Intercloud Federation using via Semantic Resource Federation API and Dynamic SDN Provisioning

David Bernstein
Deepak Vij

Copyright 2013, 2014 IEEE. All rights reserved.

Redistribution and use in source and binary forms, with or without modification, are permitted provided that the following conditions are met:

1. Redistributions of source code must retain the above copyright notice, this list of conditions and the following disclaimer.
2. Redistributions in binary form must reproduce the above copyright notice, this list of conditions and the following disclaimer in the documentation and/or other materials provided with the distribution.

THIS SOFTWARE IS PROVIDED BY THE IEEE ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE FREEBSD PROJECT OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

The views and conclusions contained in the software and documentation are those of the authors and should not be interpreted as representing official policies, either expressed or implied, of the IEEE.
Cloud Computing is the New Pervasive Ubiquitous Intelligence & Communications Platform for Planet Earth

- Education
- Relationships
- Communications
- Infrastructure
- Commerce
- Transportation
- Entertainment
- Day to Day Life
IEEE P2302 Working Group
Standard for Intercloud Interoperability & Federation
IEEE Intercloud Testbed Project

- An Open Source project
- Architecture Similar to Internet Routing protocols, with Autonomous System and distributed capabilities concepts
- Cloud Implementation Independent – Openstack, VMware, C12G, MS, ..
- Identity and Trust scheme
- Uses Semantic Resource definitions to federate any imaginable IaaS or PaaS resource, and to allow for dynamic SDN based federation network transport
Architectural Classification of Interoperable Clouds

Inter-Clouds

Volunteer Federation
- Peer-to-Peer: IEEE P2302 Intercloud
- Centralized: U of Melbourne Inter-Cloud

Independent/Multi-Cloud
- Service: CloudSwitch
- Libraries: OGF OCCI or Helix Nebula

Example Projects
- Inter-Cloud architectures and application brokering: Nikolay Grozev and Rajkumar Buyya

12/16/2014
**Topologies - different cloud interoperability**

**Federations**
- Peer-to-Peer Inter-Cloud Federation: Clouds collaborate directly with each other but may use distributed entities for directories or brokering
- Centralized Inter-Cloud Federation: Clouds use a central entity to facilitate resource sharing

**Multi-Clouds**
- Multi-Cloud Service: Clients access multiple clouds through a service
- Multi-Cloud Library: Clients develop their own brokers by using a unified cloud API as a library
Reference Intercloud Components

- CSP Namespace
- Federated Identity
- Conversational Substrate (XMPP)
- Transport/Services (Web Sockets)

- Replication (BitTorrent)
- Semantic Directory (OWL Ontology)
- Certificate Authority
- XMPP Servers
- CSP/DNS NAPTR

Intercloud Root

- CSP Namespace
- Federated Identity
- Conversational Substrate (XMPP)
- Transport/Services (Web Sockets)

- Replication (BitTorrent)
- Semantic Directory (OWL Ontology)
- Solver (Hadoop/Sparql)
- Auditing
- SDN Controller

Intercloud Exchanges

- CSP Namespace
- Federated Identity
- Conversational Substrate (XMPP)
- Transport/Services (Web Sockets)

- Federating API
- Federating Transport via SDN VPC
- Federating Implementation

Intercloud Gateway

12/16/2014
Intercloud Protocols Taxonomy

Presence and Conversational Protocols
- XMPP
- Web Sockets
- HTTP
- BitTorrent

Generic Services and Transport Infrastructure
- Mgt. API’s
- Directory Replication

Internet Routing and Transport
- DNS
- IP Routing

Specialized Storage Transport Infrastructure
- UDT

TCP
- IP

12/16/2014
Intercloud Namespace

• Representation of CSP Numbers
  – Conceptually similar to ASN scheme as defined in RFC 5396
  – Textual representation of “cspplain” (simple integer form)

• URN CSP Number Designation
  – <nnnn>.csp.intercloud.net
  – Eg, 4.csp.intercloud.net is CSP 4

• XMPP Mapping using DNS
  – Utilize Name Authority Pointer ("NAPTR") DNS Resource Record 35 (RFC 3403) to map CSP URN to CSP XMPP Service Endpoint
  – Using an example of Megacloud Inc. with CSP 4, a NAPTR query of 4.csp.intercloud.net
  – Would be mapped to xmpp://intercloud.megacloud.net
  – Which resolves to the IP address of the Conversational Service of Intercloud Gateway of Megacloud
Intercloud Resources Catalog

- Hosts & Manages Intercloud Catalog
- Enforces Policies And Standards
- Publishes Computing Resources Artifacts
- Adheres to Policies & Standards
- Consumes
- Consumes
- Intercloud Exchanges
- Discovers – XMPP based Service Call
- Governance
- Provider Cloud
- Consumer Cloud
- Intercloud Catalog
  - Resources Catalog
  - Policies Standards
  - Service Contracts
- Service Level Agreement Binding
- Intercloud Exchanges
- Intercloud Exchanges
- Intercloud Exchanges
- Intercloud Exchanges
- Intercloud Exchanges

12/16/2014
Semantic Resource Definitions have both Resource and Bearer Network Declarations

- **Semantic Resource Definition**
  - Uses OWL Specification against a common “Ontology Schema” for Resources (Incl SLA, Pricing)
  - Uses OWL Specification against a common “Ontology Schema” for Bearer Network

- **Suppliers of Resources** declare the Offered Resources and the Bearer Network within which they can be Supplied

