Defining InterCloud Architecture Framework (ICAF) for Interoperability and Integration

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Outline

- Cloud Computing Architecture research at SNE group (Univ Amsterdam)
- General use cases for Intercloud Architecture
- Related standardisation initiatives
  - NIST Cloud Computing Reference Architecture (CCRA) and extension for network aware cloud resources provisioning
  - IEEE Intercloud Working Group
  - ITU-T Cloud Interest Group final report
  - OGF ISOD-RG infrastructure services definition
  - IETF Internet-Draft on Cloud Architecture Framework
- 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 Cloud Architecture Research

Intercloud Architecture for Interoperability and Integration, Release 1, Draft Version 0.4. SNE Technical Report 2012-03-02, 19 June 2012
http://staff.science.uva.nl/~demch/worksinprogress/sne2012-techreport-12-05-intercloud-architecture-draft04.pdf

Main contributing research:

(1) Generic Cloud IaaS Architecture, Release 1, 15 April 2011
Published as http://staff.science.uva.nl/~demch/worksinprogress/sne2011-techreport-2011-03-clouds-iaas-architecture-release1.pdf

- Virtual Infrastructure Composition and Management (VICM) layer
- Infrastructure Services Modeling Framework (ISMF)
- Composable Services Architecture (CSA)
- Service Delivery Framework (SDF)

(2) InterCloud OS/Middleware (low level Intercloud integration)

- Targeting for Intercloud BGP-like protocol

(3) Security Infrastructure for Cloud (dynamically provisioned)

- Dynamic Access Control Infrastructure (DACI)

- Contributing to cloud standardisation by OGF, NIST, IEEE, IETF
- Implementation – EU projects GEYSERS, GEANT3
  - Telco and NREN driven – core network and last mile

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 Infrastructure for Big Data
  - Enterprise/campus cloud infrastructure evolution and migration/mobility
  - Infrastructure disaster recovery (Vodafone NL Datacenter Incident)
    - Data require supporting infrastructure
  - Educational Lab deployment in clouds
- *ICAF intends to open Cloud market to more players and rise so-called "cloud curtain"*

InterCloud: Related standardisation activities

- OGF ISOD-RG
  - BCP on existing on-demand network and cloud infrastructure resources provisioning systems (including GEYSERS)

- 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 http://standards.ieee.org/develop/wg/ICWG-2302_WG.html
- ITU-T Focus Group on Cloud: Technical Report (Part 1 to 7) http://www.itu.int/en/ITU-T/focusgroups/cloud/Documents/FG-coud-technical-report.zip
- IETF Internet Drafts
  - Cloud Reference Framework. Internet Draft, by B. Khasnabish, J. Chu, S. Ma, Y. Meng, N. So, P. Unbehagen, M. Morrow, M. Hasan, Y. Demchenko http://tools.ietf.org/html/draft-khasnabish-cloud-reference-framework-03.txt
  - Cloud Service Broker, Internet Draft by Shao Weixiang, Hu Jie, Bhumip Khasnabish. http://tools.ietf.org/html/draft-shao-opsawg-cloud-service-broker-03.txt

Work on I-Draft "Cloud Reference Framework" (Version 0.3)

http://tools.ietf.org/html/draft-khasnabish-cloud-reference-framework-03.txt

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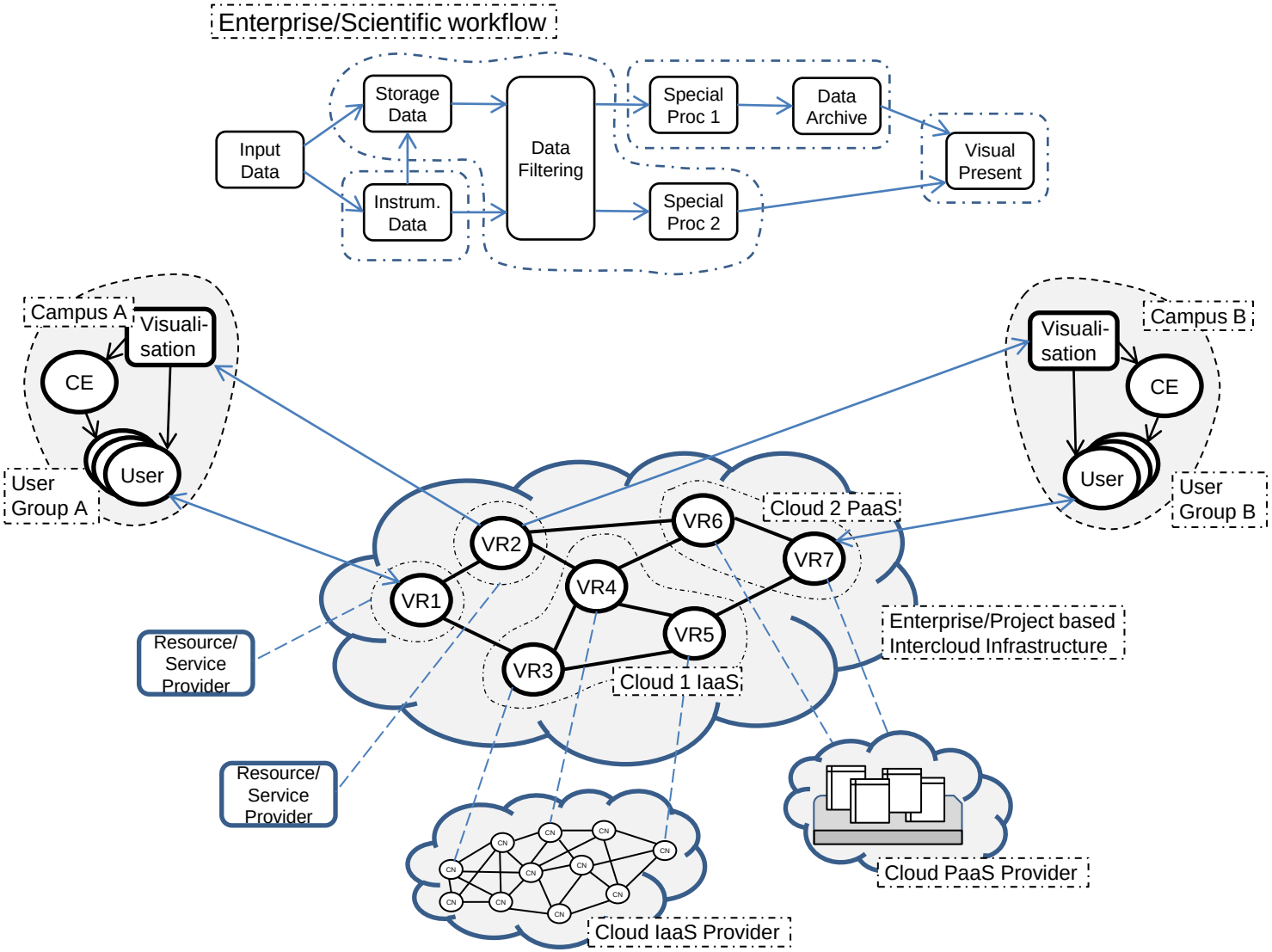
Version 0.3 – 29 June 2012
Version 0.4 – End July 2012
Version 0.5 – October 2012
(To be considered)

Intercloud Architecture - Requirements

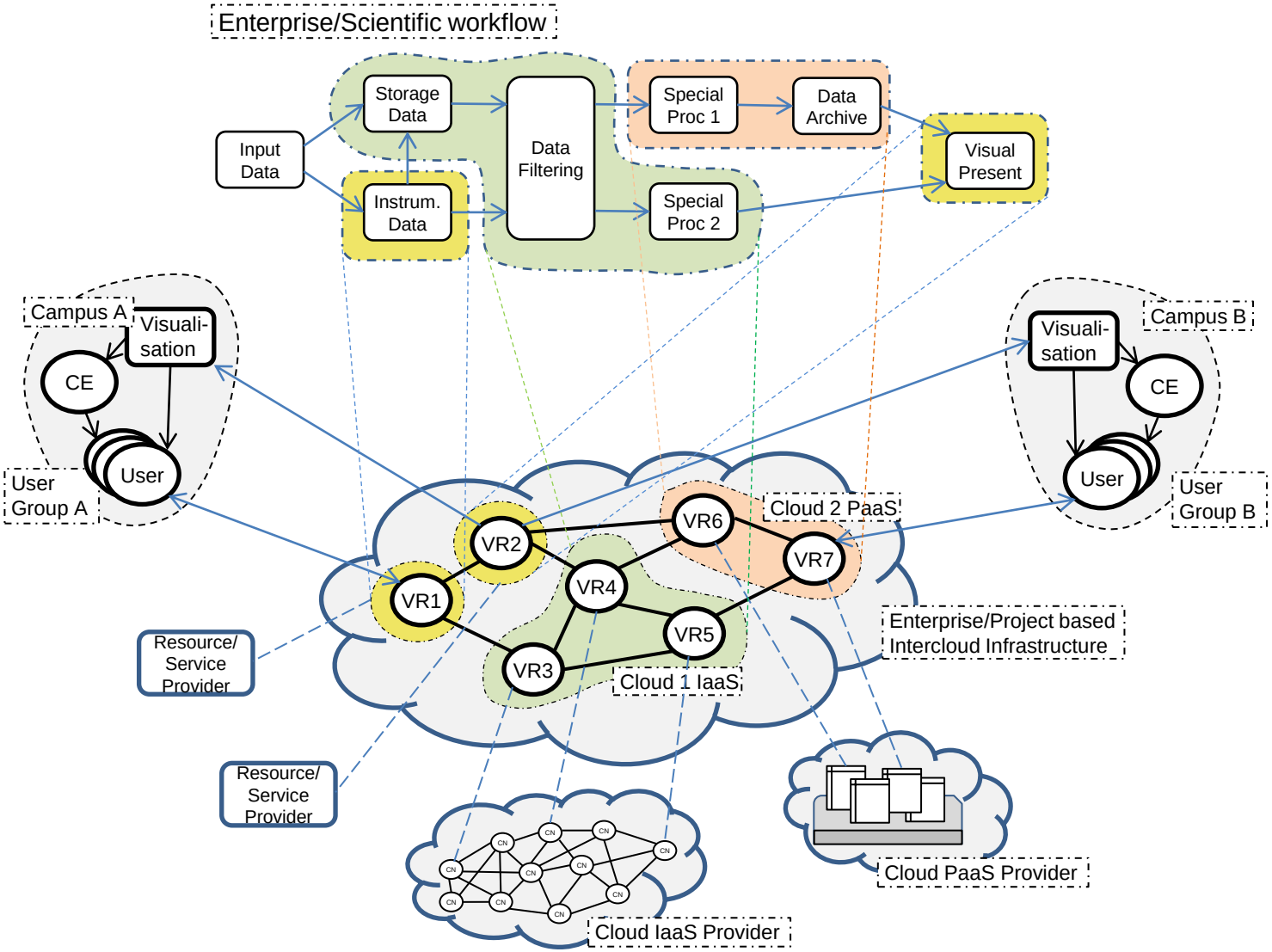
Intercloud Architecture (ICA) should address interoperability and integration of different cloud service platforms and multi-cloud integration, including with legacy campus/enterprise infrastructure

