Indian Journal of Science and Technology, *Vol 8(18), DOI: 10.17485/ijst/2015/v8i18/77721, August 2015*
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

A Cloud Service Selection Model based on Analytic Network Process

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Abstract

A cloud computing service is the next-generation core service of green ICT for operational management of ICT resources and maximization of energy consumption efficiency. Cloud service is expected to rapidly increase in its market size in the future through its convenience in usage, efficiency of operational management and economic effects and so on. In users' perspectives, the choice of the appropriative cloud service is very important to meet their business goals and strategies. A cloud service selection problem is a multiple-criteria decision analysis with feedback. An Analytical Network Process (ANP) is a popular decision analysis technique. This study proposes a cloud service selection model based on ANP. According to the proposed model, the criteria and sub-factors for cloud service selection are identified and then determined their weights. In this study, ANP based the multiple criteria decision-making model is applied to choose the best cloud services.

Keywords: Analytic Network Process, Cloud Service, Multiple Criteria Decision Analysis

1. Introduction

In global business environment, ICT is an essential for the growth of firms and the role of it has been increasing. Cloud computing services are the next-generation core services of green ICT for operational management of ICT resources and maximization of energy consumption efficiency. Cloud services are expected to rapidly increase in its market size in the future through its convenience in usage, efficiency of operational management and economic effects and so on. Some countries such as the US, UK, Japan, Australia and Singapore are seeking to develop the market first by introducing cloud service for public organization, called cloud first policy, while striving to provide an advanced level public services by developing cloud-based trial services in the public service areas. In Korea, the global CSPs (Cloud Service Providers) such as amazon, google, Microsoft, salseforce, etc and domestic CSPs such as KT, SKT and LGU+ etc are providing the cloud services and competition between them is severe. Cloud services give an new business opportunity for companies without high ICT capital investment, so many organizations such companies, government agencies and communities try to introduce the cloud services[1].

In users' perspectives, the choice of the appropriative cloud service is very important to meet their business goals and strategies. A cloud service selection problem is the multiple-criteria decision analysis problem. An Analytical Network Process (ANP) is a popular multiple decision-making technique. This study proposes a cloud service selection model based on ANP which determines the importance of decision-making critera and subfactors consisted of a hierachy model. In addition the proposed model compare alternateives of IaaS services and select the best IaaS service.

The configuration this paper is as follows. The research background is briefly described in section 2. In section 3, we propose our research model and present IaaS provider selection processes. Section 4 concludes the study with a brief summary.

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2. Research Background

2.1 Cloud Computing Service

There are some definitions of cloud computing. This study describes two representative concepts of cloud computing such as NIST and wikipedia.

The concept of cloud computing by NIST is as follows[2]:

"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".

The concept of cloud computing by wikipediais as follows[3]:

"Cloud computing relies on sharing of resources to achieve coherence and economies of scale similar to a utility over a network[2]. At the foundation of cloud computing is the broader concept of converged infrastructure and shared services. The cloud also focuses on maximizing the effectiveness of the shared resources. Cloud resources are usually not only shared by multiple users but as well as dynamically re-allocated as per demand. Cloud computing allows companies to avoid upfront infrastructure costs, and focus on projects that differentiate their businesses instead of infrastructure[4]. That is to say, cloud computing allows enterprises to get their applications up and running faster, with improved manageability and less maintenance and enables IT to more rapidly adjust resources to meet fluctuating and unpredictable business demand[4-6]".

As mentioned above, CSPs generally provide their services according to basic and essential services such as IaaS, PaaS and SaaS[2,3,7].

Cloud computing has additionally some deployment models such as private, public, community and hybrid clouds. The definition of these deployment models are presented as follows:

"Private cloud is cloud infrastructure operated solely for a single organization, whether managed internally or by a third-party and hosted internally or externally"[5].

"Public cloud is open for public use. Technically there is no difference between public and private cloud architecture, however, security consideration may be substantially different for services[8]".

"Community cloud shares infrastructure between several organizations from a specific community with common concerns whether managed internally or by a third-party and hosted internally or externally[5]".

"Hybrid cloud is a composition of two or more clouds (private, community or public) that remain unique entities but are bound together, offering the benefits of multiple deployment models[5]".

Cloud services change the ICT paradigm and are novel business models. They provide computing services via network called the Internet. Cloud services operate and manage the hardware, platform and software, etc. on behalf of customers. The users of cloud services send their data to database located in cloud, these data are processed and operated by application software operated by CSP, and the results are returned to the users[9]. Therefore they are precious cloud computing based solutions and consist of a novel method to use and consume ICT services through the Internet. In addition, the important characteristics of cloud services are as follows: First of all, they enable enterprises to give all their attention to improve business processes and to enhance competitive advantages; and secondly, Companies get out of the pressure of design, develop and manage information systems by using cloud services[10].

As we know, the representative CSPs as follows: 1. IaaS CSPs: Amazon, Google, MS, Rackspace, Dimension Data, etc. whereas KT, SKT, LG U+, CJ Hellovision and Hyosung ITX, etc. 2. PaaS CSPs: Google, Red Hat and Salesforce, etc. whereas there is no special PaaS providers in Korea. 3. SaaS CSPs is: Salesforce, Oracle, Google and SAP.com, whereas Hancom, Younglimwon, Soft Lab, Duzon, Handy soft and Tilon, etc. in Korea.

