Defining Generic Architecture for Cloud Infrastructure as a Service (IaaS) Provisioning Model

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Outline

• System and Network Engineering (SNE) Group at the University of Amsterdam
• Basic use case from e-Science
• Proposed architectural framework
  • Infrastructure Services Modeling Framework (ISMF)
  • Composable Services Architecture (CSA)
  • Service Delivery Framework (SDF)
• Security aspects in Cloud computing
  • Security Services Lifecycle Management (SSLM) model
System and Network Engineering (SNE) Group at University of Amsterdam

- 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 and infrastructure services description
  - Security and generic AAA Authorisation framework (GAAA-AuthZ)
    - Evolving from client/security model to dynamically provisioned services
- Long term research cooperation with SURFnet and GigaPort programs in NL
- Re-building own testbed for optical network technologies, Cloud experiments and AAA/Security
- Recent and current projects participation – DatGrid, NextGrid, EGEE, Phosphorus, GEYSERS, GEANT3, NOVI
- Interest to Cloud technologies as an emerging common method to access complex infrastructure services – network and IT resources
  - Defining architectural framework for Cloud IaaS
  - Extending it for infrastructure security services and related security and trust models
Use case for Infrastructure Services Provisioning

Project based Collaborating user groups located in remote campuses on data intensive projects requiring high performance computing and rich visualisation

Cloud infrastructure provisioned on demand

Campus infrastructure including visualisation tools

Grid based core eScience Infrastructure including data intensive scientific instrument

Visualisation

Ctrl&Mngnt Plane

User Group A

User

User Group B

User

Grid CE Data Filtering

Control & Monitoring

Sc. Instrument (Manufactrg)

Grid Storage T0

Experimental Data

Specialist Data Processing

Data Filtering

Processed Data

Campus A

Campus B

CloudSE T1

Grid Storage T0

Grid Storage T1
Proposed Architectural Framework for Cloud IaaS

The proposed framework should support on-demand infrastructure services provisioning and operation

- **Infrastructure Services Modeling Framework (ISMF)** that provides a basis for the infrastructure resources virtualisation and management, including description, discovery, modeling, composition and monitoring

- **Composable Services Architecture (CSA)** that intends to provide a conceptual and methodological framework for developing dynamically configurable virtualised infrastructure services

- **Service Delivery Framework (SDF)** that provides a basis for defining the whole composable services life cycle management and supporting infrastructure services

- (Optionally) **Service Control and Management Plane/Framework** may be defined as combination of management functionality in all 3 components

- **Security services/infrastructure** have a dual role:
  - Virtual Security Infrastructure - provisioned as a part of virtualised infrastructure
  - Support normal/secure operation of the whole provisioning framework
IaaS Abstract Model

Legend
ND* - Network Domain
VIR* - VI Resource (deployed)
VR – Virtual Resource
LR – Logical Resource
PR – Physical Resource
Virtual Infrastructure Composition and Management (VICM) Layer Operation

• Main actors involved into provisioning process
  – Physical Infrastructure Provider (PIP)
  – Virtual Infrastructure Provider (VIP)
  – Virtual Infrastructure Operator (VIO)

• Virtual Infrastructure Composition and Management (VICM) layer includes
  – VICM middleware - defined as CSA
  – Logical Abstraction Layer and the VI/VR Adaptation Layer facing correspondingly lower PIP and upper Application layer.

• The infrastructure provisioning process includes the following main SDF stages
  – (1) virtual infrastructure creation request
  – (2) infrastructure planning and advance reservation;
  – (3) infrastructure deployment including services synchronization and initiation;
  – (4) operation stage
  – (5) infrastructure decommissioning

• VICM redefines Logical Infrastructure Composition Layer (LICL) proposed by GEYSERS project
  – Basic functionality is implemented as GEMBus/CSA
ISMF - Relation between PR-LR-VR-VI

