The Planning of the Architecture of a Public E-Procurement Environment under the Cloud – the Case of Taiwan

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ABSTRACT

The concepts of innovation and services have become the spindle of e-government. The technologies that will support the realization of the concepts will obtain the focus of governments. Cloud computing provides the most possible solutions to the emerged transformations. E-procurements are the major activities in G2B, which accounts for the economic planning and development of a nation. This research aims to first understand the current e-procurement flow and locate the bottlenecks of the existing systems. Secondly, to explore the services that is necessary to the new systems. Finally, this study presents the architecture of public e-procurement under the cloud. 

Keywords: Cloud Computing, Service Oriented, E-procurement, E-government

INTRODUCTION

The purposes of E-government are providing better and more efficient services by utilizing the advantages of information technologies. With the maturity of the development of e-government, the next phase of the promotion of e-government focuses on the integration, innovation, personalization, and in-time and interactive services. For example, the iN2015 project in Singapore considers “innovation” as the foundation to building an intelligent country. The spindle of e-government in the U.S. concentrates on innovation of information technologies and the improvement of both efficiency and benefits. The British government plans to standardize desk top computers so that the establishment of the environment of cloud-computing will be promoted smoothly. The facts indicate that innovation and services have been recognized as the core of e-government. The architecture that will support the tendency, such as cloud computing, is believed to become the mainstream in the design of the infrastructure of e-government.

E-government is classified into government-to-government (G2G), government-to-citizen (G2C), and government-to-business (G2B). Among them, G2B has the greatest affect the on the entire economic planning and development of the nation. In the meantime, G2B provides the most opportunities for government employees to become involved in bribery and corruption [Transparency International, 2009]. The main reasons are that the majority of activities in G2B are purchasing, and public procurement often encompasses confidential issues and regulations and involves serious mutual trust [Liao, Wang and Tserng, 2002]. The amount of money is extensive as well [Liao, Wang and Tserng, 2002, Reddick, 2004]. Moreover, the lengthy processes, the quality of the subjects as well as the businesses themselves, and the issue of possibly asymmetric information, etc. are very common in public procurement.

According to the Public Construction Commission of Taiwan, in 2010 approximately 200 thousand procurement cases between the governments and enterprises were over one hundred thousand dollars. The total amount of public procurement was near 40 billion U.S. dollars [PCC, 2010]. Small and Medium enterprises accounted for almost 60 percent of the transactions. In 2009, Taiwan acceded to the WTO Agreement on Government Procurement (GPA), it is expected that public procurement of Taiwan will also open to other GPA members and the amount may reach 6 billion dollars. Experiences and literature has proved that the rise of e-procurement could effectively lower the cost of public procurement, lower the expenses of administration, choose qualified vendors, and standardize as well as to expedite the whole process.

The integration of information technologies in coping with ideal innovative services in e-government has become imminent. Cloud service is one of the most possible solutions that most governments adopt. Gartner reported that cloud computing would be one of the top 10 strategic technologies for 2011 and estimated that by 2014, revenues gained from a “cloud computing” infrastructure will exceed 14 billion dollars [Gartner, 2010].
However, the concept of cloud services exits various shortcomings as well. Literature surveys indicate that most software suppliers redesign the services that are currently used in the market instead of developing the new applications that are more suitable to the cloud environment. Furthermore, most of the suppliers do not have sufficient experience or techniques in the specific domain [Tsai, 2009]. E-procurement plays an important role in the promotion of e-government. There is no doubt that the planning of e-procurement under a cloud environment will be taken into account when governments are ready to comprise the concept of cloud computing in the advancement of e-government. Therefore, the design of e-procurement architecture under cloud requires more cautious work so that the problems of processes, regulations, securities, qualities, and the possibility of waste will be managed effectively. In fact, in the white paper of the promotion of cloud computing presented by the Ministry of Economic Affairs of Taiwan, the initiation of new e-procurement cloud service is one of the most important cloud services that the government plans to create in the foreseeable future.

