Research Article

Survey for Sensor-Cloud System from Business Process Outsourcing Perspective

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Cloud computing is a new IT trend to meet the new business requirements such as business agility and operational efficiency with business process outsourcing (BPO). Sensor-Cloud infrastructure is the extended form of cloud computing to manage the sensors which are scattered throughout the network. Several benefits of adopting cloud computing including cost saving, high scalability, and business risk reductions also can be applied to sensor data collection. As a first investment for new technology, we analyze IT managers’ feedbacks to identify the most important factors of decision making for cloud platform adoption and IT outsourcing. Even though the technological motivation is persuasive in Korean IT market, survey results show that the cost efficiency is the most important for cloud platform adoption. Also surveys reveal that IT service consumers have difficulties understanding complicated service contracts and data sharing issues with infrastructure providers, which serve as main blockers of adopting cloud computing.

1. Introduction

Nowadays, the requirements of computing power become more pervasive within an organization and the complexity of information infrastructure has made it more expensive [1]. Cloud computing is a new approach for IT services utilizing highly scalable computing resources to deliver the IT functionalities with cost reduction [2]. By sharing centralized and scalable IT resources, cloud computing suggests two major benefits for business purpose, efficiency, and business agility [3].

The National Institute of Standards and Technology (NIST) defines cloud computing as “a model for enabling 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.” [4, 5]. Within the cloud computing environment, IT services should be deployed and scaled rapidly to respond to user requirements. The concept of virtualization makes it possible to isolate computing resources into logically separated heterogeneous resources. Virtualization is a framework or methodology of dividing the resources of a computer into multiple execution environments.

Sensor-Cloud infrastructure is the extended form of cloud computing which manages the sensors scattered throughout the network. Cloud computing provides a vast storage capacity and processing capabilities, which makes it easier to collect huge amount of sensor data. Huge data streams coming from diverse sensor devices will challenge the data management for capture, storage, search, analysis, and virtualization [6, 7].

Besides, cloud computing can be recognized as an outsourced service from business perspective. For a long time, implementation, operation, and maintenance of the IT systems were the business owner’s responsibilities. However, the requirements of changed business environment [8] such as business agility, operational efficiency, cost reduction, and improved competitiveness make business owners consider business process outsourcing (BPO) [9], delegating noncore business functionality to specialized external entities. Outsourcing of IT functions as a BPO could be easier and more reliable with the advance of cloud computing technology. Besides, security and privacy become major concerns because outsourced resources with cloud environments are managed by external parties. For example, data stored in cloud storage can be considered as data outsourcing, where data is managed by cloud service providers.
According to recent survey results, IT managers in Korea consider using cloud computing as a next platform of IT service, but actual ratio of cloud computing utilization is still behind other developed countries. In spite of the explicit benefits of cloud computing, it is not an easy decision for them to adopt new technologies and to transform IT services to outsourcing, because there are various considerations on the change from the business perspective.

In the following, we give a short description of advantages and challenges in utilizing cloud computing. Then, we discuss the considerable decision making factors based on the survey results on it in Korean business environment.

2. Cloud Computing from Business Perspective

Providing cloud computing environment requires large amount of investments to implement it as a service. The role of IT service provider is divided into two: the infrastructure providers and service providers. The larger companies strive to provide more powerful, reliable cloud platform as a worldwide service, while other participants remodel their services adopting new platforms to gain benefits from it. The service providers utilize the cloud platform and reform their services such as SaaS (software as a service).

As a consumer of the services, IT managers should consider current cloud platform or other possible solutions such as SaaS compared to traditional methods to implement required computational functionalities of his corporation.

Business enterprises may get the following benefits adopting provided cloud platform, while infrastructure providers put efforts for several compelling features that make it attractive to business owners [10, 11]. It includes cost saving, agility, efficiency, and resource consolidation, while customer may extend the benefits into seeking more business opportunities.

(i) Using cloud infrastructure is appropriate for Cost-Saving. Cloud platform needs limited up-front investment and operating cost. Rapid allocation and deallocation of resources on demand and pay-as-you-go model of the service allow customers to expect lower cost for implement and operations.

(ii) Using cloud infrastructure is appropriate for Business Agility. Rapid resource allocation on demand provides quick responses of IT requirement for new business. Customers can access provider’s service through various devices with Internet within short period.

(iii) Using cloud infrastructure is appropriate for highly scalable IT requirements. Service provider can expand its service to large scales to rapidly provide additional support capability.

(iv) Using cloud infrastructure is appropriate for reducing business risks and maintenance expenses. Outsourcing shifts business risks to infrastructure providers and cuts down maintenance costs.

Sensor-Cloud system is a network of virtualized physical sensors accumulating its data and transmitting all sensor data into a cloud computing infrastructure. By utilizing cloud computing infrastructures, huge sensor data can be stored easily and Sensor-Cloud service providers enable customers to share information on big scale and to collaborate with the applications on cloud in addition to the above benefits [7].

