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Development of Service Verification Methodology Based on Cloud Computing Interoperability Standard

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Abstract

Recently, cloud computing has become an important new technology for the dissemination of information and it has spread dramatically into the corporate field. In order to provide more stable and advanced services for the future, greater interoperability has become a target for developers. In this study, we focused on four key capabilities in the search for greater interoperability: scalability, universality, continuity, and specialty. Cloud computing can only be considered interoperable to the extent that it incorporates these four issues. Assessing these issues comprises the methodology we propose to verify the interoperability of cloud computing architecture. Also, in order to effectively assess and implement the methodology described in this paper, there must be a stringent and detailed process of preparation, with regards to full implementation and institutionalization.

Keywords: *Cloud computing, Interoperability, Cloud Service*

1. Introduction

As the environment, surrounding information and communication technology has evolved rapidly since the beginning of the new millennium, a variety of sociotechnical changes have occurred. The amount of information that we have accumulated over the past few centuries is increasing exponentially. In our daily lives and our business dealings, the methods and types of communication between people and organizations are also rapidly changing. As we attempt to summarize and organize these emerging information technologies from a strategic point of view, cloud computing is attracting our attention. In this paper, we look at the interoperability of cloud computing. The establishment of a single standard in any field can contribute to the efficient utilization of the target and the spread of the technology. Demand for interoperability enables us, whenever we require, to unite various platforms. The ability to coordinate online activities with a single platform can be said to be more important than aiming for platform unification or homogenization by standardization.

Therefore, this study intends to organize opinions and research on interoperability and determine the various requirements and functions of the interoperability of cloud services.

2. The Concept of Cloud Computing and Interoperability

It can be said that the concept of cloud computing is hidden behind the cloud service that is offered. Cloud services can be regarded as products and services as well as real-time solutions

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for consumers, whereas cloud computing is a model for the new IT environment to provide products, services, and solutions through the Internet. Cloud computing combines concepts and configurations developed from previous platforms, such as grid computing, utility computing, server-based computing, and network computing, and new terms such as Naas (Network as a Service), DaaS (Database as a Service or Desktop as a Service), DSaaS (Data Storage as a Service), CaaS (Communication as a Service), SDPaaS (Service Delivery Platform as a Service) have emerged. Even the term 'the era of XaaS (Everything as a Service)' has come out. This study defines cloud computing as "Internet-based information technology resources (software, storage, server, and network) and technology-based information resources, borrowing whatever resources necessary, supporting real-time scalability according to the service load and taking a pay-as-you-go computing approach." There are three types: software-centric SaaS, hardware-centric IaaS, and platform-centric PaaS.

Interest in cloud computing interoperability has been active since The Academic Cloud Computing Initiative (ACCI), one of various projects to showcase students' ideas about cloud computing and improve technical knowledge, was announced in October 2007 [6]. In April 2009, UC Santa Barbara released their first open-source PaaS, which could run Google Apps. Since then, the St Andrews Cloud Computing Joint Institute was set up to focus on new critical research on cloud computing. As a result, interest in cloud computing interoperability has amplified and the TClouds (Trustworthy Clouds) project was launched in October 2010 with the support of the European Commission. The goal of this project is to investigate and assess the legal foundation and structural design to develop a resilient and reliable cloud-based framework. The project also focused on the development of a prototype to verify the results [7]. In December, The TrustCloud Research Project was started at the HP Institute in Singapore [1, 2]. The TrustCloud framework, which consisted of five layers with management responsibility and computing transparency, began with a data-centric approach [3]. The project team monitored the movement between the cloud and the data life cycle, declaring the need for discussion of major cloud computing security issues, cloud data loss, cloud accountability, and the inter-cloud data transmission around the country.

In June 2011, the Telecommunications Industry Association developed the Cloud Computing White Paper. This paper was published to analyze the challenges and opportunities for integration between cloud services and the American Communications Standards Act [8]. In July, the High Performance Computing Cloud (HPCCLoud) Project was launched to seek performance enhancements of scientific applications in the cloud environment. Moreover, the HPCCLoud Performance Analysis Tool Kit was supported by the CIM-Returning Expert Program under the supervision of Professor Shajulin Benedict.

The FEMhub provides free the SaaS application 'NCLab' for science, technology, engineering, and mathematics. Three issues must be considered from the consumer's point of view for cloud services: interoperability, portability, and security.

