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Design of Cloud Service Brokerage System Intermediating Integrated Services in Multiple Cloud Environment

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***Abstract*—**Cloud service brokering is a new service paradigm that provides interoperability and portability of application across multiple Cloud providers. In this paper, we designed Cloud service brokerage system, anyBroker, supporting integrated service provisioning and SLA based service lifecycle management. For the system design, we introduce the system concept and whole architecture, details of main components and use cases of primary operations in the system. These features ease the Cloud service provider and customer's concern and support new Cloud service open market to increase Cloud service profit and prompt Cloud service echo system in Cloud computing related area.

***Keywords*—**Cloud service brokerage, multiple Clouds, Integrated service provisioning, SLA, network service.

I. Introduction

CLOUD Computing is an emerging IT System solution and its fully service-based business model appeals to an overwhelming majority of decision makers. However, there are still several technological challenges to be addressed and current solutions are far from satisfying the needs of all stakeholders, such as cloud providers, services and applications developers and providers, as well as end-users [1], [2], [11].

Moreover, cloud data centers are more and more constructed in diverse area and cloud-based services are getting rapidly increased. At the same time, cloud service consumer and provider's concern is increased. In aspect of cloud service consumers, finding appropriate cloud service is getting difficult. To find best-matching cloud, they should contact many cloud service portals. It is time-consuming job and not easy situation to make a decision. In aspect of cloud service provider, they will have difficulty to attract customers and to increase usage rate of their existing cloud infrastructure because competition among Cloud service providers is getting serious.

To ease the upper described problems, Cloud service brokerage system is able to make open Cloud service market between Cloud service providers and consumers and it provides interoperability and portability of application across multiple Cloud providers [3]. A Cloud service brokerage system provides a single and common interface through which consumers can provision and manage their services on multiple clouds. In Cloud service brokerage, Cloud service provider, consumer and broker don't have complete control over actions of the others. Cloud service broker intermediates, rather than control in coordinating inputs and outputs of multiples services [4].

In this paper, to realize upper described merits of Cloud service brokerage system, we designed anyBroker system, Cloud service brokerage system, supporting several key features. It includes new integrated service concept in service provisioning and management, SLA based service lifecycle management, flexible connection and interaction with heterogeneous clouds and customer/service requirement based best-fit Cloud service provisioning.

Section II describes the related technical researches and works. In Sections III, IV and V, we discuss the design about anyBroker system and it introduces main concept, whole architecture and its main component details. In Section VI, we take a look at sequence diagram of several key operation flows in designed Cloud service brokerage system.

II. Related Works

The NIST enhances the description of the roles and types of services that a Cloud service brokerage system may offer to cloud Consumers. A Cloud service brokerage system renders some combination of services that can be divided into five architectural component categories, secure service aggregation, secure service arbitrage, secure service intermediation, secure Cloud service management, and secure Cloud ecosystem Orchestration [5], [6].

According to Gartner [7], Cloud service brokerage system is a role of intermediary, in which a company or other entity adds value to one or more cloud services on behalf of one or more consumers of those services. Cloud-enabled technology services are a prominent aspect of the cloud services supplied by a Cloud service brokerage system. The Cloud service brokerage system offering will also often include some combination of capabilities that fall under three primary roles, aggregation brokerage, integration brokerage, customization brokerage. Gartner's Intermediation encompasses these three primary roles.

On cloud brokerage, the positive opinion of different cloud experts towards cloud brokerage confirms Gardner's trend that

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"Cloud computing will evolve from a one-to-one relationship to a one-to-many ecosystem" [8], [9]. Especially the argument of assisting companies in selecting the right cloud services and the argument of cost saving are important value adds of cloud brokerage. Furthermore, the experts see that cloud brokerage will be very interesting for small and medium-sized enterprises, whereas large companies in the field of cloud computing will themselves evolve towards cloud brokers.

In [10], open source service brokerage solutions are compared, according concerns like, system category and type, core capabilities, core features and advanced features, architecture and interoperability, service languages, programming model and service engineering, and quality (scalability / Elasticity and SLA). In the research, the authors place emphasis on the emergence of cloud broker solutions on top of cloud management, the need for further separation of marketplaces and cloud broker solutions and service description mechanisms to commoditize the cloud. The authors proposes a taxonomy of Cloud services brokerage capabilities based on two orthogonal dimension of clouds brokerage space, Cloud service type (SaaS/PaaS/IaaS) and Cloud brokerage capabilities such as discovery, integration, aggregation, customization, quality assurance and optimization. And classify 30 current providers and enablers of Cloud service brokerage capabilities. This analysis shows that the majority of Cloud service broker service providers or enablers appear to focus on discovery, integration, aggregation, customization with a particular emphasis on SaaS services. For both kinds of offerings, PaaS is the least supported type of cloud services. IaaS appears to be the most commoditized category of cloud services today. Coverage of quality assurance and optimization capabilities is sparser.