2.2 Analytic Network Process (ANP)

AHP and ANP introduced by Thomas Sattyare different methods to apply multiple criteria decision-making models. AHP tries to solve the decision problem by modeling it in a hierarchy while ANP is used when the problem is so complex that cannot be modeled as a hierarchy. This complexity occurs because of the effect of criteria on each other or the effect of alternatives on criteria[11].

The advantage of ANP is the capability of solving the problems in which alternatives and criteria have such interactions that cannot be shown in a hierarchy model. When the decision-maker decides to model a problem as a network, he did not need to identify hierarchylevels[12]. A network contains clusters (components, nodes or criteria) and elements (sub-criteria factors) in

these clusters. However, when problems are represented by organizations, a system may be larger than elements. Depending on size, there is a system that consisted of sub-systems and each subsystem was comprised of elements[13]. The differences between AHP and ANP are shown in Figure 1[14].

The governing hierarchy for ANP gives first priority criteria to compare each type of mutual interaction represented by the network. Two types of governing criteria exist in ANP[15].

First of all a governing criterion can be directly interacted with the organization. In this case the governing criterion is called a "linking" comparisons in a network. If a governing criterion does not interacted directly with the organization, it is called a "induce" comparison criterion.

ANP was applied to multiple-criteria decision analysis problems and a lot of case studies and application examples have been published in previous researches.

Generally ANP consists of six phases as follows[16]:

2.2.1 First Phase

The given decision-making problem is broken down into its decision components and organized into a hierarchy model. The organized hierarchy model consists of goal, criteria, sub-criteria, elements and alternatives.

2.2.2 Second Phase

The decision maker decides the importance of each component by comparing elements in pairs.

2.2.3 Third Phase

The relative importance or weights of the components are computed by pair wise comparisons with the derivation of eigen vectors.

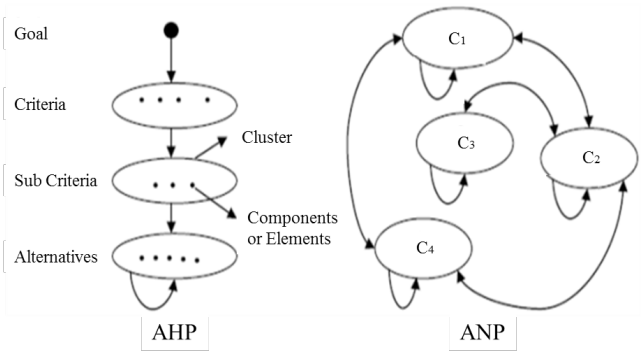


Figure 1. The differences between AHP and ANP of a decision-making model.

2.2.4 Fourth Phase

The relative local weights of the components are accumulated and summarized into global weights, which can explain the significance of alternatives.

2.2.5 Fifth Phase

Supplementary clusters of components are continuing made, so the dependency examinations are performed both among components within a cluster. Additionally they are carried out between components of one cluster and those of other clusters. Eventually the given decision-making problem can be constructed as networks.

2.2.6 Sixth Phase

Networks are converted into block matrices, and they are formed as a super matrix. Finally the weights are computed and then the weighted stochastic super matrix is obtained. Finally the decision maker determines strategic criteria and selects the best alternative with the top ranked priority[17].

3. The Proposed Model

3.1 The Procedures for Model Development

First of all, the hierarchy model for the cloud service selection model is constructed that consist of overall goal, criteria, sub-criteria and components (or elements). The overview of goal of the cloud service selection model is to choose the best cloud service. The important criteria, sub-criteria and components to assess traditional ICT providers and to assess cloud services, especially IaaS as an example of cloud services, are investigated and identified. After examining the previous researches and interviewing with ICT and cloud computing experts, total three criteria and eight elements in criteria are refined as shown in Table 1. Table 1 provides the final high level and low level factors which are used in the decision analysis model to choose the optimal cloud service[1].

As mentioned before, it is necessary to decide the relations among the components in the decision analysis network. The proposed decision network of this research has both mutual relationship and hierarchical association in the network.

The network associations happen at the component level, which means that diverse components can affect

Table 1. Criteria, Sub-Criteria and Elements for the Cloud Service Selection Model

Criteria	Provider viewpoint	Service viewpoint	Support viewpoint
Sub-criteria	- Service Brand Name - Service Price	- Service Availability - Service Performance - Service Scalability - Security	- Service Level Agreement (SLA) - Service support

the other elements. The impact of each of element was achieved by using block matrices derived from pair wise comparisons, and then matrices are incorporated into a supermatrix as mentioned above. The rest of the decision network is more conventional that the relationship the criteria and sub-criteria elements are hierarchical. Each sub-criterion element's impact on its governing components was decided by a separate block matrices derived from pair wise comparisons.