Interoperability (commonly known as API) refers to the properties of a product or system that are fully compatible with other products and systems without any restricted access or poor performance. The IEEE Glossary defines it as two or more systems that exchange and use information.

Portability (standard packaging and application format) refers to the degree of ease for simplistic programs to move to other models, lack of lock-in between technology and operator, and ease compatibility between service providers, with users easily switching between providers to meet their business needs.

Security (standards-based security infrastructure) prohibits access to data or programs for non-authorized users.

3. Trends of Related Organizations Regarding Interoperability

As shown in the seven-part technical report of the clouding computing focus group of ITU-T, the interoperability institutes are CCIF (Cloud Computing Interoperability Forum), Cloud Computing Use Case Discussion Group [4], DMTF (Distributed Management Task Force) [5], and IEEE [5] and the trends of the related organizations are as follows:

CCIF cloud computing technology and associated services were formed to apply to a wide range of industries [4, 9]. The clouding computing interoperability forum consists of open and neutral vendors, supporters of non-profit endeavors, and users promoting the rapid adoption of global cloud computing services. This forum was designed to create a unified cloud interface (UCI) environment and develop an open and standardized cloud interface with API integration. UCI focuses on internal cloud interoperability. These requirements can aid in the integration process of designing a cloud platform, developing a cloud infrastructure, and stipulating the terms of access for various cloud providers. For a unified cloud interface, RDF is used to describe an integrated cloud data model.

The Standardized Survey of the Cloud Computing Use Case Discussion [10] intends to discuss how to create an open standard for cloud computing. This group has highlighted the requirements for standardization within the cloud resources in order to emphasize the interoperability of cloud computing from the most typical scenario.

IEEE has been investigating cloud portability and internal cloud interoperability of the CPWG (Cloud Profiles Working Group) and ICWG (Intercloud Working Group). Their efforts created the two new standards, scoring approval for the project. IEEE P2301 is a guide for Cloud Portability and Interoperability Profiles (CPIP), IEEE P2302 is a definition of public management for SIIF, standard topology, function and cloud-to-cloud interoperability and its partnership.

The OCCI Working Group of OGF (Open Grid Forum), an industry consortium written by the OCCI WG of the OGF, uses API and Protocol to remotely manage tasks for IaaS-based services. Flexible API has been developed, focused on integration, portability, interoperability, and innovation while providing high scalability. The OCCI standard document, issued in April 2011, consists of three parts: OCCI Core, Infrastructure, and HTTP Rendering.

DMTF uses the standards developed by the Open Cloud Standards Incubator of the DMTF, an industry consortium. One of the main criteria is to maintain the Common Information Model. The DMTF Cloud Management WG focuses on the standardization among cloud environments. It released a standard called Open Virtualization Format in August 2010 and published three other white papers: “Interoperable Clouds,” “Architecture for Managing Clouds,” and “Use Cases and Interactions for Managing Clouds.”

SNIA (Storage Networking Industry Association) is a non-profit industry consortium. SNIA's Cloud TWG cloud-based storage company is interested in standardizing the interaction between services and clients. The Cloud Data Management Interface Standard released in April 2010 provides open and safe API so that the cloud service provider can use DaaS. It also generally provides cloud service providers with interoperable cloud storage management using the RESTful HTTP-based protocol.

The ITU-T FG Cloud is an international standardization organization that mostly analyzes the need for standardization from the point of view of common carriers. It deals mainly with cloud service delivery through communication networks, network security, and service requirements.

OCM (Open Cloud Manifesto), an industry consortium, is interoperable and independent, pursuing flexible and open cloud computing. It has completed two white papers. One of these papers, “Cloud Computing Use Case White Paper Version 4,” includes various use cases,

customer scenarios, developer requirements, and security scenarios, as well as the contents of service level agreements not only in English but in Chinese, Japanese, and Korean versions as well. The white paper "Moving to the Cloud," released in February 2011, handled the benefits and risks of moving applications and data to the cloud.

The Open Group's Cloud Working Group exists to create a common understanding about how to set prices between purchasers of various sizes, operating systems, and providers, and how to introduce the cloud computing technology into their current infrastructure with enhanced security in order to obtain the benefits of scalability and flexibility. The Open Group has published eight white papers to handles the contents about how to benefit from cloud computing, how to increase competitiveness using the cloud, and other cloud fundamentals, such as cloud computing concepts, infrastructure, buyer requirements, and cloud security.