III. anyBroker Concept and Architecture

In this section, we describe the concept and whole architecture design of our Cloud service brokerage system, anyBroker. The anyBroker system enables the unified management of heterogeneous cloud service providers because of its modular approach. Design concepts are as following.

1) Provisioning and management of the integrated service including computing service (VM, storage, software) and network service (Cloud-across network using SDN technology).
2) SLA based service provisioning and lifecycle management.
3) Searching customer and service requirement based best-fit clouds in aspect of price, location, security, availability and so on.
4) Flexible connection and interaction with the geographically dispersed and heterogeneous Clouds.

As showed in Fig. 1, anyBroker system consists of three main parts that include anyBroker portal, anyBroker core engine and anyBroker Cloud connection proxy. anyBroker portal is the frontend of the Cloud service brokerage system for Cloud service consumers and providers and includes various business support functionalities. anyBroker Core engine supports key functionalities for service brokerage, such as request verification, service provisioning, arbitrage, monitoring, service lifecycle management and so on. Finally, anyBroker Cloud connection proxy is in charge of the interaction between Cloud service brokerage system and the specific Cloud service provider system or network service provider system. In case of network service, it interacts with SDN service provider system.

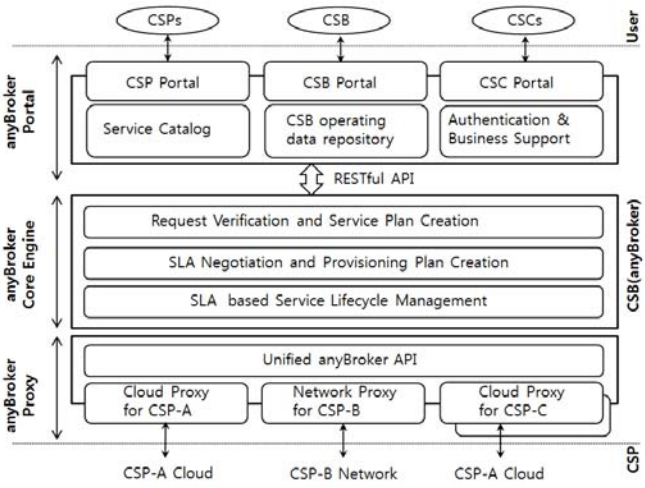


Fig. 1 anyBroker whole architecture

As showed in Fig. 1, we defined 3 kinds of users to use anyBroker system, Cloud service provider, broker system administrator and consumer. And in case of consumer, it can be separated to two user types, Cloud based application service provider and Cloud service brokerage system end-user.

IV. anyBroker Portal

This part represents the frontend of the anyBroker system for Cloud service provider (CSP), consumer (CSC) and broker administrator (CSB). So, anyBroker system supports three different portals for each user.

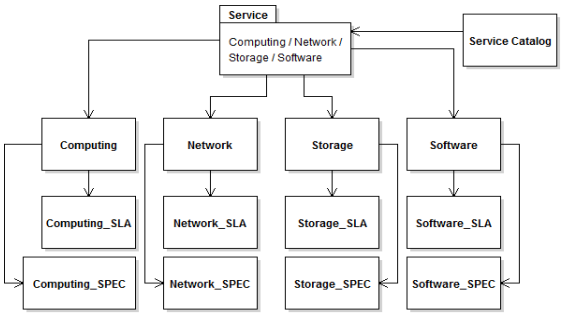
TABLE I
Main Roles of CSP, CSB and CSC Portal

user portal	main functions
CSP portal	CSP user management Cloud resource management(quantity registration, update, monitoring) service catalog management(service registration, modify, delete) accounting, billing, report
CSB portal	user management(CSP, CSC, CSB) Cloud service management(monitoring, start, stop) accounting, billing and report
CSC portal	CSC user management service management(create, update, delete, monitoring for only user own service) inquiry for accounting, report