In order to design more appropriate e-procurement architecture under a cloud environment in Taiwan, this research aims to first, understand the flow of the current public procurement system in Taiwan and locate the bottle necks of the system. Secondly, this research conducts several interviews and tries to organize the cloud services that are required for e-procurement. Finally, this research proposes the framework of e-procurement under cloud for Taiwan. This paper is organized as follows: Section 2 contains the literature review, this paper first briefly explains the concept of cloud computing. The business architecture under the cloud that was proposed in the previous research is then introduced. The current e-procurement status of Taiwan as well as the comparisons of the flow of e-procurement with other nations is also presented in this section. Section 3 describes the methodology of this research. The interviews conducted by this study are described in this section. The framework of e-procurement under cloud is explained in section 4 and section 5 concludes this paper.

LITERATURE REVIEW

Cloud Computing

The major function of cloud is the delivery of services. It is not new to consider the pursuit of “service” as the entire and only philosophy in the adoption of new technology. Clustering computing, grid computing, and service oriented architecture are the three famous examples that have seamlessly combined technologies with business flow. Cloud computing is similar to the aforementioned concepts but with three unique characteristics, which include virtual, dynamic provision on demand, and negotiation. Therefore, in the literature, cloud computing is defined as, “offering hardware and software resources as services across a parallel and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned. The one or more unified computing resource(s) is determined based on service-level agreements established through negotiations between the service provider and consumers.” [Tsai et al., 2009; Motahari et al., 2009]

Clouds have been developed to cover both private and public areas. The private clouds are usually owned by large enterprises and all the resources are shared within the enterprises. The public clouds, on the other hand, are supported by companies such as Google, Amazon, and IBM. The services are broadcasted to thousands of businesses and millions of people. Furthermore, according to the types of services, clouds are usually known for four categories:

- Infrastructure as a service (IaaS): IaaS basically considers virtual infrastructure as services. Main services include the provision of virtual hardware, network, storage, computing power, etc. The clients include IT managers or software developers. Amazon S3 (simple storage service) and EC2 (elastic compute) are the two well known services in the category.
- Database as a service (DaaS): DaaS, such as the SSDS of Amazon, moves the traditional database features, including the definition of data and the storage and retrieving of data, over to the network. The services protect clients from tracking long timing transactions or assist with the maintenance of the integrity of the data. Software developers may be the major clients.
- Software as a service (SaaS): SaaS represents a new concept of “software on demand”. The software refers to application systems that can be activated directly on the internet. For example, the customer relationship management system provided by Salesforce.com is commonly adopted by businesses.
● Platform as a service (PaaS): PaaS delivers a service oriented platform. The whole process in the software development life cycle (i.e., design, test, execution, and deployment) would be provisioned as an integrated service over the internet. Services in this category include the APP engine from Google and Azure from Microsoft. The software developers are possibly the major clients in this category.

Cloud computing is a big, trendy word now. The IaaS and PaaS promise users no longer being confined to limited space, time, or the compatibility of computers. To adopt existing services from the internet will minimize the expenditures spent on the information facilities and management. The pay-by-use mechanism will rationalize the market of intelligent property. Furthermore, with all services in cyber space, businesses or users will have more flexibility and options in search of the best alternatives, and hence save more preprocess time. The new technology may guarantee the leverage of acceptance of users and smooth the introduction of new systems to the users as well. The users will always be updated with the new version and will not be bothered by copyright issues. For the enterprises, the management of documents, the cooperation, as well as the coordination within the organization, will be easier.

However, cloud computing is by no means perfect. According to [Heiser and Nicolett, 2008, Mansfield-Devine, 2008], the problems with cloud computing may include the lack of control of data; the lack of master control over the quality, the privacy, or the stability of service; the security issue; the question of the sustainability of services, etc. In the public domain, West [2010] suggested that to improve cloud computing in the public sector, the governments need to develop more consistent rules for computing, speed public sector innovation, harmonize the laws, revise outdated policies, encourage portable data exchange platforms, and improve transparency of cloud computing. Apparently, the laws and the rules get more attention in the migration of government systems.