- Virtual Resource lifecycle – defines relations between different resource presentations along the provisioning process.
- Physical Resource information is published by PIP to the Registry service serving VICM and VIP
  - Logical Resource representing PR includes also properties that define possible (topological) operations on the PR, such as e.g. partitioning or aggregation.
- Published LR information presented in the commonly adopted form (using common data or semantic model) is then used by VICM/VIP composition service to create requested infrastructure as combination of (instantiated) Virtual Resources and interconnecting them with the available network infrastructure.
- Network infrastructure can be composed of a few network segments (from the network topology pool) run by different network providers.
- Composed LRs are deployed as VRI/VI to VIP/VIO and as virtualised/instantiated PR-LR to PIP.
- Resource/service description format considered
  - NDL/NML (Network Description Language / Network Markup Language at OGF)
  - USDL (Unified Services Description Language) at W3C
  - VXDL infrastructure service request format by INRIA
Composable Services Architecture (CSA)

- Defined as middleware for on-demand provisioned Composable Services
- Proposed in the GEANT3 JRA3 Composable Services project
- Implemented as GEMBus (GEANT Multidomain Bus)
Composable Services Layered Model

- Application Layer hosts application related protocols
- GEMBus Messaging Infrastructure (GMI) includes
  - Messaging Layer
  - Virtualisation (Composition&Orchestration) Layer
- Network&Transport Layer should allow using/binding to standards communication and security protocol
- Composable services are defined as “dynamically re-configured virtualised services” according to OSIMM model
Composable Services Architecture – Version 0.13

Applications and User Terminals

Proxy (adaptors/containers) – Composed/Virtualised Services and Resources

Control & Management Plane
(Operation, Orchestration)

Composable Services Middleware (GEMBus)

Composition Layer/Serv (Reservation SLA Negotiation)

Logical Abstraction Layer for Component Services and Resources

Proxy (adaptors/containers) - Component Services and Resources

Storage Resources

Compute Resources

Network Infrastructure

Component Services & Resources

Composable Services lifecycle/provisioning stages
(1) Request
(2) Composition/Reservation
(3) Deployment
(4) Operation
(5) Decommissioning

User Client

MD SLC Registry Logging Security

Control/ Mngnt Links

Data Links
Composable Services Lifecycle/Provisioning Workflow

- **Main stages/phases**
  - Service Request (including SLA negotiation)
  - Composition/Reservation (aka design)
  - Deployment, including Registration/Synchronisation
  - Operation (including Monitoring)
  - Decommissioning

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

- The whole workflow is supported by the Service Lifecycle Metadata Service (SL MD)
Composable Services Architecture – Version 0.13

Lifecycle stages workflow

1. Request
2. Composition/Reservation
3. Deployment
4. Operation
5. Decommissioning

User Client

Control & Management Plane
(Operation, Orchestration)

Applications and User Terminals

Composable Services Middleware (GEMBus/GESB)

Logical Abstraction Layer for Component Services and Resources

Proxy (adaptors/containers) – Composed/Virtualised Services and Resources

MD SLC – Service Lifecycle Metadata

GEMBus – GEANT Multidomain Bus

GESB – Geysers ESB

Storage Resources

Compute Resources

Network Infrastructure

Component Services & Resources

Proxy (adaptors/containers) - Component Services and Resources

Control/ Mngnt Links

Data Links
CSA functional elements interaction

• (1) Request
  – User Client -> Control and Management

• (2) Composition/Reservation
  – Control&Mngnt -> Registry -> Composition/Reservation Serv -> (Logical Abstract -> Resr Adapters) -> LC Metadata Serv

• (3) Deployment
  – Control&Mngnt -> Composition/Reservation Serv -> (Logical Abstract -> Resr Adapters) -> LC Metadata Serv -> User Client

• (4) Operation
  – User Client -> Control&Mngnt (Orchestration) -> Rsr Adapters -> Virtualised/Composed Applications

• (5) Decommissioning
  – Control&Mngnt -> LC Metadata Serv -> (Logical Abstract -> Resr Adapters)
GEMBus provides common dynamically configurable messaging infrastructure for Composable services communication.
Example Service Composition – Service NX

- **CSrvID, SesID** – bind component services into the on-demand provisioned Composed service NX

Role and place for Composition and Orchestration

* Composable services or GEMBus infrastructure service
Cloud Security – Problem area and issues

