - Educational Lab setup in cloud
    - Easy to suspend and deploy when necessary
- *ICAF intends to open Cloud market to more players and rise so-called “cloud curtain”*
InterCloud: Related standardisation activities

- NIST Cloud definition (NIST SP 800-145), and Cloud Computing Reference Architecture (CCRA), v1.0 (NIST SP 500-292)
- IEEE - WGs on InterCloud issues and Cloud Profiles
  - IEEE ICWG/2302 WG - Intercloud WG (ICWG) Working Group  
    [link](http://standards.ieee.org/develop/wg/ICWG-2302_WG.html)
- OGF ISOD-RG
  - BCP on existing on-demand network and cloud infrastructure resources provisioning systems (including GEYSERS)
- IETF Internet Drafts
  - Cloud Service Broker, Internet Draft by Shao Weixiang, Hu Jie, Bhumip Khasnabish.  
    [link](http://tools.ietf.org/html/draft-shao-opsawg-cloud-service-broker-03.txt)
Draft SP 800-145 A NIST Definition of Cloud Computing (published Nov 2011)

• Five essential clouds characteristics
  – On-demand self-service
  – Broad network access
  – Resource pooling
  – Rapid elasticity
  – Measured Service

• 3 service/provisioning models
  – Software as a Service (SaaS)
  – Platform as a Service (PaaS)
  – Infrastructure as a Service (IaaS)

• 4 deployment models
  – Public cloud
  – Private cloud
  – Community cloud
  – Hybrid cloud
NIST Cloud Computing Reference Architecture
(CCRA) 2.0 - Main Roles

- Cloud Carrier as a role to accommodate telco’s interests
NIST Cloud Computing Reference Architecture (CCRA) 2.0 – Consolidated View
Work on I-Draft “Cloud Reference Framework” (Version 0.3)


1. Introduction ................................................................. 4
2. Terminology ................................................................. 5
3. Cloud Services Reference Model .............................. 6
   3.1. HORIZONTAL LAYERS ........................................... 7
       3.1.1. Application/Service Layer ............................ 7
       3.1.2. Resources Control Layer .............................. 8
       3.1.3. Resources Abstraction and Virtualization Layer .... 9
       3.1.4. Physical Resources Layer ............................. 10
   3.2. VERTICAL LAYERS (planes?) .............................. 10
       3.2.1. Cloud Management Layer ............................. 10
4. Inter-Cloud Framework .............................................. 17
   4.1. Inter-Cloud Requirements .................................. 17
   4.2. Intercloud Framework Components .......................... 17
   4.3. Intercloud Control and Management Plane (ICCMP) .... 17
   4.4. Intercloud Federation Framework (ICFF) .................. 19
   4.5. Intercloud Operation Framework (ICOF) .................. 19
5. Use Cases ................................................................. 19
   5.1. Virtual Network Management .............................. 19
   5.2. Telecom Network Virtualization ........................... 19
   5.3. Virtual Data Center ........................................... 21
   5.4. Security infrastructure for on-demand provisioned  
        cloud-based services/infrastructures .................. 22
7. Conclusion ............................................................... 25
8. Security Considerations ....................................... 26
9. Acknowledgement .................................................. 27
10. IANA Considerations ........................................... 28
12. Normative references ........................................... 29

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Version 0.3 - 29 June 2012  
Version 0.4 - December 2012  
Version 0.5 - Summer 2013  
(To be considered)
Intercloud Architecture (ICA) should address interoperability and integration of different cloud service platforms provided by multiple cloud providers, including integration with legacy campus/enterprise infrastructure

- Be compatible and provide multi-layer integration of existing cloud service models – IaaS, PaaS, SaaS and Apps clouds
- Facilitate interoperable and measurable intra-provider infrastructures
- Provide a framework for heterogeneous inter-cloud federation
- Support/provide Intercloud Control and Management Plane functionality for performance critical cloud services and network integration
- Support intra- and inter-cloud network infrastructure provisioning with controlled performance and QoS (as NaaS service model)
- Support existing Cloud Provider operational and business models and provide a basis for new forms of services provisioning and operation
  - Support provider side federation (for resources sharing) and customer/broker side federation for multi-provider infrastructure integration
InterCloud Architecture components