- 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
- Common Intercloud Control Plane and signalling for better cloud services and network integration
- Explicit/Guaranteed intra- and inter-cloud network infrastructure provisioning and performance (as NaaS service model)
- Support existing Cloud Provider operational and business models and provide a basis for new forms of services provisioning and operation

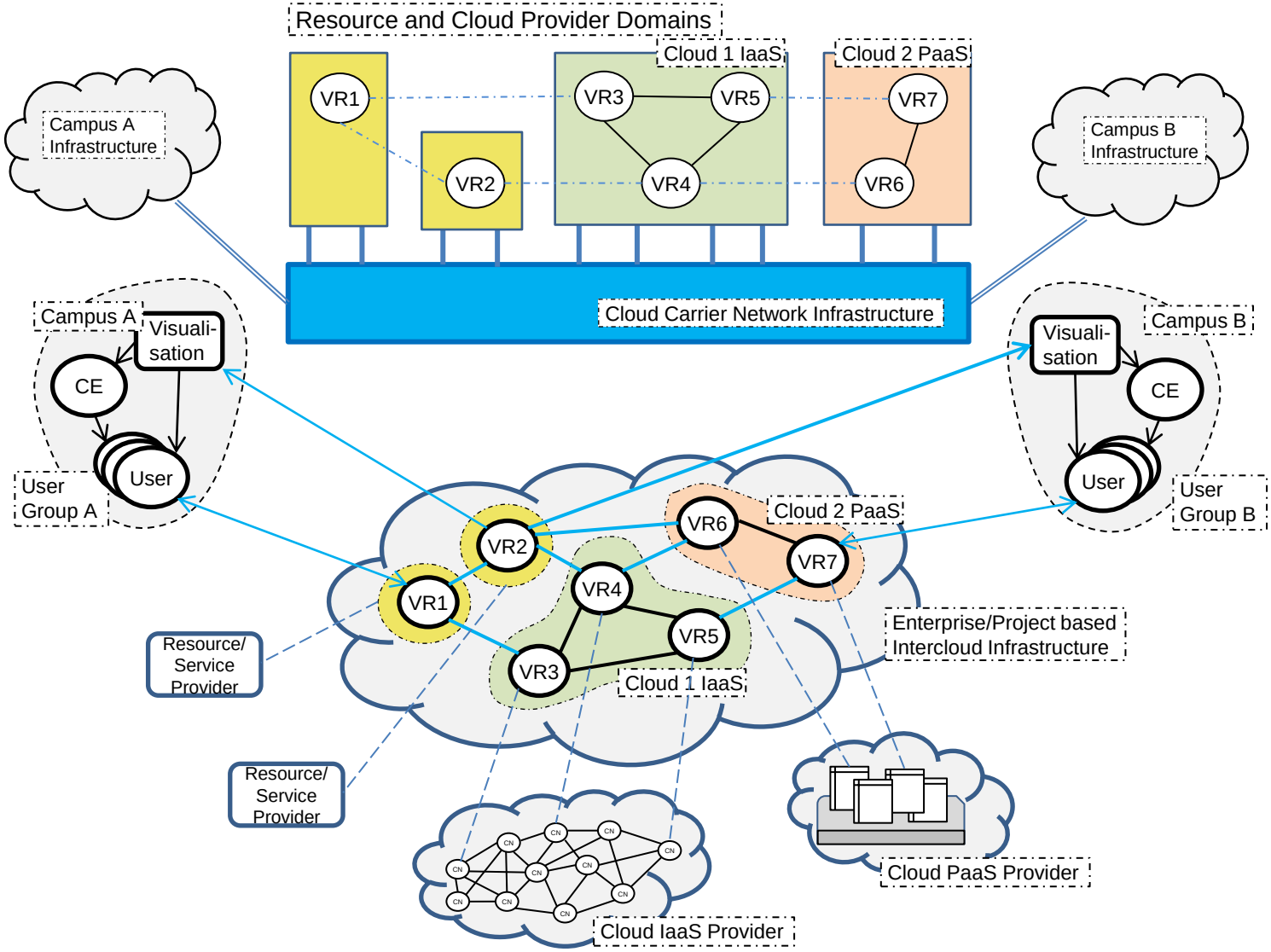
General use case for infrastructure provisioning: Workflow => Logical (Cloud) Infrastructure (1)



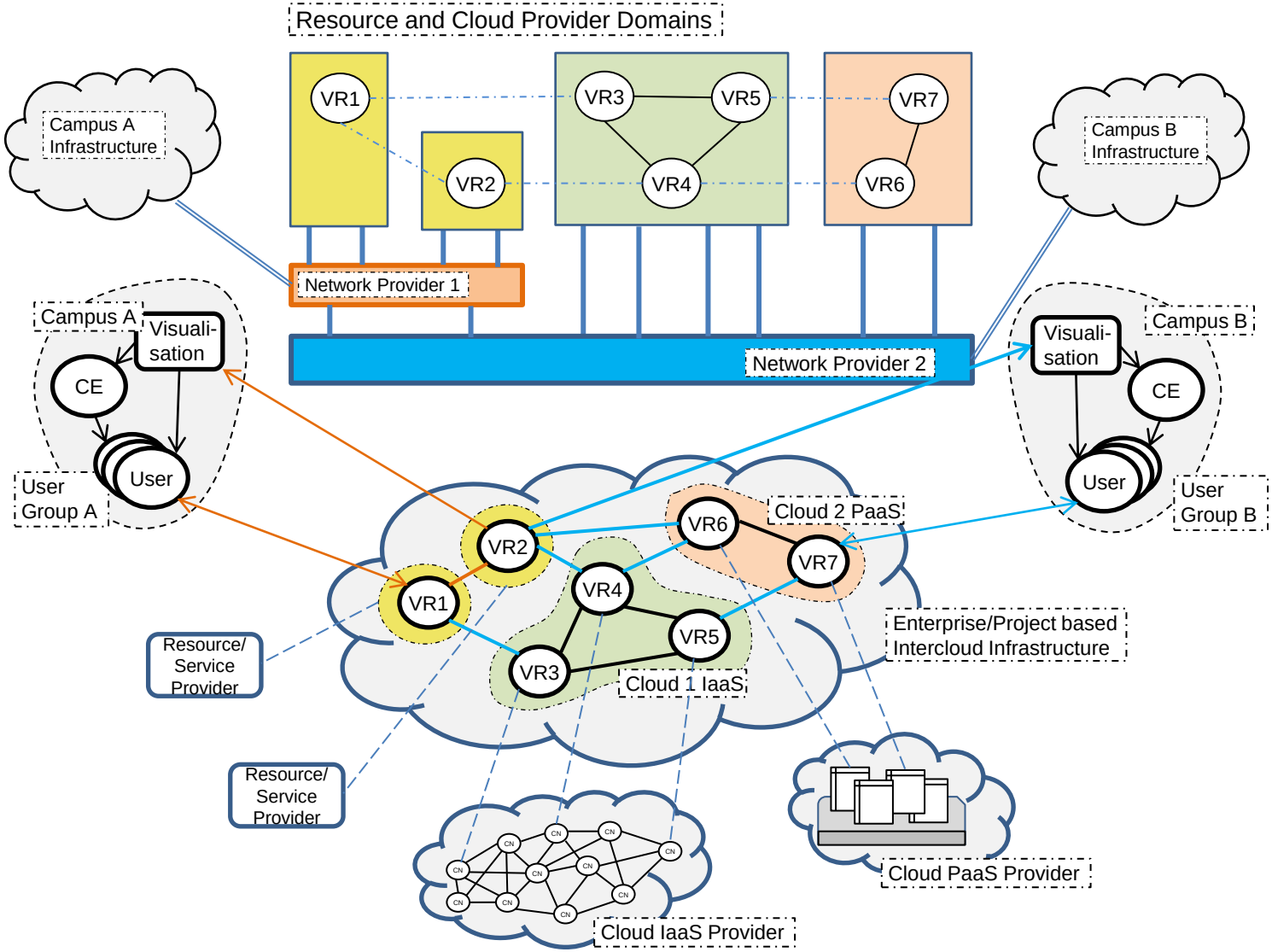
General use case for infrastructure provisioning: Workflow => Logical (Cloud) Infrastructure (2)



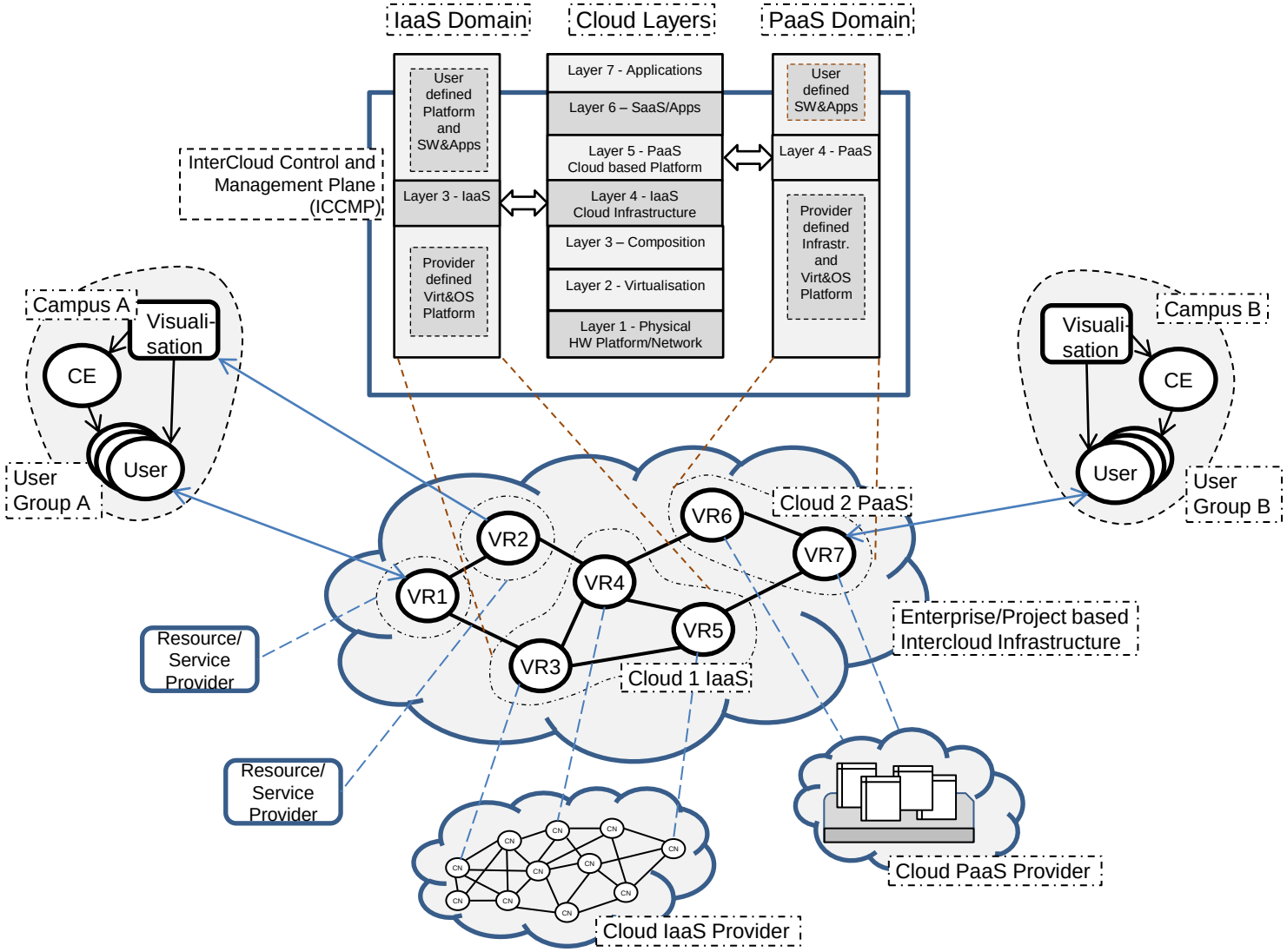
General use case for infrastructure provisioning: Logical Infrastructure => Network Infrastructure (1)