Even though the cloud computing provides several benefits to IT consumers, IT service providing consignment in cloud computing environment brings several concerns. In addition to the technical issues of cloud computing related to multitenancy or shared resource pool management, we have business related and organizational issues for running business in cloud computing [12].

Shifting business owners’ responsibilities of the backend IT systems to infrastructure providers requires complicated contacts based on service level agreement (SLA). The cost allocation for usage and corresponding reactions for the case of service failure should be minutely described in the contract. It requires experts in service monitoring and legal review, which is a pain point for small-sized companies.

Another concern on cloud computing is how to share computing resource for sensitive data. Considering the fact that sensitive information is routinely leaked from subcontractors of outsourced tasks with poor data management practices, the following concerns of data privacy and security also should be resolved before the decision for utilizing cloud computing [13–15].

(i) For data protection and security, infrastructure provider cannot support mandating specific data protection policies to service providers.

(ii) For data privacy, infrastructure provider cannot specify the policies on how the sensitive data is shared among cloud service providers.

Those require additional investment for data management contradictory to cloud computing’s cost-saving factors in initial stage for up-front investment. Besides, the issues of SLA or data management related to cloud computing are complicated and the customers need experts understanding details to find proper solutions.

3. Survey for Cloud Computing in Korea

According to previous surveys [16] in Korean IT market, business owners’ motivations to utilize outsourced information systems can be classified into economic reasons, strategic reasons, and technological reasons. Technical aspiration was the most impulsive and reinforced motivation for BPO in Korea. Cloud computing was an interesting topic during the last few years in Korea.

In the same context, cloud computing was expected to be popular in Korean IT market, but the expectation is not realized yet. We identify its main causes as follows:

(i) misunderstanding complicated service contracts between service consumer and provider,

(ii) data sharing issue between infrastructure providers and multicutomers,

(iii) lack of experts in service monitoring and legal issues for using cloud computing.
Table 1: Usage plan of cloud computing.

| Size (employees) | Current using | To use within 1-2 years | To use as long term plan | To consider with cost comparison | No plan |
|------------------|---------------|-------------------------|--------------------------|----------------------------------|---------|
| 5~9              | 5.90%         | 1.30%                   | 2.90%                    | 5.80%                            | 84.10%  |
| 10~49            | 9.60%         | 0.70%                   | 3.20%                    | 7.10%                            | 79.50%  |
| 50~249           | 9.70%         | 1.40%                   | 5.70%                    | 9.30%                            | 73.90%  |
| 250+             | 9.90%         | 1.90%                   | 9.30%                    | 9.70%                            | 69.30%  |
| Total            | 7.80%         | 1.10%                   | 3.30%                    | 6.60%                            | 81.20%  |

Table 2: Reasons of no planning for cloud computing.

| Size          | Reason A | Reason B | Reason C | Reason D | Reason E | Reason F | Reason G | Reason H | Others |
|---------------|----------|----------|----------|----------|----------|----------|----------|----------|--------|
| 5~9 employees | 76.6%    | 24.4%    | 20.0%    | 20.0%    | 13.1%    | 9.3%     | 8.9%     | 5.5%     | 0.5%   |
| 10~49 employees| 75.4%    | 24.8%    | 22.5%    | 19.1%    | 14.9%    | 9.3%     | 7.9%     | 5.6%     | 1.1%   |
| 50~249 employees| 71.0%    | 23.4%    | 22.9%    | 11.8%    | 20.7%    | 10.4%    | 10.5%    | 7.9%     | 1.6%   |
| 250+ employees | 64.2%    | 14.7%    | 32.8%    | 6.1%     | 27.4%    | 12.5%    | 12.7%    | 10.5%    | 1.4%   |
| Total         | 75.6%    | 24.4%    | 21.4%    | 18.9%    | 14.5%    | 9.4%     | 8.6%     | 5.8%     | 0.8%   |

The survey results of KISA (Korea Internet and Security Agency) conducted in 2013 [17] are a good reference to the current status of cloud computing usage in Korea. KISA generated a company list having more than 5 employees and 1 network connected computer. The company list is also classified with its employee number and we have following company counts based on it:

(i) 5~9 employees: 1,590 (30.3%),
(ii) 10~49 employees: 1,766 (33.7%),
(iii) 50~249 employees: 1,060 (20.2%),
(iv) 250+ employees: 827 (15.8%).

The survey results from the companies shows only the 7.8% of them are already using cloud computing environment. The company having actual utilization plan takes only around 19%, while 81% of the replies say that they do not have any transition plan to cloud computing environment. Table 1 has more details on the survey results from the sample.

According to company size, the responses were slightly different especially for cost issue. The results show that the most important motivation for adopting cloud computing is being cost saving. Final IT customer in Korea is considering cloud computing only if the cost-saving effect is clear and large companies are more affected by the cost-saving factor. 5.8% of 5~9 employee sized companies are affected by cost comparison, while 9.7% of 250+ companies are affected by it.