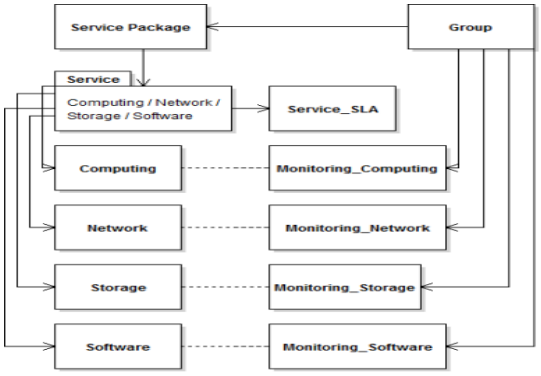
The portal provides the following functionalities, user management and authentication, service discovery, subscription management, specification of requested services and SLAs, service provisioning request, monitoring, accounting and billing, reporting and so on. And Table I

represents main roles of each portal for the different user type.

To support described functions in Table I, anyBroker portal maintains data structure schema showed in Fig. 2.



(a) Service catalog data schema of CSP



(b) Service operating data schema of CSB

Fig. 2 Main data structure schema of anyBroker portal

Primary data structure has three main parts, such as service registration and management by CSP, service operating management and billing/payment management by CSB. We designed anyBroker supporting service package concept, service package consists of VM, storage, software and network services. And it separated by two kinds of service package type. One is a CSP defined service package which one CSP is able to deal with the all services in. The other is CSC defined one that CSC selects the required services and make them to be a new service package. The service package concept enables CSC to perform provisioning and management in the service package unit and CSB to handle service lifecycle management in same way. CSP also have to register and manage their Cloud service in same manner. In general, one solution of application service provider, like CDN, includes several services, such as multiple VMs (e.g. origin server, Pop servers), a set of application related software, several content storage space and system-across network with stable bandwidth. Therefore, CDN service provider can request anyBroker system CDN service package at one go. Each service in a service package can belong to different service provider. So each service has separate SLA data structure in respect of service registration. Of course, a service package can be composed with only one service, like a VM or only storage.

From now on, we explain more details of each user portal focused on main role.

A. Cloud Service Provider (CSP) Portal

This component stores a list of the available Cloud service providers and their service types they can provision as well as the available SLA parameters. The services are defined by the providers involved in anyBroker system. The service catalog contains the needed information to search and find services matching the user or service requirement. In this way, it will be in charge of delivering the marketplace elements to the consumer frontend. CSP register its Cloud service using detailed information with resource quota. Table II shows primary information for CSP to register service package.

TABLE II
PRIMARY INFORMATION FOR REGISTRATION OF SERVICE PACKAGE

attribute	description
name	service package name
description	service brief description
CSP profile	CSP general information
package profile	service package details including each service specification
SLA profile	SLA specification of each service
support profile	customer support information(e.g. refund)
billing profile	price and it's policy information

Through this process, CSP register its service into service catalog in anyBroker portal and the related information is reflected to anyBroker core engine. After this process, CSC can look for the best-fit cloud service based on his/her requirement against the information.

B. Cloud Service Broker (CSB) Portal

CSB portal supports administrative functions to intermediate and deal with whole information about all CSP and CSC, such as management of users (CSP, CSB, CSC), registered and running services, monitoring, billing/invoice, reporting and etcetera.

TABLE III
MAJOR SLA SPECIFICATION INFORMATION

classification	item	detail elements
service	specification	CSP info, service (VM, storage, SW, network) spec, service image
	security	level, policy
	account	user info
	service support	interface, configuration
provisioning	property	provisioning policy(zone, price, price, location, etcetera)
	condition	condition of property
guarantee	guarantee condition	guaranteed property(availability, usage, etc.)
	reward/ penalty	type, action by type

In addition, to be able to provide SLA based service provisioning and management between CSP and CSC, it is necessary to receive service descriptions, guarantee terms, resource usage, pricing, and everything else related to service usage in a formal manner. For this purpose, we use the SLA specification described in Table III.

This SLA specification is submitted by CSP first when

he/she register service packages and CSC also inputs this form to search the required service among registered CSP service.

Automated SLA negotiation is a topic that is still in a quite early stage of research. So far, it is based on the principle that a customer can either accept the provider's terms and use the offering, or disagree with them, which in consequence means he cannot use the offering. In anyBroker system, we use static SLA specification description and it is used for CSC to search proper service with best-fit SLA. In future, this part should be extended for automated and dynamic SLA negotiation.

Billing and accounting is an essential component as it helps the cloud service providers to charge the users for their services and resources consumed. In order to precisely charge the users for their consumption, a monitoring is required that provides the utilization information of virtual resources in service package.