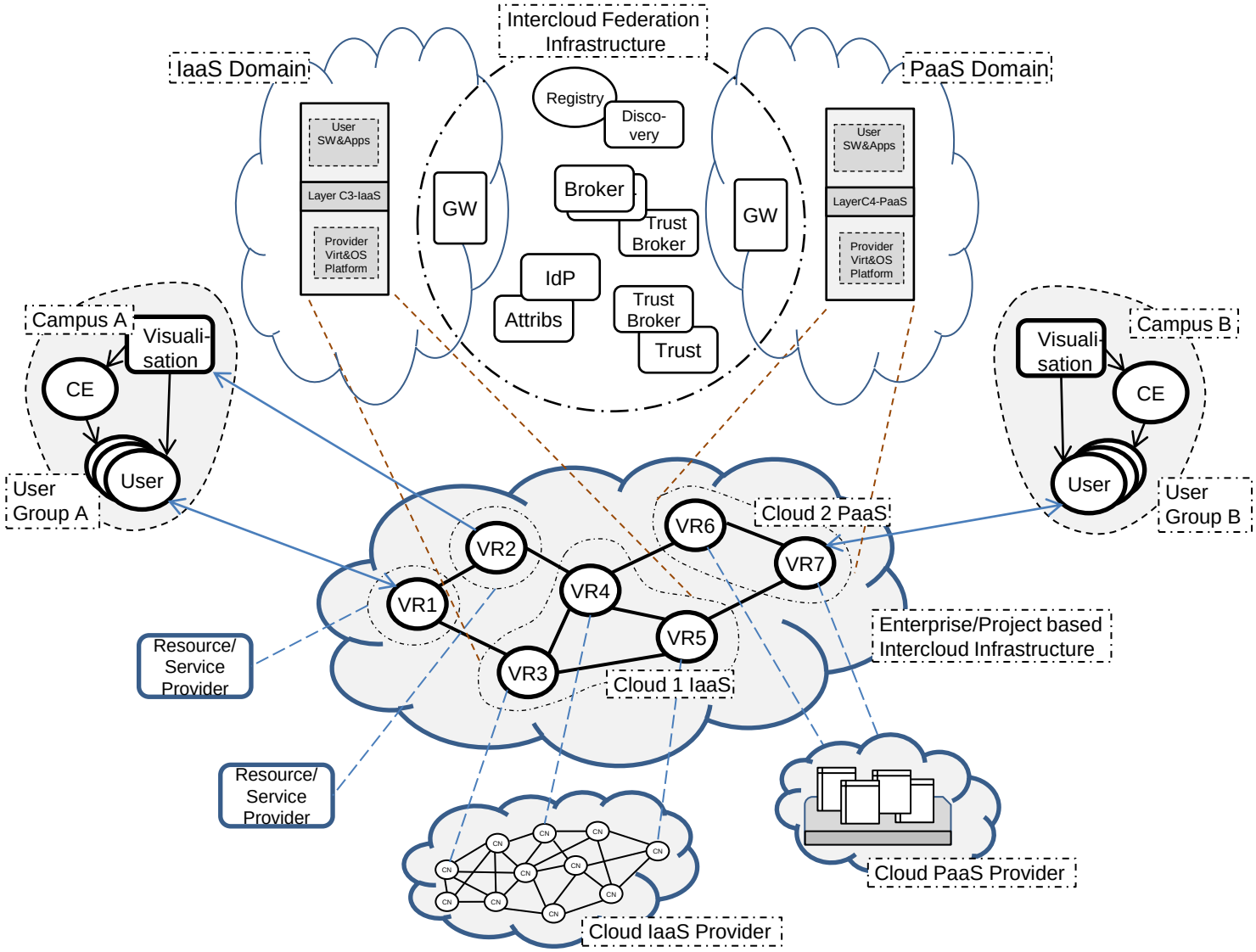
General use case for infrastructure provisioning: Logical Infrastructure => Network Infrastructure (2)



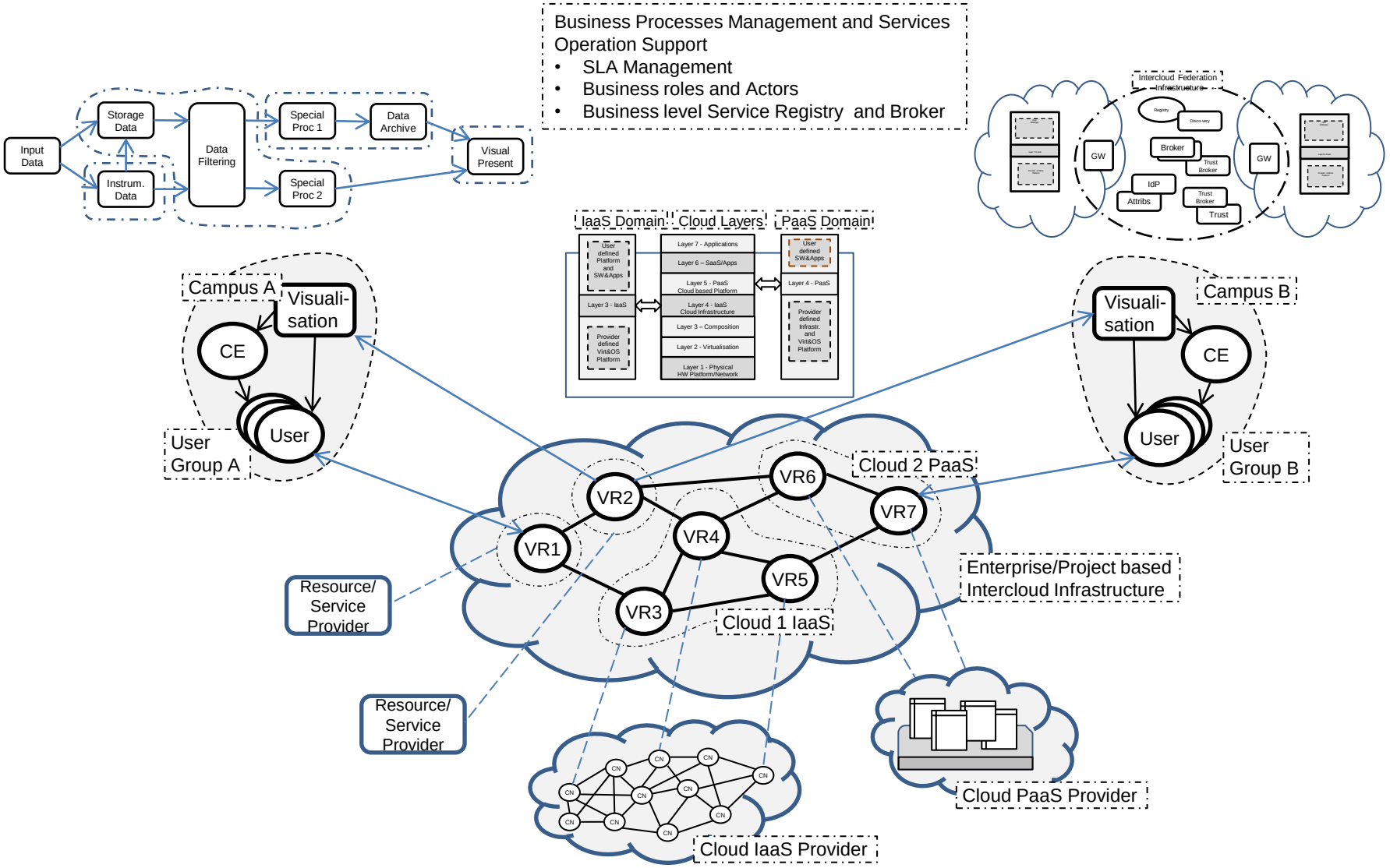
Intercloud Applications Interaction (1) - ICCMP