- **Multi-layer Cloud Services Model (CSM)**
  - Combines IaaS, PaaS, SaaS into multi-layer model with inter-layer interfaces
  - Including interfaces definition between cloud service layers and virtualisation platform

- **InterCloud Control and Management Plane (ICCMP)**
  - Allows signaling, monitoring, dynamic configuration and synchronisation of the distributed heterogeneous clouds
  - Including management interface from applications to network infrastructure and virtualisation platform

- **InterCloud Federation Framework (ICFF)**
  - Defines set of protocols and mechanisms to ensure heterogeneous clouds integration at service and business level
  - Addresses Identity Federation, federated network access, etc.

- **InterCloud Operations Framework (ICOF)**
  - RORA model: Resource, Ownership, Role, Action
    - RORA model provides basis for business processes definition, SLA and access control
  - Broker and federation operation
General use case for infrastructure provisioning: Workflow => Logical (Cloud) Infrastructure (1)

Implementing Enterprise/Scientific workflow or supporting a business model is an ultimate goal of any infrastructure.
General use case for infrastructure provisioning: Workflow => Logical (Cloud) Infrastructure (2)

Enterprise/Scientific workflow

Is mapped to heterogeneous cloud infrastructure containing IaaS, PaaS components
General use case for infrastructure provisioning: Logical Infrastructure => Network Infrastructure (1)

Distributed heterogeneous cloud infrastructure requires separately provisioned network infrastructure that can outsourced to Cloud Carrier.
General use case for infrastructure provisioning:
Logical Infrastructure => Network Infrastructure

Resource and Cloud Provider Domains:

Campus A Infrastructure
VR1
VR3
VR4
VR5
VR6
VR7
Network Provider 1

Campus B Infrastructure
VR2
VR4
VR5
VR6
VR7
Network Provider 2

Campus A
CE
User Group A
User

Campus B
CE
User Group B
User

Cloud 1 IaaS
Virtualization

Cloud 2 PaaS
Enterprise/Project based Intercloud Infrastructure

Network Service Provider

… or to regular
Network Service Provider

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InterCloud Applications Interaction (1) - ICCMP

Consistent and tight management of the heterogeneous cloud infrastructure requires InterCloud Control and Management Plane (ICCMP)

ICCMP – InterCloud Control and management Plane
Intercloud Applications Interaction (2) - ICFF

Independently managed cloud domains may use federated model for resources and processes integration and interoperation.
Intercloud Applications Integration (3) - ICOF

Business Processes Management and Services Operation Support
- SLA Management
- Business roles and Actors
- Business level Service Registry and Broker
- Mobility?

Operational and business issues are typically addressed by Operations services and a framework.
InterCloud Architecture components

- **Multi-layer Cloud Services Model (CSM)**
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Multilayer Cloud Services Model (CSM)

CSM layers
(C7) User Client/Application
(C6) Cloud Application (SaaS)
(C5) Cloud Platform (PaaS)
(C4) Cloud Infrastructure (IaaS)
(C3) Virtual Resources Composition and Orchestration
(C2) Virtualisation Layer
(C1) Hardware platform and dedicated network infrastructure
Multilayer Cloud Services Model (CSM) – In development

Compose into one Cloud Services layer and define intra-model

CSM layers
- (C7) User Client/Application
- (C6) Cloud Application (SaaS)
- (C5) Cloud Platform (PaaS)
- (C4) Cloud Infrastructure (IaaS)
- (C3) Virtual Resources Composition and Orchestration
- (C2) Virtualisation Layer
- (C1) Hardware platform and dedicated network infrastructure