C. Cloud Service Customer (CSC) Portal

CSC portal supports a dedicated user workspace and unified portal view for CSC to perform service provision and monitor its service usage by their provisioned service in multiple Clouds. Once all the service provisioning steps are finalized, users are provided with a dedicated virtual environment fully operational and configured with the originally requested cloud resources and services.

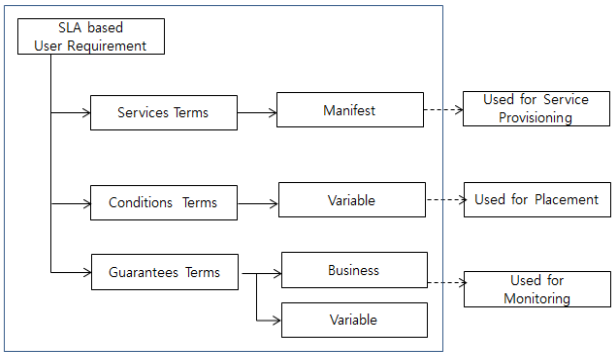


Fig. 3 CSC SLA based service requirement specification

To search and provision a service package, CSC inputs needed information through CSC portal GUI interfaces and it creates user SLA based customer request that is similar with CSP's SLA specification. The information is used to search best-fit Cloud service and set the SLA related configuration such as guaranteed item and its action. The created user request format is like Fig. 3.

V. anyBroker Core Engine

In this section, we explain main components of anyBroker core engine. Core engine receives various user requests from the portal in defined form and returns processed result to user via each portal. And it interacts with Cloud proxy to communicate with dispersed heterogeneous Cloud. Fig. 4 represents the relationship among the core engine components that include request verification and service plan creation, SLA negotiation and provisioning plan creation, service provisioning and lifecycle management.

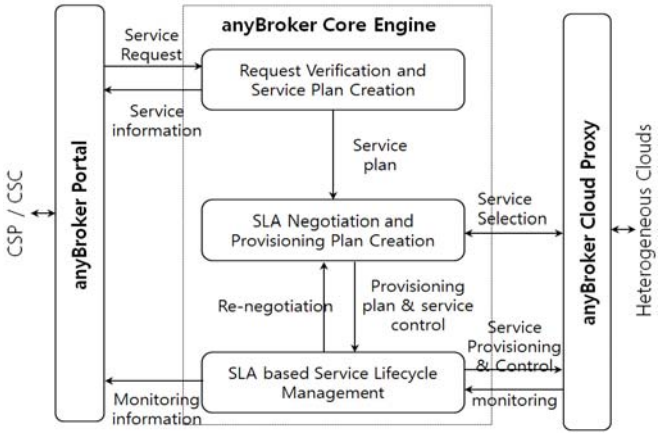


Fig. 4 Component relationship of AnyBroker Engine

The role and main operation flow of each component is explained from the next sub-sections

A. Request Verification and Service Plan Creation

This component ensures that the service request issued by the consumer is valid or not. This verifies the service description syntax and semantics are correct and can be interpreted. The requested service types are known, this will require verification with the service provider registry information

B. SLA Negotiation and Provisioning Plan Creation

This component performs several functions as following.

1) Matching consumer requests and rights (e.g. quotas) with provider business policies against the description of Cloud services stored in the registry.
2) Aggregation of the proposed SLAs and ratings from different providers into a list of possible combinations of services by different providers.
3) Selection of the final provisioning solution according to the specified metric by proposing a list sorted by a consumer-defined metrics (cost, performance…).
4) Translation of the selected provisioning request and its associated SLA terms into a deployment plan with rules to maintain Service-Level Objectives.
5) Submission of the result to the lifecycle management component.
6) Submission of the contract information to the business support services, especially to the subscription component.

C. Service Provisioning and SLA Based Service Lifecycle Management

The provisioning component performs the sequence of provisioning and configuration actions that are generic across heterogeneous providers to achieve the objectives of the service lifecycle workflow.

It is in charge of parsing the manifest and split the provisioning plan (initial deployment) from the Service level objectives (runtime management). It will manage the deployed service at runtime. It stores the current deployment topology. It

is in charge of updating the topology or the configuration of the services to maintain the SLA taking into account the monitoring information and the rules sent by SLA negotiation and provisioning plan creation component. In case of change, it will use the provisioning and configuration module to apply it.