Intercloud Applications Interaction (2) - ICFF



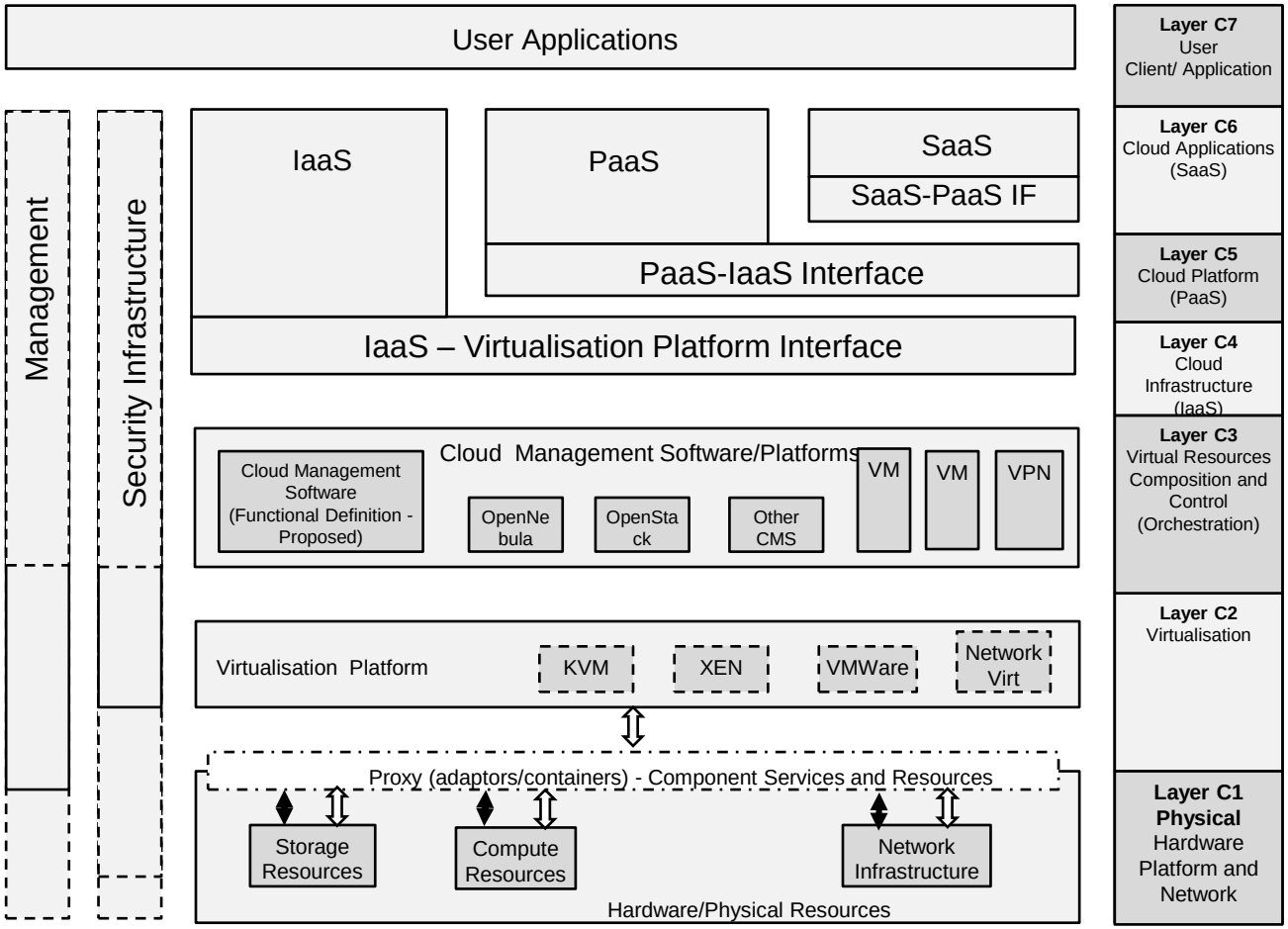
Intercloud Applications Integration (3) - ICOF



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

Multilayer Cloud Services Model (CSM)



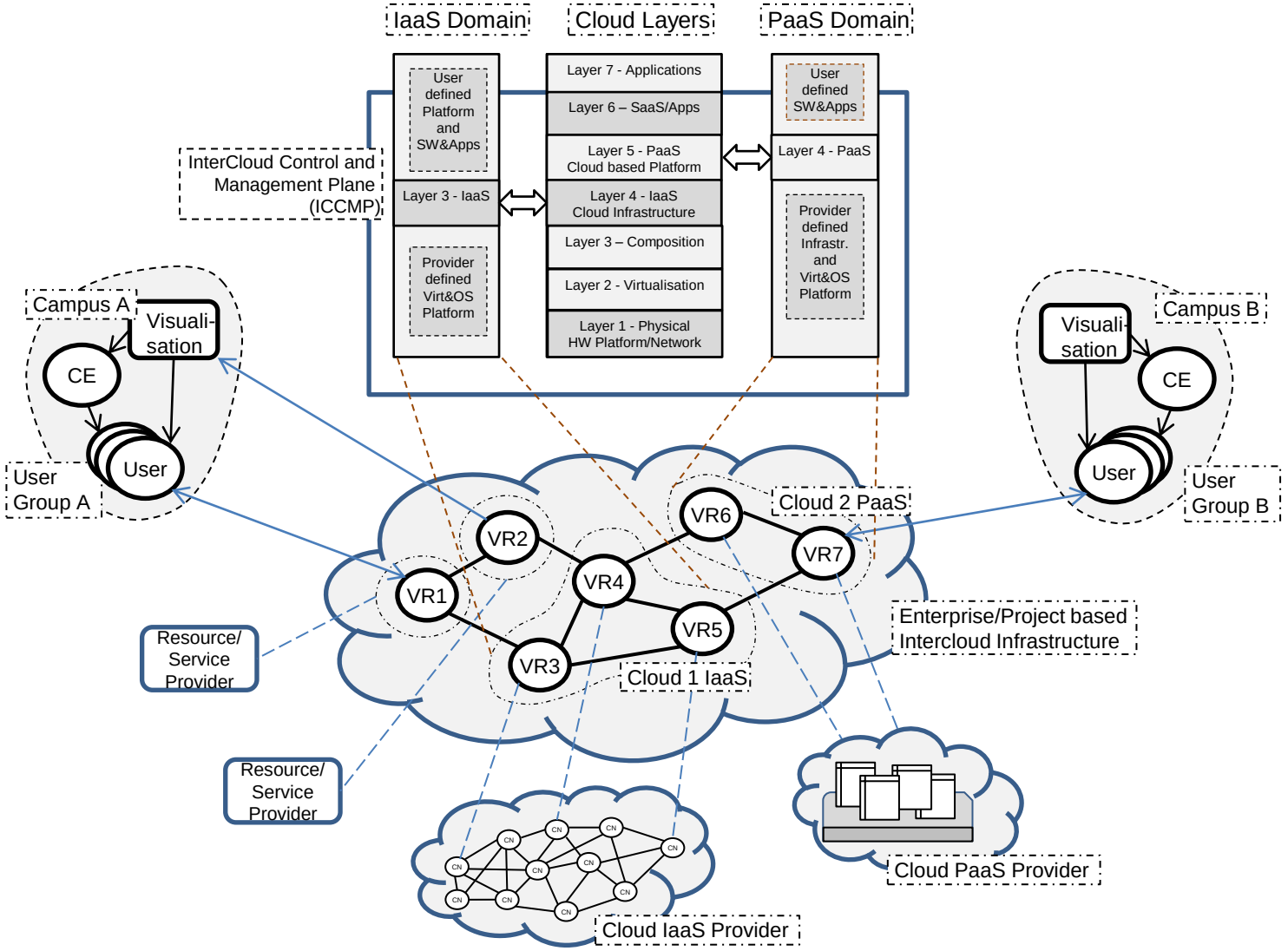
CSM layers

(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

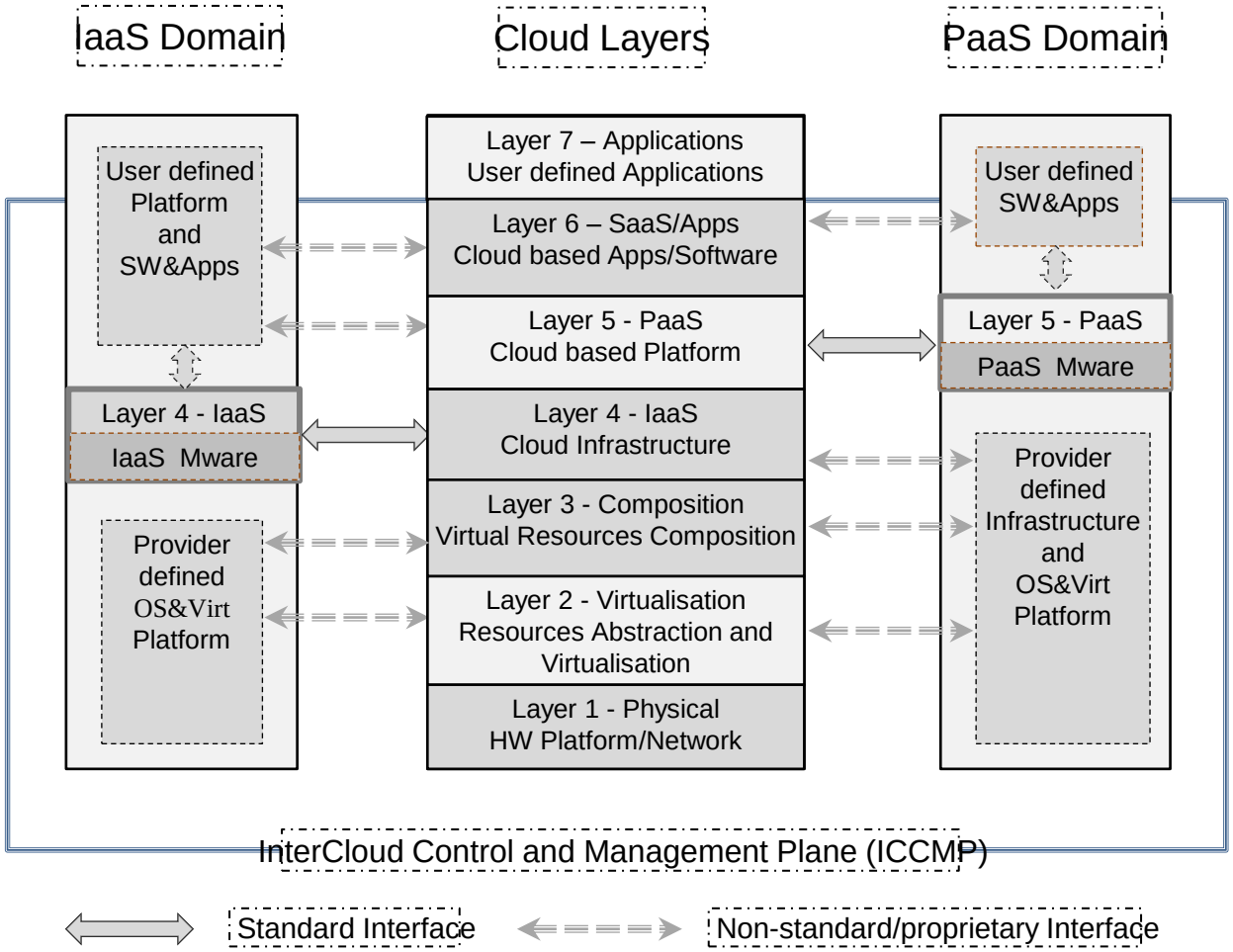
InterCloud Control and Management Plane (ICCMP)

- 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 (1)



Intercloud Control and Management (2)



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
- Main functional components include
  - Cloud Resource Manager
  - Network Infrastructure Manager
- Possible ICCMP Interfaces include
  - Signaling
  - Control
  - Monitoring
  - Management
  - Location
  - Message routing

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.
- 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 (ICOF)

- Defines the main roles and actors
  - RORA model: Resource, Ownership, Role, Action
    - 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