- **Requesters of Resources** declare the Desired Resources and the Bearer Network within which they can be Consumed

```
SUPPLIER
Resource {
    ----------
};
SLA {
    ----------
};
Pricing {
    ----------
};
Bearer Network {
    ----------
}

REQUESTER
Resource {
    ----------
};
SLA {
    ----------
};
Pricing {
    ----------
};
Bearer Network {
    ----------
}
```

Supplier meets / exceeds requester specification for Resource and SLA

Supplier meets / exceeds requester specification for Bearer Network
Examples of Bearer Network Declarations

• **Network Performance, specifications like**
  – Average and Maximum end to end latency specification
  – Average maximum sustained throughput, peak measured throughput
  – Bandwidth Delay Product, etc

• **Type of Network, specifications like**
  – Public Internet
  – NREN
  – Private Interconnection

• **Security of Network, specifications like**
  – Encryption type
  – Key Lengths
  – Route Path Restrictions

• **Special Network Connection**
  – Private IP Peering (a la Direct Connect)
  – Co-located shared switch fabric (a la Powered by Peak)
  – Network Type (a la Infiniband using RDMA/OFA)

• **Metric**
  – Just like in an IP Router, a Bearer Network Ranking
1(a). User Requests Cloud Resources by issuing existing cloud specific UNI API call (EC2/S3, Nova/Swift, OCCI, MS SC 2012) to a Home Cloud.

1(b). If the Home Cloud is able/configured to fulfil the entire User Request locally, it does so and returns the User Request API. The flow stops here as there is no need for rest of the Intercloud federation steps.
2(a). Where the Home Cloud wishes to use Intercloud federation to fulfill certain of the User Request, the Home Cloud uses a Cloud OS specific interface to the it’s associated Gateway communicating the User Request. User Request API has not returned yet.

2(b) The Gateway constructs the canonical Resource Description Declaration Including Resource, SLA, and Bearer Network sections.

2(c) The Gateway serializes these into the Federation API format including and invokes them onto the implicit Gateway at the Exchange.
3(a). The implicit Gateway at the Exchange and forms appropriate Exchange-Internal API’s for the Solver/Matching process.

3(b). The Resource Description Declaration General Form is used to create a SPARQL/SWRL query to the Solver/Matcher; the timestamp/deadline requirements

3(c). The Solver/Matcher seeks qualifying inventory (here this example from Supplier Cloud) solving the constraints/quantifiers and if found, constructs a canonical Resource Description Declaration Including the specific Resource, SLA, and Bearer Network which the Supplier Cloud would deliver.
4(a). If the Exchange did not solve for inventory it returns an error to the Home Cloud Gateway, which unwinds this to return the User Request API with an error.

4(b). If the Exchange found inventory it produces a Resource Description Declaration Supplier Cloud Form onto the Gateway at the Home Cloud.

4(c). In this case the Exchange will also construct a Federation API for the Supplier Cloud, The Supplier cloud may or may not choose to optimistically reserve or begin to provision those resources. The User Request API has not returned yet.
5(a). The Network Management (SDN Controllers) in the Exchange reach out to the Network Management points in the Home Cloud and Supplier Cloud Gateways.

5(b). The Home Cloud and the Supplier Cloud Gateways may have self-provisioned based on the bearer network information in the Federation API supplied in Step 4.

5(c). If not, the Network Management system (SDN Controller) provisions the connectivity to the bearer network specified in the Resource Description Declaration.

5(d). If the bearer network cannot be provisioned, the Exchange returns an error to the Home Cloud Gateway, which returns to the User Request API.
6(a). The Home Cloud Gateway serializes the Resource Description Declaration Supplier Cloud Form onto the Supplier Cloud Gateway.

6(b). The Supplier Cloud provisions the resources, if not done optimistically earlier.

6(c). If the Supplier Cloud resources cannot be provisioned, it returns an error to the Home Cloud Gateway, which unwinds this to return the User Request API

7(a). The Resources are provided over the Bearer network via VPN based VPC, to the User as if they were supplied directly by the Home Cloud
VPC Federation Mechanism

Enterprise Sites

Customer Edge

VPN

Provider Edge

SDN Software

Logical Customer Edge

SDN Software
Federation of Workloads – Looks like Dynamic/SDN VPC (Virtual Private Cloud)

- IPSEC VPN Tunnel, or MPLS VPN

Requesting Cloud

CSP 1
Availability Zone 1
Availability Zone 2
Workloads in Network Space of CSP 1, AZ 2
Federated (Phantom) Workloads in Network Space of CSP 1, AZ 2

Fulfilling Cloud

CSP 2
Availability Zone 1
Availability Zone 2
Federated (Actual) Workloads in Network Space of CSP 1, AZ 2
Workloads in Network Space of CSP 2, AZ 1
Federation of Storage – Storage System Replicate Extension

**Requesting Cloud**

- CSP 1
  - Availability Zone 1
  - Native Storage CSP 1 Replicates
  - Federated (Phantom Consumer) Storage CSP 2 Replicate

**Fulfilling Cloud**

- CSP 2
  - Availability Zone 1
  - Federated (Phantom Supplier) Storage CSP 2 Replicate
  - Availability Zone 2
  - Federated (Actual) Storage CSP 2 Replicates

UDT or other UDP/IP protocol

12/16/2014 21
david.bernstein@ieee.org
andrew.hughes@ieee.org

http://www.intercloudbased.com/
http://cloudcomputing.ieee.org/intercloud
http://www.linkedin.com/groups/IEEE-Cloud-Computing-2856284
https://www.facebook.com/IEEECloudComputing
https://twitter.com/ieeecloud