The proposed model was surveyed and tested with 7 experts consisted of ICT experts, CIO, CEO and cloud consultants. The next question is an example of a survey used in this study: "How much more important is service price than service brand name in selection of a cloud service alternative?" In this study, a respondent to a questionnaire of survey can compare criteria, sub-criteria, element and alternatives on a scale of 1 to 917.

As a contribution to the cloud service selection process, this study uses ANP to select the cloud service regarding high level and low level factors in Table 1. The process of the cloud service selection by ANP is described in the below stepwise manner:

Step 1: Survey from some CEOs, CIOs and ICT and cloud computing experts.
Step 2: Determining the important criteria to select a cloud service.
Step 3: Designing the network of decision (as shown in Figure 2).
Step 4: Deriving the CTOs' and ICT experts' judgments from comparison matrices and establishing the supermatrix.
Step 5: Calculating the weighted supermatrix (stochastic supermatrix).
Step 6: Calculating the final weights of the alternatives and the criteria.

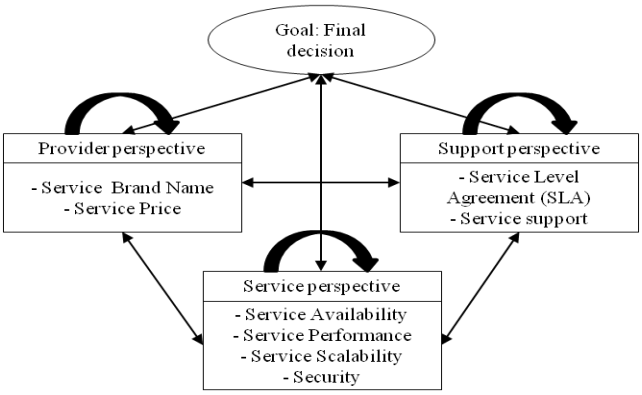


Figure 2. The decision-making network for selecting a cloud service.

The weights of high level criteria and low level factors for decision analysis model were decided by the above steps. The six domestic and global IaaS as examples of cloud services are applied to comparing as alternatives which are serviced in Korean cloud market as shown in Figure 3.

3.2 The Results of ANP Application

We performed all pair wise comparisons for each participant and calculated the weights and priorities of high level criteria and low level factors of the proposed model for the best IaaS. The consistency of the judgments shows 0.01, so final results of importance of criteria seems to be satisfactory.

As shown in Figure 4, IaaS service D was selected with 0.236 finally after applying the decided weights of high level criteria and low level factors calculated by ANP. The Provide E has the second importance with 0.213 and the rest of them are similar between 0.112 and 0.173.

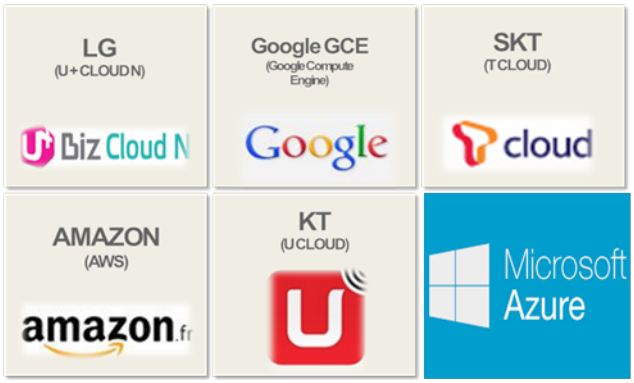
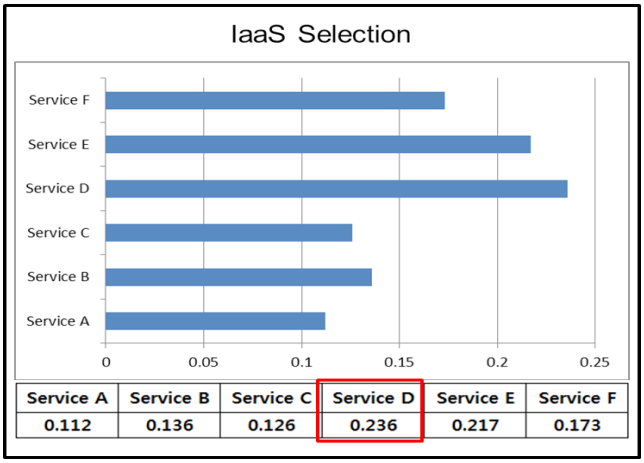


Figure 3. The candidate IaaS for the proposed model.



Service A	Service B	Service C	Service D	Service E	Service F
0.112	0.136	0.126	0.236	0.217	0.173

Figure 4. The selection result of the best cloud service by the proposed model.

4. Conclusion

Sometimes managers face the decision-making problems, which require specific techniques to deal with complexity and interactions among important factors to select the best alternative. ANP is one of techniques suggested to solve complex decision-making problems.

This paper explored a cloud service selection model based on ANP which determines the weights and priorities of decision-making critera and sub-criteria elements of a hierachy model. The three criteria, eight sub-criteria elements and six IaaS as alternatives were used to organize the hierarchy for the proposed model. And then the proposed model compared alternatives of IaaS and select the best IaaS. Eventually, the proposed cloud service selection model was applied successfully and the results seem to be satisfactory.

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