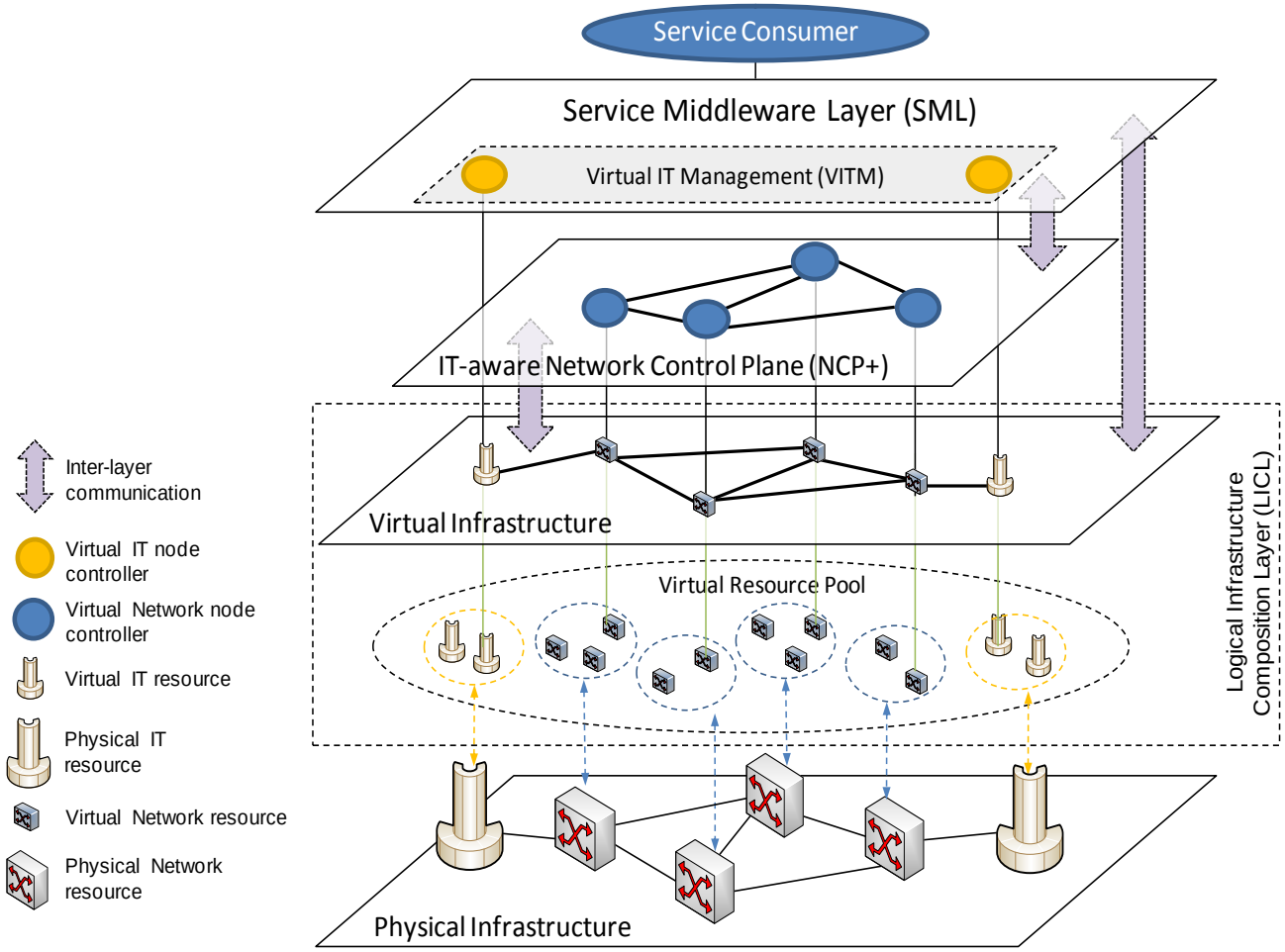
Ownership/Management model needs to be applied to these actors using extended RORA model

Implementation: Architectural Framework for Cloud IaaS

- Abstracted from the GEYSERS LICL (Logical Infrastructure Composition Layer) architecture
- Includes Composable Services Architecture (CSA) being developed in GEANT3 JRA3
- Incorporates RDF based Network and Infrastructure Description Languages (NDL, NML, INDL) research at SNE/UvA
- Includes the following main components
  - Infrastructure Services Modeling Framework (ISMF)
  - Composable Services Architecture (CSA)
  - Service Delivery Framework (SDF)
- Additional components (orthogonal)
  - Cloud Security Infrastructure
  - Control and Management Plane

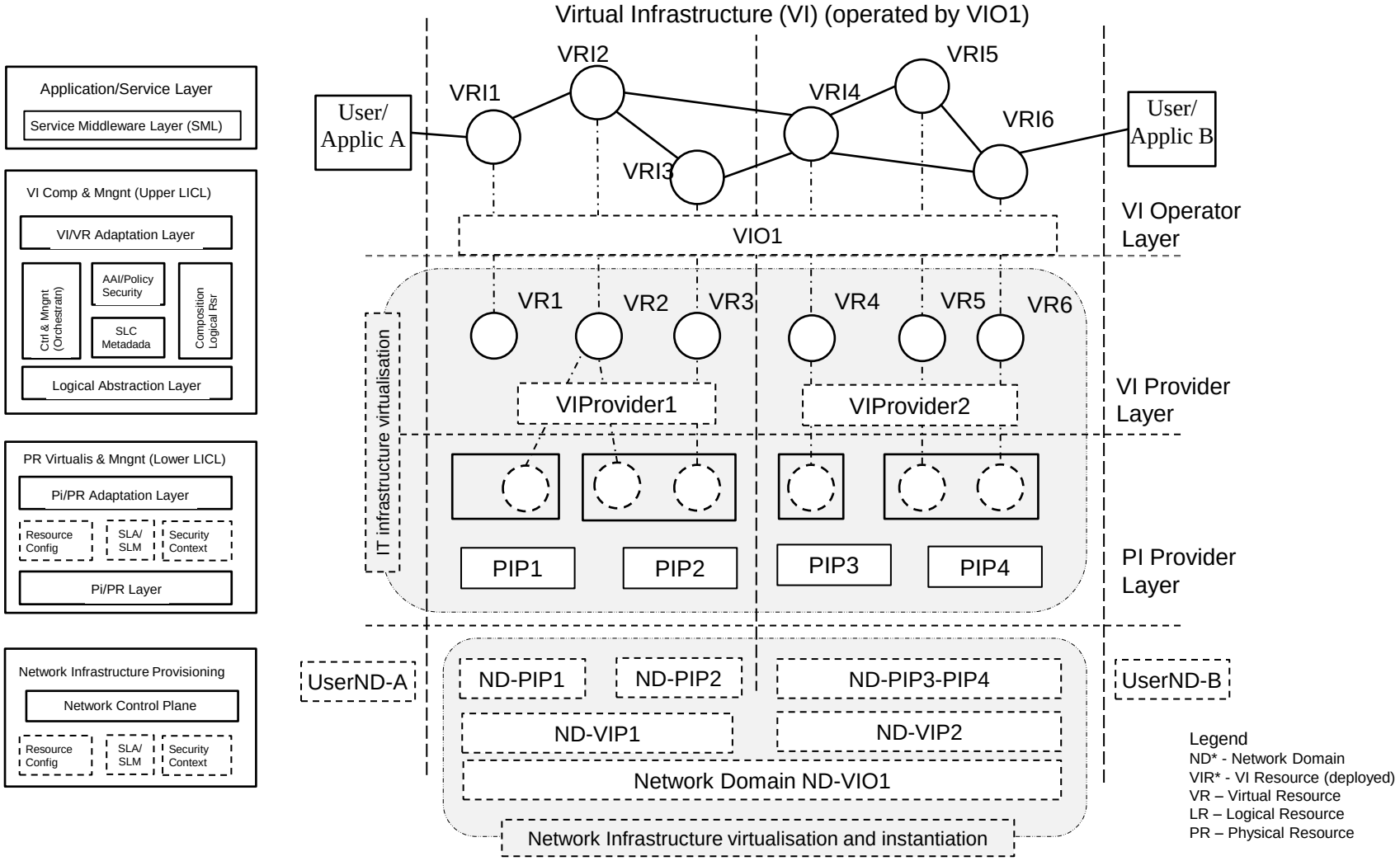
Published as SNE Technical Report (2011)
http://staff.science.uva.nl/~demch/worksinprogress/sne2011-techreport-2011-03-clouds-iaas-architecture-release1.pdf

GEYSERS Layered Architecture – CSM and ICCMP



- Developed and implemented in the GEYSERS project http://www.geysers.eu/

Abstract (Cloud) IaaS Provisioning Model



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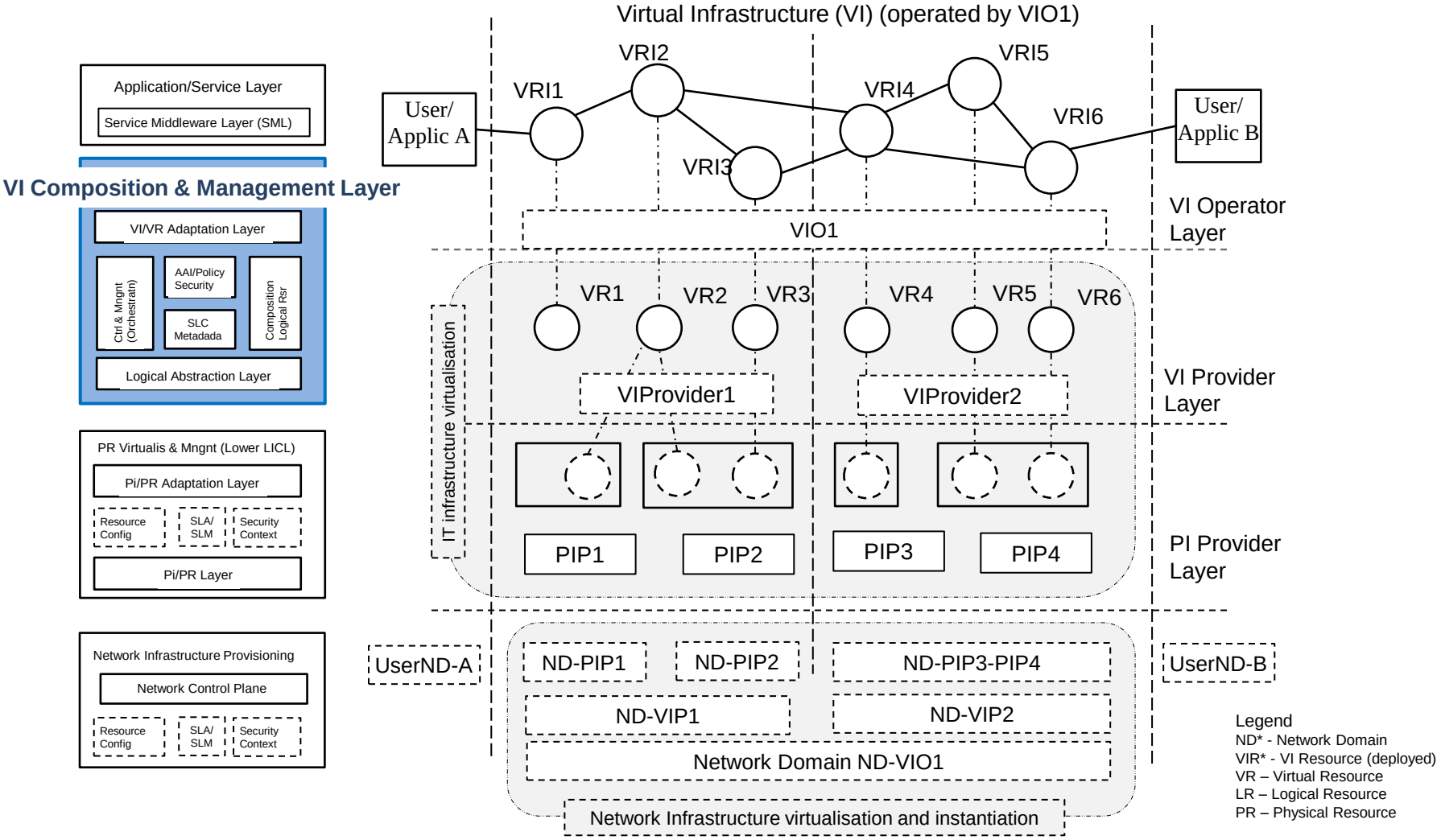