For further survey on reasons for not having a plan for cloud computing platform adoption, KISA reported that the following items were identified from participants:

(i) Reason A: no urgent requirements,
(ii) Reason B: no useful services,
(iii) Reason C: higher cost than expected,
(iv) Reason D: no information on cloud computing,
(v) Reason E: data security issues for external storage,
(vi) Reason F: no confidence for service provider,
(vii) Reason G: no information on service outage management,
(viii) Reason H: no information on compatibility or standardization of diverse cloud infrastructures and current system.

Table 2 has the result of survey on why some companies do not have any transit plan for cloud computing. Results show that the expected cost is the main factor regardless of the company size. However, service outage management or system compatibility is additional blocking factor for larger companies, while small companies having 5~9 employees point out the lack of information on cloud computing or urgent requirements as the blocking factors of cloud platform adoption.

The cost saving factor is the most important factor for decision making on cloud platform adoption except for the demands or useful applications. Overall investment for IT service can be simplified as the following equation, which indicates the present net value of IT services.

We assume that the new system requires one time initial investment and continuous operation cost every financial period. For cloud computing adoption scenario, we save the initial investment by using cloud computing, which is expressed with negative sign in (1). Also the equation represents the present value of difference of routine operation costs between traditional IT investment and cloud computing based on interest rate "r." Consider

\[ NPV_{\text{new}} = \text{Invest}_{\text{t}=0}^{\text{new}} + \sum_{t=0}^{N} \frac{(\text{Cost}_{\text{current}} - \text{Cost}_{\text{new}})}{(1+r)^t}, \]

where NPV, is net present value of IT service at time t, Invest, is investment at time t, Cost, is operation cost at time t, and r is rate of interest.

The benefits for new IT infrastructure should be greater than investment to be considered for decision making. If we
compare current system and cloud computing, we can see the following inequality as a benefit of new system:

\[
\text{Invest}^{\text{Cloud}}_{t=0} > \sum_{f=0}^{N} \left( \frac{\text{Cost}^{\text{current}}_t - \text{Cost}^{\text{Cloud}}_t}{(1 + r)^f} \right).
\] (2)

Survey results show that most companies in Korea cannot assure the above inequality yet. Logically, initial investment for transit to cloud computing platform would be minimal amount compared to traditional IT environment though.

Equation (1) shows how we can expect long-term benefits of cloud platform adoption in operational cost compared to initial investment. Initial investment for transit to cloud computing platform may include several facets of IT operation model. One of the biggest blocking factors for cloud platform adoption is the compatibility of current IT functionality with new cloud environment. Many companies suffer similar issues caused by keeping too old software for operations.

Another issue IT managers should consider for cloud infrastructure is sharing sensitive data with service providers. Sometimes, it requires additional investment according to adopted solutions for better security. The following are examples of currently plausible scenarios for additional implementations.

(i) Additional inquiry servers provide additional servers for remote querying of encrypted database on untrusted servers [18].

(ii) Hierarchical key management separates public key information matching to domain space and private information associated with certain class [19, 20].

(iii) Two layers of encryption imposed on data separate inner layer for initial protection and outer layer for policy modifications [21].

(iv) Group key management initializes multicast group with common net key and rekeying the multicast group [22].

(v) Group/multicast key management triple \((U, K, \text{and } R)\) key element where \(U\) indicates a set of users, \(K\) denotes set of keys held by the users, and \(R\) is the user-key relation [23].

The additional investment for data protection and privacy depends on the overall data management schemes. The modeling of required additional investment for each example scheme may be another research topic for cloud computing.

4. Discussion

Cloud computing service is widely used and is changing paradigm of IT service. The trend of new technology with cloud computing such as Sensor-Cloud computing or big data also utilizes a vast storage capacity and processing capabilities of cloud computing. However, the impact of cloud computing in Korea is not comparable to other developed countries yet. We summarize the benefits and challenges for running business in cloud computing. Also we analyze the survey results on cloud platform adoption in Korean business environment. Survey results from KISA (Korea Internet and Security Agency) show that there are many concerns. For adoption of cloud computing, the cost efficiency is the main decision making factor and different concerns are engaged according to company size in Korea. Small companies focus on urgent demands such as useful applications, while big companies focus on incident management or service outage manuals. It helps to understand the current status of adopting new IT paradigm and blocking issues of cloud platform adoption in Korea.

According to the survey results, IT managers in Korean companies understand that adoption of cloud computing has many benefits and enables a foundation of new technology such as sensor clouding system or big data. However, they need a concrete model to measure business benefits obtained by cloud computing adoption, by which decision makers in Korean IT market could be supported because the cost effectiveness of cloud computing adoption is the main decision making factor.

Conflict of Interests

The author declares that there is no conflict of interests regarding the publication of this paper.

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