ISO/IEC JTC 1 SC38/SGCC had its first conference in May 2010 and set its sights on organizing cloud computing concepts and terms for future research, analyzing standard trends related to cloud computing, and analyzing requirements for market standardization/businesses/users. It cooperated with cloud computing standardization organizations to settle international cloud computing standardization issues, such as system requirements, service compatibility, security issues, and public API.

CIF (Cloud Industry Forum), an industry consortium, has been focusing on accumulating credits between cloud business service providers and consumers. In this process, most participating service providers are qualified under the Code of Practice, which means they must adhere to standards of transparency, competence, and accountability.

An industry consortium and non-profit organization, CSA (Cloud Security Alliance) develops 'best use' plans and security guidelines for the cloud and provides secure cloud computing education. Currently, their eight work groups have published three white papers regarding major security threats in cloud computing.

ETSI Technical Committee (TC) Cloud is a European standardization organization that as of yet has not decided on a particular function. OASIS, an industry consortium, is also active in the Internet information processing sector but is currently only working indirectly, developing standardization processes for technology elements rather than direct cloud-related standardization initiatives. The already approved standard is the Cloud Data Management Interface released by SINA, and the standard being developed are the IEEE P2301 and IEEE P2302.

4. Capabilities for Cloud Interoperability Standardization Initiatives

Interoperability may be a stumbling block in the process of unifying organizational information systems with the cloud. Solving this problem should aid in the delivery of internal information-related services to the cloud while, at the same time, decreasing costs. Furthermore, interoperability will greatly increase productivity and efficiency. Therefore, the main issues now to be standardized are movement, connectivity, and portability. Moreover, standards for support, convenience, industrial revitalization, information, user protection, and increased satisfaction should be established, rather than just regulatory standards. In this premise, the atmosphere that enables service providers to participate in standardization tasks in order to revitalize industry must be developed institutionally to form market and technology-driven industrial revitalization. Having said that, we can identify an overview of the status of interoperability through the paper "ICT Standardization Strategy Map Ver. 2012" put out by Telecommunications Technology Association of Korea.

This map includes six parts: "Realistic Convergence Media," "Intelligent Service SW," "Convergence Contents," "ICT Convergence," "Wired and Wireless Communication

Infrastructure," and "Information Security." Among those, the second report includes such items as: "Web," "Smart Device Cooperation and Service,' and "Cloud Computing/SOA."

Cloud computing-related standardization targets include the standards of Governance, Cloud SLA, Cloud Metering, Cloud Reference Model, Inter-cloud, Mobile Cloud, Cloud Security, Cloud Metadata Management, Virtual Desktop, Computer System Virtualization, Storage Virtualization, and Cloud Network Resource Management.

The item most directly related to cloud interoperability is the 'Inter-cloud Standard,' as described in the report. Interoperability is one of the standard issues that configure the entire field of cloud computing. Considering the differentiation and linkage to other items, the capabilities of cloud computing interoperability can be summarized as scalability, universality, continuity and specialty.

Scalability includes both horizontal expansion, connecting the same system in a parallel architecture, and vertical expansion, moving into a larger system. The concept involves five functions:

1. Establishment of Scalability Policy: to identify whether or not all the rules and procedures for IT-driven structure expansion for all services are prepared by the service provider. Not only identifying the related policies on a regulatory level, but also verifying established policies, application procedures and carrying out activities.
2. Scalability Level Management: to clarify the direction of expansion (increase, decrease, change and transfer) and identify whether or not the work scope is clear.
3. Platform Management: to be a part of the system management sector along with the interface management, identifying management level of the operating system-centric (basic infrastructure such as storage, network management system) platform. Not only for maintenance activities, but also to identify whether or not it is accepting evolution of the platform in the industry and the degree of development correctly.
4. Interface Management: It verifies whether the scalability-based system and its management have been conducted properly. It also identifies the applicability of recent trends, such as SOA.
5. Internal Management: It verifies the service provider's organizational configuration and management to secure scalability, human resource management, and research and development sectors.

Universality, the second requirement, is a property not dependable for universal operators, hardware (server or client), networks, and operating system. This sector, as well as the scalability sector, includes the following functions:

1. General-purpose policy-making: identifies whether or not the service provider has general policies governing usage and verifies the appropriateness of policy and management.
2. Management of the Generality Level: provides general, standardized services, but it might lack difference and specialty and ignore the demand for specialty.
3. Prevention Activities and Quality Measurement: identifies whether or not service should be interrupted by the artificial or spontaneous accidents, as well as changes in technology and user requirements. In addition, it maintains and manages general quality levels.
4. Operation of Service Instructions: identifies whether or not it prepares instructions for prior utilization.
5. Internal Management: it verifies the service providers' sectors such as organizational establishment and management, responsibility management, human resource management, and R&D to satisfy certain requirements.