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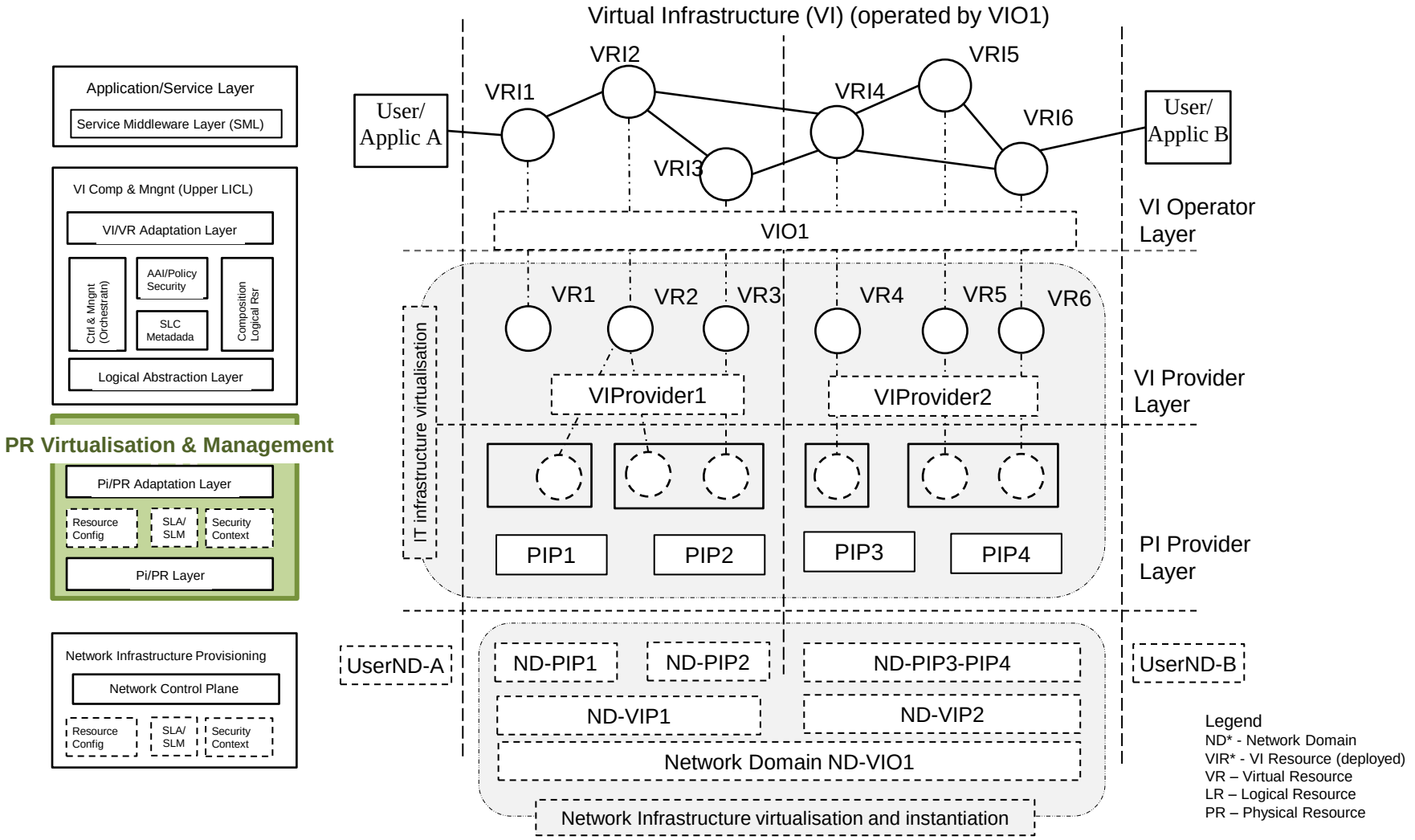

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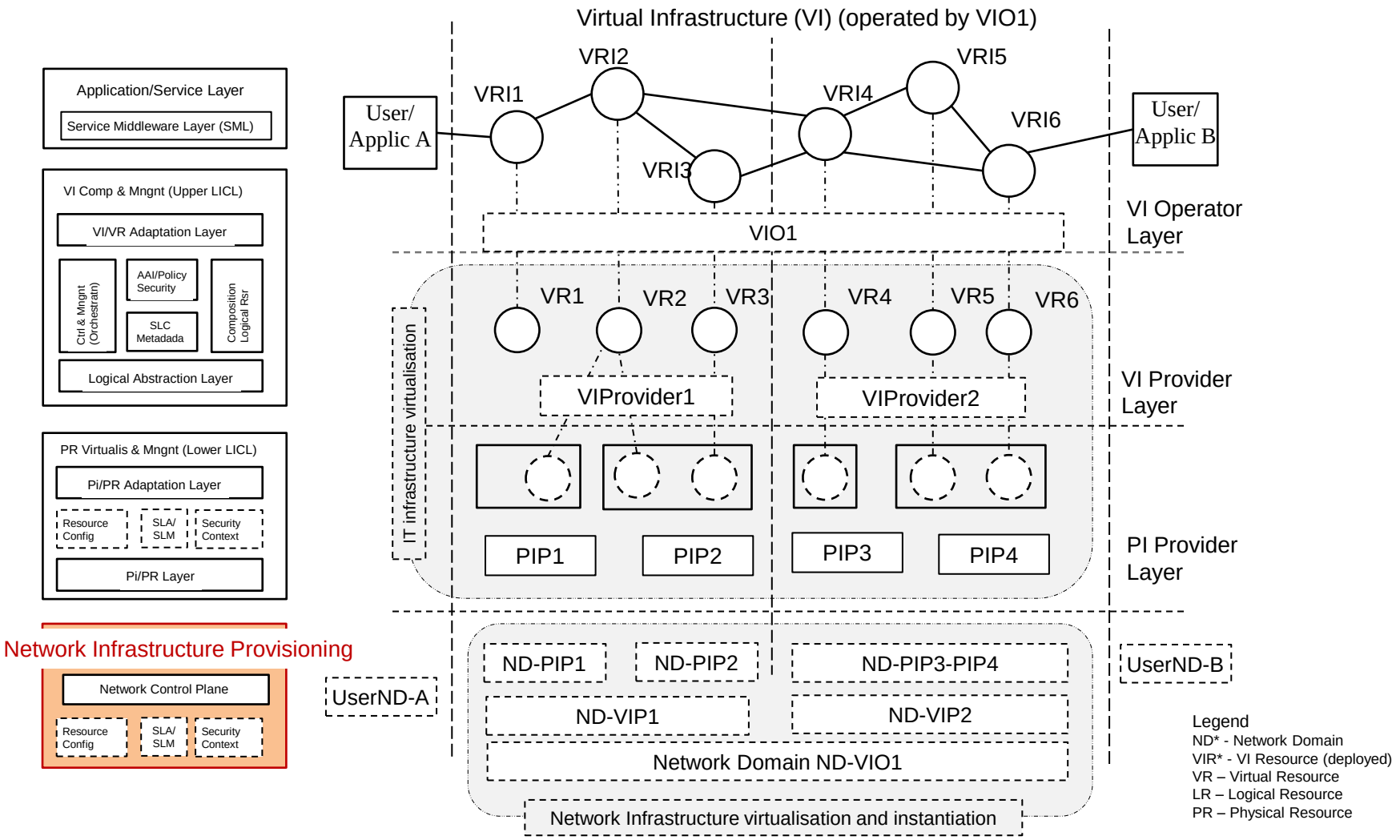
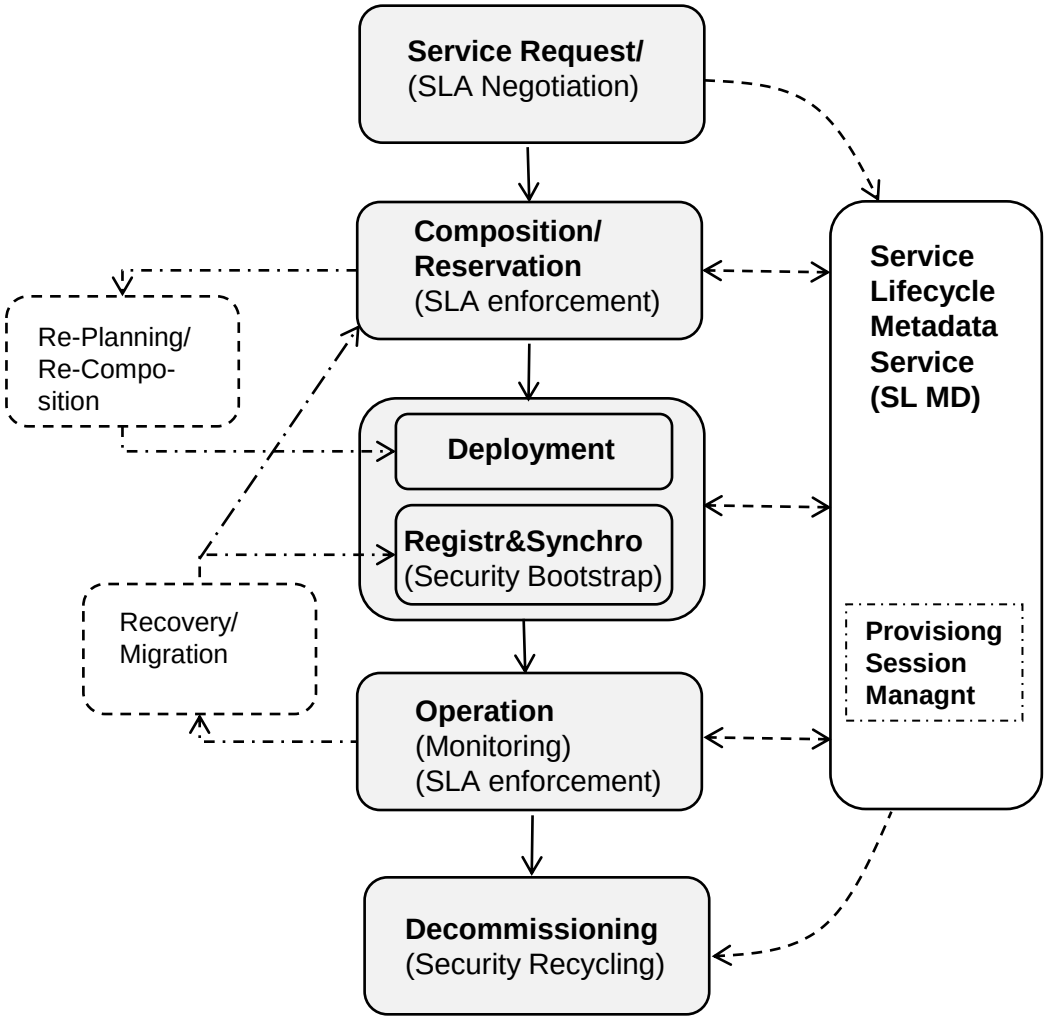


