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An inter-cloud bridge system for heterogeneous cloud platforms

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HIGHLIGHTS

- We model a service-centric service for Inter-Cloud communication.
- The architecture relies on different cloud providers and their open SaaS.
- We examine Inter-Cloud using cloud platform API interfaces (OpenStack and FIWARE).
- Approach shows efficiency regarding service stability and minimizes delays.
- Experiments show effective Inter-Cloud request, response and deployment times.

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ABSTRACT

Over the years, more cloud computing systems have been developed providing flexible interfaces for inter-cloud interaction. This work approaches the concept of inter-cloud by utilizing APIs, open source specifications and exposed interfaces from cloud platforms such as OpenStack, OpenNebula and others. Despite other works in the area of inter-cloud, that are mainly resource management-centric, we focus on designing and developing a service-centric architecture. We implement an inter-cloud bridge system that is elastic, easy to be upgraded and managed. We develop a prototype composed not only from heterogeneous cloud platforms but also from independent cloud services. These are developed by different cloud service providers and offered as open source Software as a Service (SaaS). The proposed Inter-Cloud Mediation Service uses Future Internet SaaS such as a Context Broker for registrations and subscriptions to services and a Complex Event Processing engine for event management. We present an experimental analysis to show interactions with various heterogeneous cloud platforms and we evaluate the performance of inter-cloud services separately and as a whole.

1. Introduction

Cloud computing provides a computer-based environment where various services and applications are available to users through the public Internet. Various cloud platforms such as Amazon Web Services (WS), OpenStack and others, provision services to clients on a pay-on-demand model. Recently, the emergence of the Future Internet (FI) concept has promoted the so-called modular cloud service developments that is derived from of the Service Oriented Architecture as in [1], yet in the area of cloud computing. In particular, this is based on the need to decompose a system in small and easy to control cloud services of basic functionalities (e.g. user authentication) called Generic Enablers (GEs). Each GE is a software block offered as cloud service followed by an open specification and flexible API as introduced by the FI-WARE project.[1] FI-WARE provides a cloud platform (named as FI-LAB) based on the Datacentre Resource Management System (DCRM) GE[2] and offers interfaces for future developments (e.g. for developing an inter-cloud). In this platform various cloud service providers deploy and offer cloud services in the context of the FI-PPP programme.[3]

The work does not aim to alter internal cloud platform processes and possible adaptions that need to be made by cloud providers, as most of the related approaches propose, but on the

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[1] FI-WARE Project: http://www.fi-ware.org/lab/.
[2] FI-WARE DCRM Architecture: https://forge.fi-ware.org/plugins/mediawiki/wiki/fiware/index.php/FIWARE.OpenSpecification.Cloud.DCRM.
[3] FI-PPP programme: //http://www.fi-ppp.eu.

interfaces and APIs as enablers for remote management of inter-cloud services in a unified manner. Further, the FI era emerges new challenges by building FI applications from services belonging to different providers, thus highlighting a crucial requirement for inter-clouds. We propose an Inter-Cloud Mediation Service by extending the work in [2] to involve public clouds forming a collaborative environment for distribution and common management of cloud services using the RESTFul protocol as discussed in [3]. This interoperability vision between heterogeneous resource providers based on open standards in the general concept of the Open Cloud Computing Interface (OCCI).[4] Lately, it is used widely e.g. by OpenStack and OpenNebula.[5]

We are motivated by the opportunities rising from FI-WARE and OpenStack platforms and particularly from the new horizons of the FI concepts as in [2,4] and in [5]. Thus we define the Inter-Cloud Mediation Service to support communication with OpenStack, FI-LAB, Amazon WS and VCloud[6] platforms to demonstrate heterogeneity that extends the work in [2] presented in [6]. We utilize available FI-WARE software, also known as Generic Enablers (GEs) that are open source implementations[7] to build the inter-cloud bridge system including the Publish/Subscribe Context Broker,[8] the Complex Event Processing (CEP),[9] the Identity Management (IDM)[10] and the Cloud Store[11] offered from FI-WARE. Based on this discussion, Section 2 demonstrates the motivation and the related approaches, Section 3 presents the model of the proposed system and, Section 4 the description of the prototype system, Section 5 details the experimental study, and Section 5 the conclusions and future research steps.