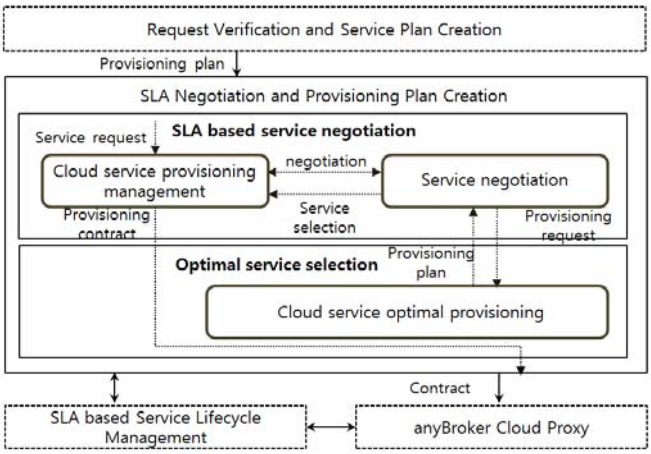


Fig. 5 Operation flow of SLA negotiation and provisioning plan creation

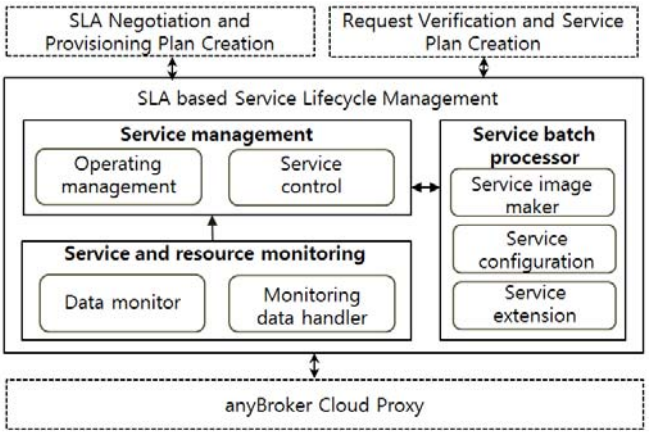


Fig. 6 Operation flow of Service provisioning and lifecycle management

The service lifecycle control loop will react from monitoring alert generated by comparison of monitoring value to SLA requirement and apply rules in accordance.

The monitoring component is responsible for measuring the Key Performance Indicators (KPIs) of the systems and services. In cloud systems, it provides the data primarily for system monitoring, accounting/billing and SLAs. Monitoring helps to diagnose hardware and software problems, to enhance the resource utilization and to ensure the system's performance and security.

VI. anyBroker Cloud Proxy

In the anyBroker system, this part manages the interoperability interface between the anyBroker and the collection of heterogeneous Cloud Providers. Fig. 7 gives an example of the anyBroker Cloud proxy with several Cloud providers. This component translates the requests from the provisioning and configuration component into understandable provider API calls. It is also in charge of the reverse translation from the final service provider to the anyBroker. For example, monitoring transmission, deployment and configuration calls return. Cloud proxy will abstract the existing APIs heterogeneity through a common API in the supposed system.

The API through which communication is performed will be the same for all anyBroker services proxies with its own specificities of service type. Each different technical kind of provisioning service will have its own proxy.

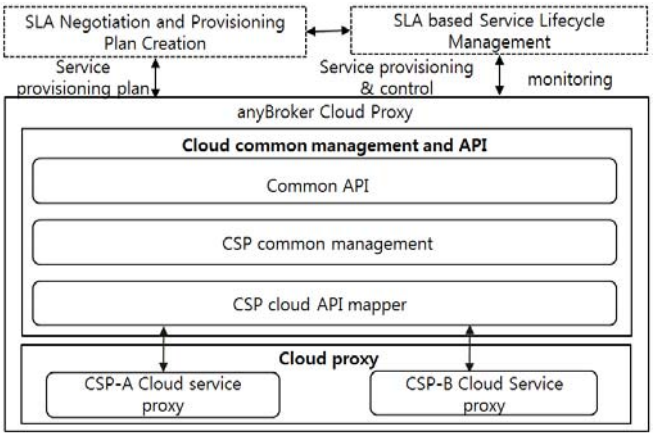


Fig. 7 Operation flow of Cloud proxy

VII. Use Cases of Anybroker

In this section, we represent sequence diagram of primary functions to clear anyBroker main operation flow, such as service registration and discovery by CSP/CSC, service provisioning and SLA based lifecycle management.