Virtual Infrastructure Composition and Management

- 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 is defined by the Service Delivery Framework (SDF)
  - Defines services lifecycle
- VICM redefines Logical Infrastructure Composition Layer (LICL) proposed by GEYSERS project
  - Basic functionality is implemented as GEMBus/ESB/CSA

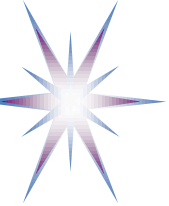
Services Lifecycle/Provisioning Workflow



- Main stages/phases
  - **Service Request** (including SLA negotiation)
  - **Composition/Reservation** (aka design)
  - **Deployment**, including Reqistration/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 re-synchronisation 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 in IETF, OGF, TMF
  - Partnership with industry

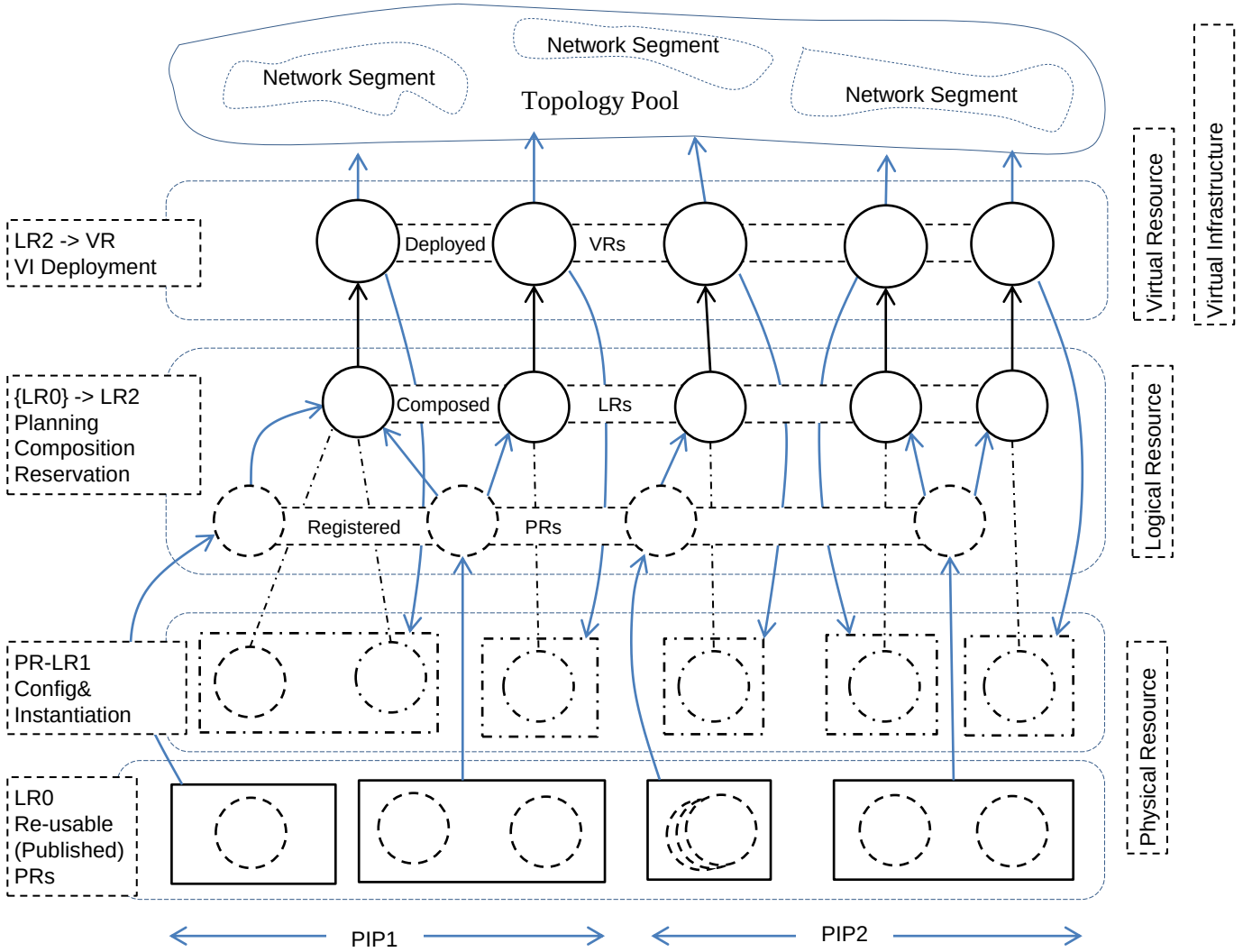


Questions and Discussion

Additional Information

- NIST Cloud definition and standardisation activity
- Useful links on Cloud standardisation and practice

ISMF – Virtual Resource Lifecycle



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)
  - Compatibility with VXDL infrastructure service request format by INRIA

NIST Publications on Cloud Computing

- [NIST CC] NIST SP 800-145, “A NIST definition of cloud computing”, [online] Available: http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf
- [NIST CCRA] NIST SP 500-292, Cloud Computing Reference Architecture, v1.0. [Online] http://collaborate.nist.gov/twiki-cloud-computing/pub/CloudComputing/ReferenceArchitectureTaxonomy/NIST_SP_500-292_-_090611.pdf
- [NIST Synopsis] DRAFT NIST SP 800-146, Cloud Computing Synopsis and Recommendations. [online] Available: http://csrc.nist.gov/publications/drafts/800-146/Draft-NIST-SP800-146.pdf
- Draft SP 800-144 Guidelines on Security and Privacy in Public Cloud Computing. [online] Available: http://csrc.nist.gov/publications/nistpubs/800-144/SP800-144.pdf
- [NIST CC Roadmap] DRAFT NIST SP 800-293, US Government Cloud Computing Technology Roadmap, Volume I, Release 1.0. [online] http://www.nist.gov/itl/cloud/upload/SP_500_293_volumeI-2.pdf
- NIST SP500-291 NIST Cloud Computing Standards Roadmap. [online] Available: http://collaborate.nist.gov/twiki-cloud-computing/pub/CloudComputing/StandardsRoadmap/NIST_SP_500-291_Jul5A.pdf

NIST Cloud definition – Draft SP 800-145 (1)

- NIST Definition of Cloud – missing network provisioning, just “limited control over network”

Cloud computing is a model for enabling ubiquitous, 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. This cloud model promotes availability and is composed of five essential characteristics, three service models, and four deployment models.

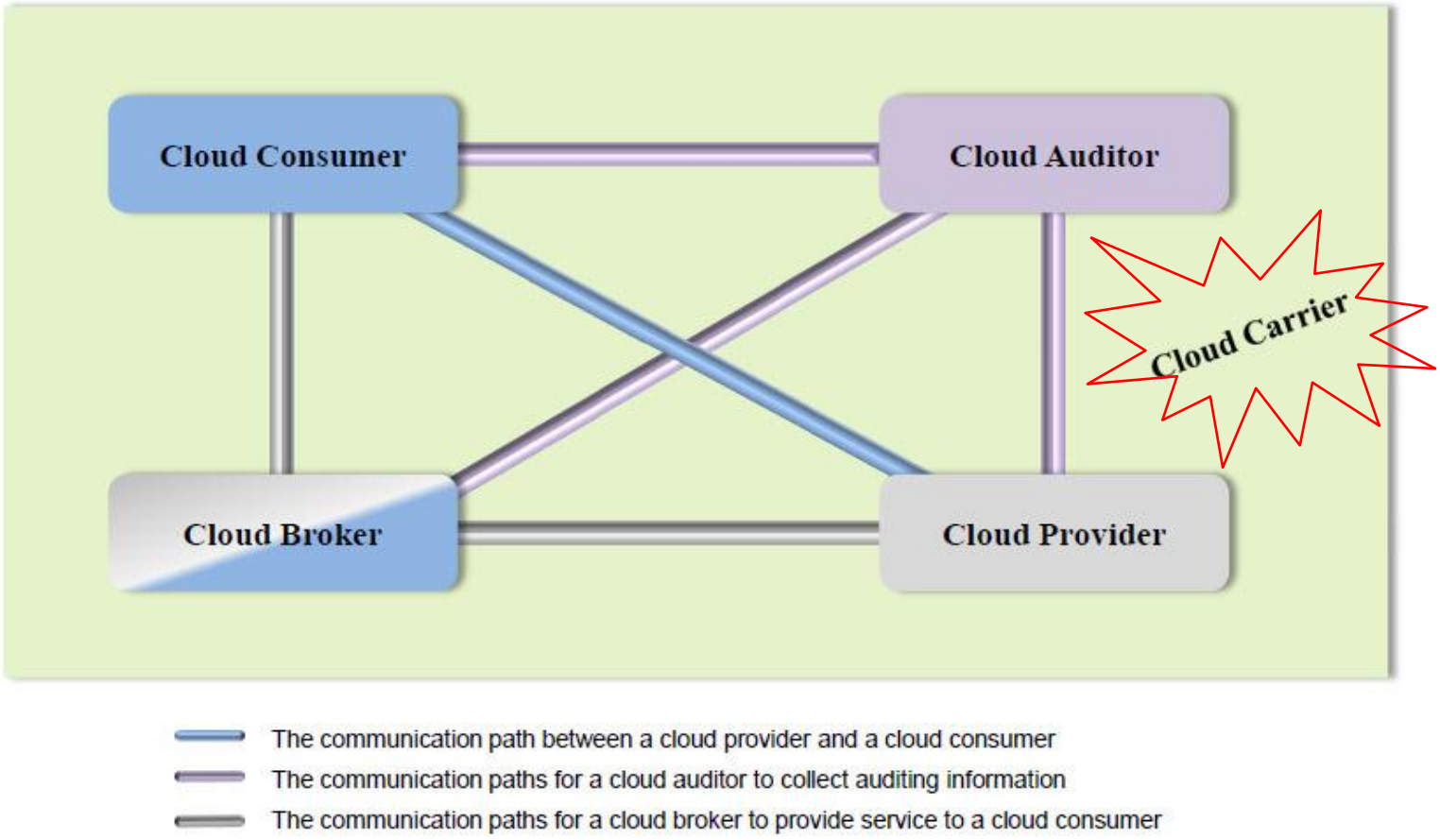
Cloud Infrastructure as a Service (IaaS). The capability provided to the consumer is to provision processing, storage, ***networks***, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, deployed applications, and ***possibly limited control of select networking components (e.g., host firewalls)***.