2. Related works

Today, various cloud vendors aimed to an interoperable cloud effort by jointly establishing federations of clouds. In [7], we presented a study on inter-cloud scheduling model a detailed discussion of related solutions as [8]. In [9] a discussion is presented to demonstrate various approaches for inter-cloud bridge systems. The mOSAIC[12] FP7 project focuses on Open-source API and platform for Multiple Clouds for cloud-based application developers, maintainers and users in order to specify the service requirements in terms of Cloud ontology and an API. The Contrail[13] FP7 project is focused on cloud software stack of components that are designed to work together for one integrated federated cloud. SeaClouds[14] FP7 project performs a seamless adaptive multi-cloud management of service-based applications, by developing a set of tools to manage complex applications, thus avoiding the problem of Cloud lock-in. Other works as in [10] aim to explore cloud computing from the perspective of high performance computing. In the past we have presented a study for Inter-Cloud schedulers as in [11], a work that demonstrates the requirements for brokers in Inter-Cloud. Here, we focus on developing a solution in the Future Internet concept, thus we utilize tools and services offered by FI-WARE.

FI-WARE provides a collection of tools that allow deployment of FI-WARE DCRM infrastructure. The latter includes a federation mechanism for accessing multiple systems[15] within a single interface, yet resources are kept separately by provider. In this study we aim to overcome the problem of vendor specific inter-clouds by focusing on the OCCI standard.[16] This means that cloud systems developers using such standard (FI-WARE, OpenStack, OpenNebula etc.) will be able to utilize their interfaces to join an inter-cloud. In addition to this, the openings arising and the general concept of cloud datacentre resource management systems that emerge by FI-WARE highlight new challenges. In particular, we attempt to build a cloud interoperable common management architecture based OpenStack API that is suitable to provide inter-cloud management service for FI-WARE based clouds that offer GEs. Lately, various FI-PPP programmes (up to 16 EU funded projects) as in [4] have been promoted to accelerate the development and adoption of Future Internet technologies in Europe.

The experimental demonstration of the architecture is executed in the Intellicloud infrastructure of the Technical University of Crete (TUC) and could be offered as a GE service. Intellicloud is an experimental cloud infrastructure for designing cloud-based Internet applications. It is an open testbed environment for researchers and developers that aims to design and deploy cloud based FI applications. The infrastructure is based on OpenStack (an open source cloud computing platform) and offers infrastructural and platform services that include pre-configured FI-WARE GEs and deployment of Specific Enablers (SEs) for exploration as in [12]. SEs are specific enablers that are integrated based on GE functionalities. We utilized various GEs and services to integrate the Inter-Cloud environment motivated by the area of business intelligence in the cloud as in [13] that highlights new opportunities for innovative services. We anticipate that the Inter-Cloud will spark creation of new services by decoupling users from the actual resources, and allow providers to integrate new resources and services in a seamless manner.

3. Modelling the inter-cloud bridge system

This section defines the model of the inter-cloud bridge system along with the related services. It encompasses an architecture based on cloud platforms that offer APIs like OpenStack[17] which is an open source platform for managing large-scale physical servers in a cloud-computing environment. This includes the transformation of the psychical resources to virtual that could be delivered over the Internet as Virtual Machines (VMs). OpenStack offers also a reference API described in [14] that works with RESTFul protocol and provides remote access to cloud services using the HTTP protocol. In detail, services can make calls to get, post, put or delete actions.

The proposed inter-cloud bridge system is designed on a modular basis of interacting RESTFul compliant cloud services. Each module is implemented as a separate service under a different endpoint. This highlights significant advantages including comprehensive structure, easy replacement of modules, flexible configuration of the system according to the needs of the inter-cloud administrator and vendor lock-in minimization as described in [3]. Based on that, the following sections present the Inter-Cloud architecture

4 OCCI: http://occiwg.org.

5 OpenNebula: http://opennebula.org.

6 VMWARE VCloud: MPLA.

7 FI-WARE catalogue: http://catalogue.fi-ware.org/enablers.

8 Context Broker specs: https://forge.fi-ware.org/plugins/mediawiki/wiki/fiware/index.php/FIWARE.OpenSpecification.Data.PubSub.

9 CEP specs: http://forge.fi-ware.org/plugins/mediawiki/wiki/fiware/index.php/Complex_Event_Processing_Open_RESTful_API_Specification.

10 IDM specs: https://forge.fi-ware.org/plugins/mediawiki/wiki/fiware/index.php/FIWARE.OpenSpecification.Security.IdentityManagement.

11 Apps Store open specs: https://forge.fi-ware.org/plugins/mediawiki/wiki/fiware/index.php/FIWARE.OpenSpecification.Apps.Store.

12 MOSAIS FP7 Project: http://www.mosaic-cloud.eu.

13 Contrail FP7 Project: http://contrail-project.eu.

14 SeaClouds FP7 Project: http://www.seaclouds-project.eu.

15 XI-FI FP7 Project: https://www.fi-xifi.eu/fiware-ops.html.

16 OCCI: http://occi-wg.org.

17 OpenStack: http://www.openstack.org.