- Virtualised services
- On-demand/dynamic provisioning
- Multi-tenant/multi-user
- Multi-domain
- Uncontrolled execution and data storage environment
  - Data protection
    - Trusted Computing Platform Architecture (TCPA)
    - Promising homomorphic/elastic encryption
- Integration with legacy security services/infrastructure of the providers
- Integration with the providers business workflow
Current Cloud Security Model

• SLA based security model
  – SLA between provider and user defines the provider responsibility and guarantee
  – Providers undergo certification
  – Standard business model
• Using VPN and SSH keys generated for user infrastructure/VMs
  – Works for single Cloud provider
• Has inherited key management problems
• Not easy integration with legacy physical resources
• Not scalable
• Simple access control, however can be installed by user
• Trade-off between simplicity and manageability
Security Infrastructure for IaaS

Application/Service Layer

Virtual Infrastructure (VI) (operated by VIO1)

User/Applic A (TA0.A)

VIR1

VIR2

VIR3

VIR4

VIR5

VIR6

User/Applic B (TA0.B)

VI Operator Layer TA1.x

VI Provider (VR/LR) Layer TA2.x

PI Provider (PR) Layer TA3.x

Legend

- DSA Security Context/Configuration
- TD - Trust Domains
- DSA – Dynamic Security Assoc.
- VIR* - VI Resource (deployed)
- VR/LR/PR – Virtual/Logical/Physical Resource

Trust links/relations

VIR/VR/LR/PR relations
Specific SSLM stages and mechanisms to ensure consistency of the security context management

- **Security Service Request** that initiates creation of the dynamic security association and may use SLA security context.
- **Reservation Session Binding** with GRI (also a part of general SDF/SLM) that provides support for complex reservation process including required access control and policy enforcement.
- **Registration & Synchronisation** stage (as part Deployment stage) that allows binding the local resource or hosting platform run-time process ID to the GRI as a provisioning session ID. Specifically targets possible scenarios with the provisioned services migration or restoration.
### Relation between SSLM/SLM stages and supporting general and security mechanisms

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<th>Deployment</th>
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Future developments

• Further development of the proposed architectural components in GEANT3 and GEYSERS projects
  – Demo at SuperComputing 2011 Conference and exhibition

• Dynamically provisioned security infrastructure
  – Dynamic security association

• Contribution to OGF ISOD-RG activity

• EU wide cooperation and possible EU project
Acknowledgement

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Additional Information

- GEYSERS project reference architecture
GEYSERS Reference Architecture

SC (Service Consumer)
VIO (Virtual Infrastructure Operator)
VIP (Virtual Infrastructure Provider)
PIP (Physical Infrastructure Provider)
GEYSERS Layered Architecture

Control and Management Planes are defined
- Important for consistent design
General security services/aspects

✓ Access Control (including AuthN, AuthZ, Identity Management)
✓ Trust Management (including key management)
✓ Policy Based Management (PBM)
➢ Data protection (Confidentiality, Integrity, Access Control)
  – Communication Security
  – Privacy (complex of measures and policy based access control)
Security Services Lifecycle Management (SSLM) Model

- **Security Service request and generation of the GRI** that will serve as a provisioning session identifier and will bind all other stages and related security context.

- **Reservation session binding** that provides support for complex reservation process including required access control and policy enforcement.

- **Deployment stage** begins after all component resources have been reserved and includes distribution of the security context and binding the reserved resources or services to GRI as a common provisioning session ID.

- **Registration & Synchronisation stage** (optional) specifically targets possible scenarios with the provisioned services migration or failover/interruption. In a simple case, the Registration stage binds the local resource or hosting platform run-time process ID to the GRI as a provisioning session ID.

- **Operation stage** - security services provide access control to the provisioned services and maintain the service access or usage session.

- **Decommissioning stage** ensures that all sessions are terminated, data are cleaned up and session security context is recycled.
SNE @ UvA take on Cloud technology

- Defining architectural framework for Cloud Infrastructure as a Service (IaaS) provisioning model
  - Consistent security architecture can only be built if the main system/services/infrastructure are well defined
- Defining architecture for dynamically configured security services/infrastructure
- OGF On-Demand Infrastructure Service (ISOD) provisioning BoF/RG
  - Including definition of IaaS and required security models