NIST Cloud definition – Draft SP 800-145 (2)

Draft SP 800-145 A NIST Definition of Cloud Computing (published)
http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf

- 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 (1)



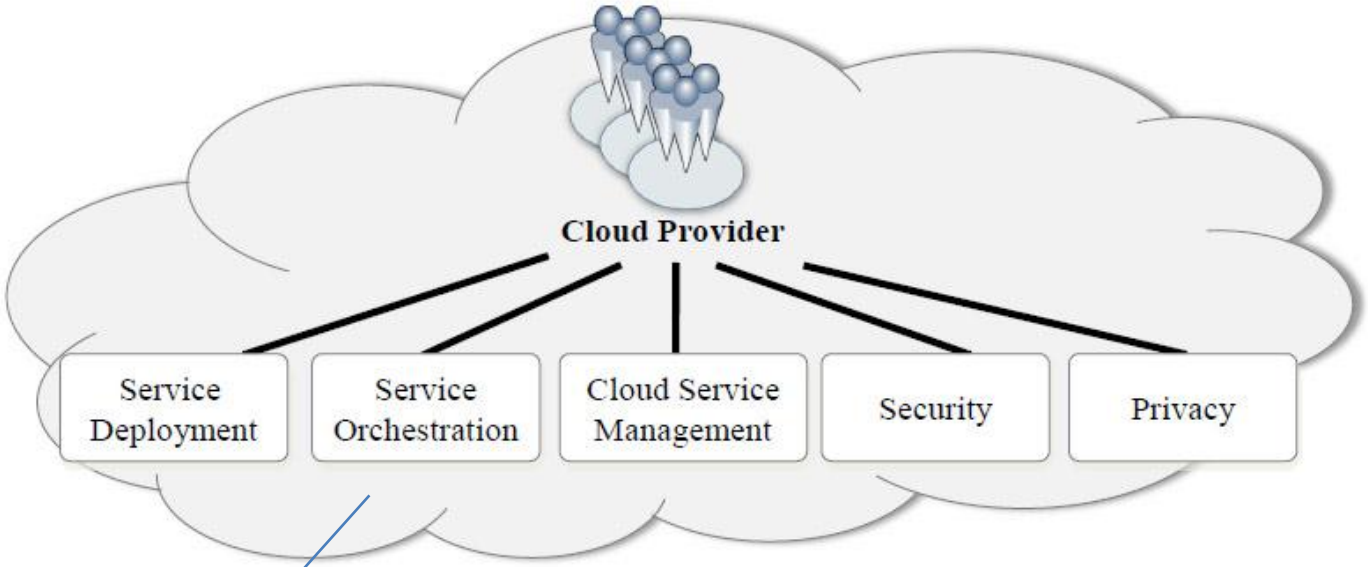
- Cloud Carrier as a role to accommodate telco's interests

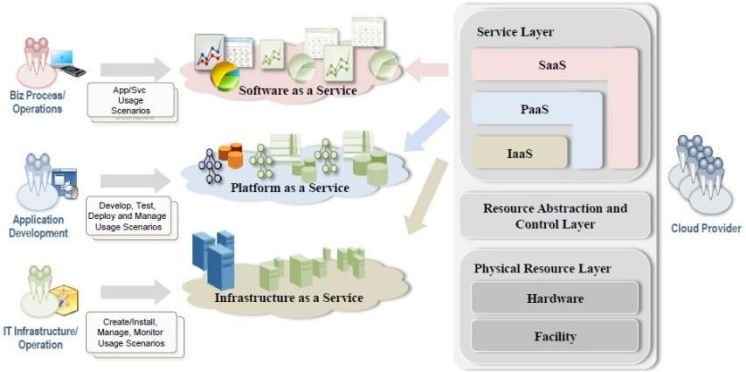
NIST Cloud Computing Reference Architecture (CCRA) 2.0 - Provider Functions (2)

Add:

Service Delivery (Framework)

- Request&SLA
- Reservation/ Composition
- Deployment
- Operation
- Decommissioning

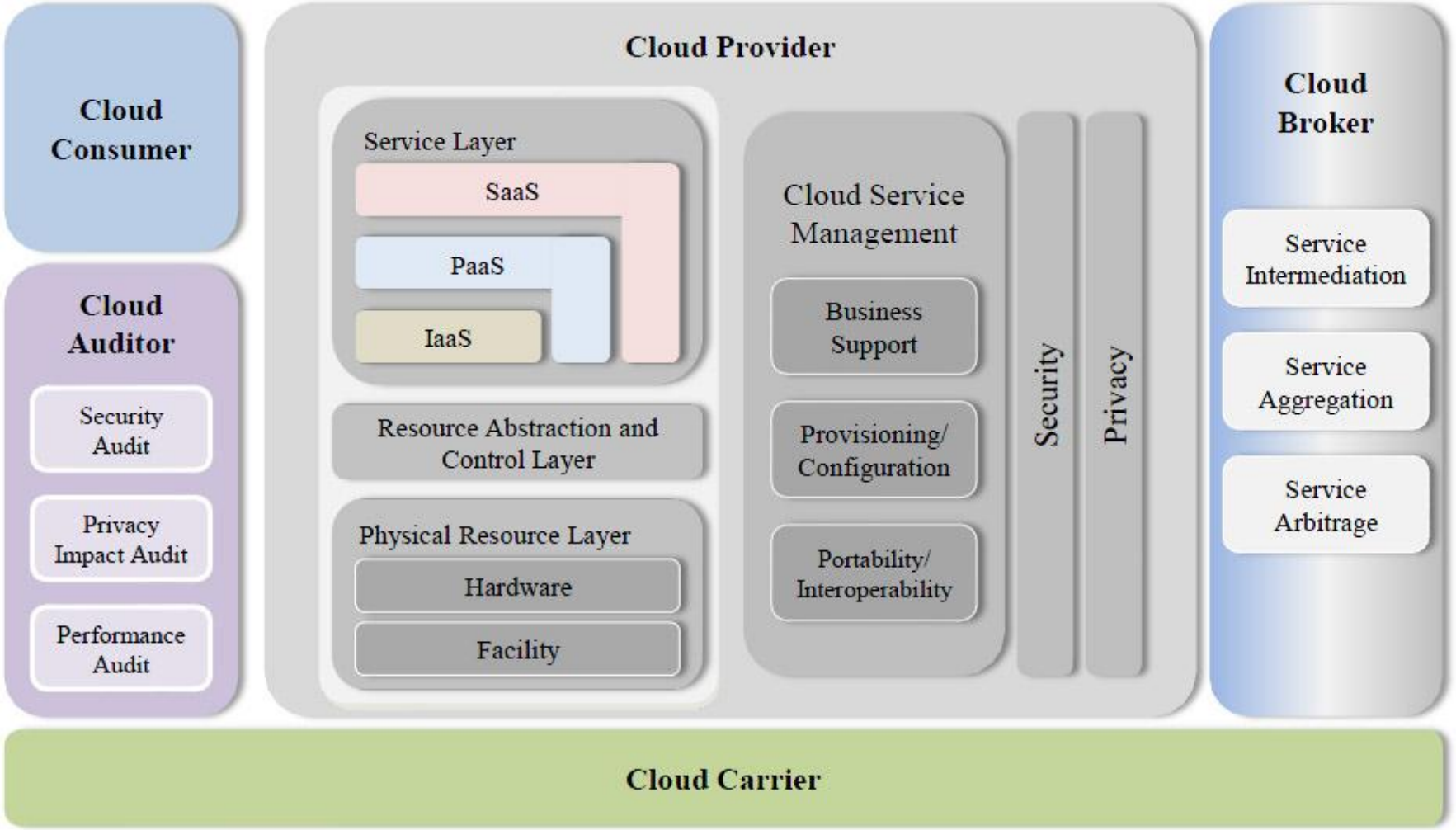




Provider functions

- Defined ambiguously
- Need clear separation between Delivery process, Operation and Control&Mngnt functions
- Service Orchestration is a Control function

NIST Cloud Computing Reference Architecture (CCRA) 2.0 – Consolidated View (3)



Dedicated Network Provisioning in Clouds

- This issue is not addressed in details in any of currently proposed CC architectures
- It can not be consistent infrastructure QoS without (dedicated) network provisioning
  - Specifically for Optical networks
- Telco, network providers and telecom equipment vendors are working in this direction
  - GEYSERS project is an example of network+IT infrastructure virtualisation
-

Extending NIST Cloud IaaS definition to support NaaS
(in the context of Network Infrastructure provisioning)

The suggested extensions to the Cloud IaaS model to meet requirements of the critical enterprise services:

- Define layered cloud services model that should be suitable for defining main inter-layer and inter-service (functional) interfaces
- Add topology aware infrastructure view
- Define resources and services virtualisation as one of generic cloud features (TBD)
- Include improved network services definition capable of provisioning required QoS and allowing control from user run applications
- At the business/operational level, the CCRA should be extended to address the following features:
  - Improved definition of the Cloud Carrier role, operational model and interaction with other key actors
  - Extended set of basic roles to reflect typical for telecom operators/providers business relations:
    - Cloud/infrastructure Operator, Customer, and User (in place of the currently used consumer role)
- Other cloud service models PaaS and SaaS should also allow management of QoS and other network related parameters