User Applications

IaaS

PaaS

SaaS

SaaS-PaaS IF

PaaS-IaaS Interface

IaaS – Virtualisation Platform Interface

Cloud Management Software/Platforms
- OpenStack
- OpenNebula
- Other CMS
- VM
- VM
- VPN

Virtualisation Platform
- KVM
- XEN
- VMWare

Proxy (adaptors/containers) - Component Services and Resources
- Storage Resources
- Compute Resources
- Network Infrastructure

Hardware/Physical Resources

Layer C1
- Physical Hardware Platform and Network

Layer C2
- Virtualisation

Layer C3
- Virtual Resources Composition and Control (Orchestration)

Layer C4
- Cloud Infrastructure (IaaS)

Layer C5
- Cloud Platform (PaaS)

Layer C6
- Cloud Applications (SaaS)

Layer C7
- User Client/Application

Control/Mngnt Links

Data Links

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Intercloud Control and Management (1)

- Supports messages delivery/routing, signaling, monitoring, dynamic configuration and synchronisation between the distributed heterogeneous cloud instances
- Includes management interfaces from upper layers and applications to network infrastructure and virtualisation platform (virtualised resources)
- Layer 1 - Layer 4 interfaces are being developed and prototyped in the framework of the GEYSERS project
InterCloud Control and Management (2)
InterCloud Control and Management (3)

InterCloud Control and Management Plane (ICCMP)

Layer 1 - Physical HW Platform/Network
Layer 2 - Virtualisation Resources Abstraction and Virtualisation
Layer 3 - Composition Virtual Resources Composition
Layer 4 - IaaS Cloud Infrastructure
Layer 5 - PaaS Cloud based Platform
Layer 6 - SaaS/Apps Cloud based Apps/Software
Layer 7 - Applications User defined Applications

User defined SW&Apps
Provider defined Infrastructure and OS&Virt Platform
Provider defined SW&Apps

Standard Interface
Non-standard/proprietary Interface
• Allows signaling, monitoring, dynamic configuration and synchronisation of the distributed heterogeneous clouds
• Including management interface from applications to network infrastructure and virtualisation platform
• Main functional components include
  – Cloud Resource Manager
  – Network Infrastructure Manager
• Possible ICCMP Interfaces include
  – Message routing
  – Signaling
  – Control
  – Management
  – Monitoring
  – Location
- All inter-services interactions involve 3rd party actor: Registry, Broker and gateways
- Requires previously established relations/contracts and trust relations – direct or via trusted broker
- Dynamic trust establishing mechanisms required for dynamic inter-cloud federation
InterCloud Federation Framework (2)

- Defines set of protocols and mechanisms to ensure heterogeneous clouds integration at service and business level
- Addresses Identity Federation, federated network access, etc.
- Main functional components include
  - Service and Trust brokers
  - Intercloud gateway including attribute/namespace translator
    - Attribute/namespace resolver
  - Service Registry
  - Service discovery service
  - Identity provider
  - Trust manager/router
- Possible ICFF Interfaces
  - Naming, Addressing and Translation (if/as needed)
  - Publishing
  - Discovery
  - Attributes management
  - Trust/key management
InterCloud Operations Framework (1)

Business Processes Management and Services Operation Support
- SLA Management
- Business roles and Actors
- Business level Service Registry and Broker
- Mobility?

InterCloud Architecture Framework
InterCloud Operations Framework (2)

• Defines the main roles and actors
  – RORA model: Resource, Ownership, Role, Action
    • Defined in the GEYSERS project to address infrastructure services virtualisation
    • Provides basis for business processes definition, SLA management and access control policy definition

• Broker and Federation operation

• Main functional components include
  – Cloud Service Provider, Cloud Operator, Cloud (physical) Resource provider, Cloud Carrier
  – Service Registry
  – Service Broker

• Possible ICOF Interfaces
  – Provisioning, Deployment, Decommissioning/Termination
  – SLA management and negotiation
  – Services Lifecycle management
  – Services deployment
Main Actors in Cloud/InterCloud Architecture