Continuity is a property that can spontaneously accept changes in ownership or type of content and data when the cloud service is upgraded or updated, or the operator or server location changes (from overseas to domestic). This includes the following functions:

1. Sustained Service Competence: identifies various capacities of service providers to provide and manage service. It verifies the type and level of technology, the structure and size of the organization, workforce configuration, intention, and the business management system.
2. Diversity of Service Delivery Approach: identifies the type of service provided, and verifies the variety of ways that users can accept the service.
3. Change Management: verifies management procedures when the service provider, infrastructure, service type, or user demands change.
4. Independence of Service Providers: identifies whether or not it is dependent on organizations that are different from the service provider itself, technology and operating workforce; and to sectors and environments. If the degree of independence is low, it might be a violation of the user's right to change services.
5. Ensuring the Rights of Service Users: identifies whether or not it can deploy decision making and work processes in a user-driven way whenever there are changes, such as moving to a new provider or other force majeure interruptions.

Finally, it is a function of specialty. This capability refers to a smoothly interlocking property that maintains its unique characteristics in each sector of the cloud, such as SaaS, IaaS and PaaS.

1. Service Level Assurance: identifies the definition and management procedures for specific services that are provided by different cloud computing types, such as policymaking functions as well as scalability and generality. It not only identifies the level of those functions but also verifies the existence of the regulations and procedures.
2. Interface Plan: identifies interface plans, such as middleware, in order to interlock with other sectors without problems and maintain different service contents.
3. Change Management: identifies management processes, accepting and deploying the changes in technology development and user demands, and when new technology emerges, service, techniques introduced and new methodologies are applied.
4. Service Quality Management: verifies whether a certain level of services are provided or not.
5. Internal Management: Like scalability and generality sector, verifies sectors such as the service provider's organizational configuration and management, responsibility, human resource management, and research in order to satisfy the demands.

"Cloud service with interoperability." These requirements, functions, and checklists can be utilized as the verification method. As a circular structure applied in various business plans and execution, management, and evaluation, such methodology needs to use gradual and careful preparation for full-scale implementation and institutionalization. For this, a road map can be considered: The initial stage (preparation and status identification and the pilot phase), the execution phase (combined with practical application), and the stage for full-scale diffusion and institutionalization. The tasks at each stage and the importance of the contents depend on experts and their field of interest, properties and position, and urgency. Considering these points, it is expected that a systematic approach is necessary.

5. Conclusion

Since the cloud computing sector itself is one of the newest information technologies, it is difficult to assess the future. We cannot be sure of the existence of related services. Due to the development of information and communication technology, communication methods have become markedly different from previous eras and the rate of change is considerable.

In addition, as standardized technology becomes more settled and creates network effects, interest in divergence has grown, pitting the multiple standards and various requirements against the requirements for convergence. Therefore, efforts to interlock and accept integration are required. Therefore, other sectors are also important, but the need for interoperability must be at the forefront.

Also, the nature of information and communication technology crosses national and socio-cultural borders. Preemption and the securing of the technology itself is important at the national strategic level, but also should put a great interest in a leading role regarding standardization.

In order for Korea to take a leading role on the international stage, let us look at the efforts being made in the interoperability sector:

- Communication channels through a B2B collaborative community configuration support is required.
- Economic and political ramifications and feasibility analysis through technology utilization.
- Contributing to the international standards activities after national deployment.
- Establishment for utilization of technology for leading international companies in the industry (cooperation, open source-based interlocking system establishment, experts training course, etc.).

This task is important and is commonly used in most science technology fields, and is continually being done in related fields. This study intends to prepare a standard to secure cloud computing interoperability and to prepare a framework for verification at the level of the service provider.

In this way, the overall strategic approach is provided in this paper, follow-up studies are necessary. Due to the nature of information and communication technology, it is difficult to predict its life span. If the length itself is not long enough, the overall roadmap should be configured immediately and be pushed forward. The biggest priority is the verification of the *de facto* standardization between the leading company and the industry.

Although the field of cloud computing is conceptually organized, utilization methods, purposes, and services vary from one organization to another. Therefore, interoperability becomes more important, which means that it is important to suggest a direction which provides smoothly interlocking services, not a standard service from a single provider.

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