A. Service Registration and Discovery

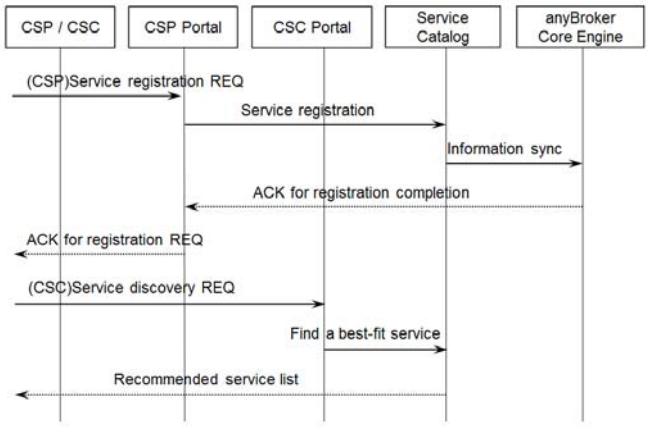


Fig. 8 Sequence diagram for CSP's service registration

B. Service Lifecycle Management

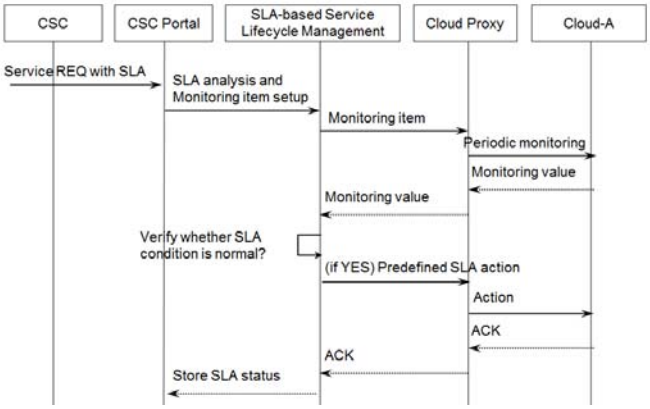


Fig. 9 Sequence diagram for SLA based service lifecycle management

C. Service Provisioning

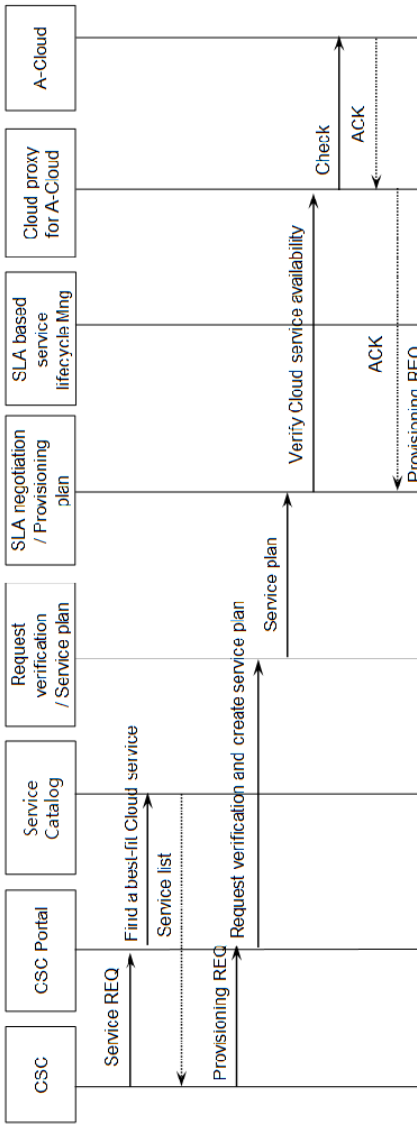


Fig. 10 Sequence diagram for CSC service provisioning

VIII. Conclusion

In this paper, we described and showed the design concept, detailed architecture and its main components of anyBroker. As explained in several sections before, the supposed Cloud service brokerage system has several key features as following.

1) Support integrated service concept including VM (computing resources), storage, software and network.
2) Support SLA based service provisioning and lifecycle management.
3) Support Flexible connection and interaction with heterogeneous clouds.
4) Support Customer / service requirement based best-fit clouds in aspect of price, location, security, availability and so on.

These features ease the Cloud service provider and customer's concern and support new Cloud service open market to increase Cloud service profit and prompt Cloud service echo system in Cloud computing related area.

Current anyBroker is focused on Infrastructure as a service (IaaS) brokerage and we will extent the coverage to PaaS, SaaS and specialized service area in future.

Acknowledgment

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