- Cloud Service Provider
- Intercloud (Cloud Service) Operator
- Cloud Customer
- Cloud User
- Cloud Carrier
- Cloud Broker
- Cloud Auditor
- Cloud Resource Provider
- Physical Resource Provider
  - Can also be a “fixed” resources provider

Ownership/Management model needs to be applied to these actors using extended RORA model
### Implementation: GEYSERS Project Layered Architecture – CSM and ICCMP

- Developed and implemented in the GEYSERS project [http://www.geysers.eu/](http://www.geysers.eu/)

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<table>
<thead>
<tr>
<th>Physical Infrastructure</th>
<th>Virtual Resource Pool</th>
<th>Virtual Infrastructure</th>
<th>Logical Infrastructure Composition Layer (LICL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT-aware Network Control Plane (NCP+)</td>
<td>Virtual IT Management (VITM)</td>
<td>Service Middleware Layer (SML)</td>
<td>Service Consumer</td>
</tr>
</tbody>
</table>

- Inter-layer communication
- Virtual IT node controller
- Virtual Network node controller
- Virtual IT resource
- Physical IT resource
- Virtual Network resource
- Physical Network resource

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InterCloud Architecture Framework
Abstract (Cloud) IaaS Provisioning Model

VI Composition & Management Layer

Virtual Infrastructure (VI) (operated by VIO1)

VI Operator Layer

VI Provider Layer

PI Provider Layer

User/Applic A

VRI1

VRI2

VRI3

VRI4

VRI5

VRI6

User/Applic B

Application/Service Layer

Service Middleware Layer (SML)

VI/VR Adaptation Layer

Logical Abstraction Layer

PR Virtualis & Mngnt (Lower LICL)

Pi/PR Adaptation Layer

PI/PR Layer

Network Infrastructure Provisioning

Network Control Plane

Network Infrastructure virtualisation and instantiation

Legend

ND* - Network Domain
VIR* - VI Resource (deployed)
VR – Virtual Resource
LR – Logical Resource
PR – Physical Resource
Abstract (Cloud) IaaS Provisioning Model

Network Infrastructure Provisioning

Network Domain ND-VIO1

User/Applic A

User/Applic B

VI Operator Layer

VI Provider Layer

VI Provider Layer

PI Provider Layer

Network Infrastructure virtualisation and instantiation

Legend
ND* - Network Domain
VIR* - VI Resource (deployed)
VR - Virtual Resource
LR - Logical Resource
PR - Physical Resource
Services Lifecycle/Provisioning Workflow

- **Main stages/ phases**
  - Service Request (including SLA negotiation)
  - Composition/Reservation (aka design)
  - Deployment, including Registration/Synchronisation
  - Operation (including Monitoring and SLA enforcement)
  - Decommissioning (including Dynamic Security Associations destroying/recycling)

- **Additional stages**
  - Re-Planning/Re-Composition should address incremental infrastructure changes
  - Recovery/Migration can use SL-MD to initiate resources resynchronisation but may require re-composition

- The whole workflow is supported by the Service Lifecycle Metadata Service (SL MD)
- Provisioning session provides a framework for services context and security context management
Summary and Future works

• The proposed ICAF is based on existing standards and proposes their integration and extension
  – Includes 4 components: CSM, ICCMP, ICFF, ICOF
    • Addresses cloud services/infrastructure lifecycle management
• Future research and development primarily focused on inter-layer and inter-cloud interfaces definition
  – Re-factor GEYSERS Infrastructure virtualisation interfaces
  – Testbeds: IaaS (GEYSERS) and PaaS (GEANT3)
• Standardisation activity at IETF, OGF, TMF
  – Partnership with industry (GEYSERS partners: Telefonica R&D, Interoute, SAP, Polish Telecom, ADVA; also Cisco, Huawei)
Questions and Discussion