Business Architecture under the Cloud

The trend has shown that cloud services are going to become the necessities of daily lives. In the investigation of whether businesses are ready to welcome the transformation of the new atmosphere, Motahari Nezhad et al. [2009] proposed that the context, services, business processes, as well as the IT services of each business have to be redefined. Figure 1 shows the new business architecture under cloud.

Figure 1: Business Architecture under Cloud (reproduced from Motahari Nezhad et al. 2009)

The definition of business context should include business goals, the structure of the organization, the strategies, as well as the anticipative performance. Business services refer to the functions, the philosophy, and the non-functional concepts. Business processes mainly include the behavior, the activities, and the design and integration of services. IT services are actually the provision or the requirement of cloud services.

In recent years, e-procurement in the framework of e-government has been deemed as an opportunity for significantly reducing cost due to centralized spending [Panayiotou et al. 2004]. Nevertheless, cutting cost is by no means the main objective in the promotion of e-government. Instead, governments are placing a lot of effort in the pursuit of better service levels [Panayiotou et al. 2004]. As aforementioned, an e-procurement system contains e-sourcing, e-coordination, and e-communities [Johnson, 2005]. In fact, the procurement process covers the whole spectrum of activities from ordering goods to outsourcing services [Dai and Kauffman, 2001], and more complex
procurement functions are yet to be considered important on the spectrum. For example, reverse auction will now occupy an important space in an e-procurement system [Johnson, 2005]. Furthermore, there is no single solution to successfully implementing e-procurement, and the design as well as the implementation must support corporate goals and strategies [Pearcy et al. 2004].

Previous literature indicated that the barrier to the successful implementation of public e-procurement also includes the contradictions of the buyers' (which are the governments, the organization of governments, or public universities) attitude toward the sellers [Vaidya, Sajeev, and Callender, 2006]. The government wants as many sellers as possible to participate in the bidding, and at the same time, the government anticipates the guarantee of qualities. Furthermore, it will be difficult to provide a system for a marketplace using different technologies, platforms, and business language [Office of Government Commerce, 2010].

In summary, the design of the architecture of public procurement must take the goals, the characteristics, the strategies, the anticipative performance of the government, the functions and activities of the government, the services that need to be integrated and provided, etc., into consideration. The framework proposed by Motahari Nezhad et al. is considered appropriate to apply to the context of public procurement.

Public E-Procurement

E-procurement is an integrated process that uses the advantages of technologies to facilitate the requisition of merchandise to establish the protocol of services as well as to complete transactions over the internet [Reddick, 2004, Moon, 2003]. The benefits that will be gained from e-procurement, no matter in public or private sectors, include the building of better relationships with vendors, improving the effectiveness of the purchasing process, elevating services levels, controlling costs to a reasonable level, accurate fulfillment of the process, and reduction of the order cycle [Panayiotoun et al., 2004]. E-procurement has been considered an opportunity to reengineer the process of purchasing in the public sector and has received serious attention in most of the countries [Panayiotoun et al., 2004].

E-procurement includes three essential functions, which are e-sourcing, e-coordination, and e-communities [Johnson and Klassen, 2005]. According to [Johnson and Klassen, 2005], e-sourcing includes electronic auction, online bidding, and tendering. E-coordination refers to the automation of business processes within organizations, and between the company and buyer and suppliers. E-communities, however, may point to different markets depending on the type of participants, goods, or interests. Figure 2 describes the flow as well as the functions of government procurements.

Traditionally, government procurement processes pay more attention to the internal efficiency, rationality, and the management that is more departmental and regulatory oriented [Ho, 2002]. In the e-procurement context, the focus has turned to the interactions between government and suppliers. The qualities of services and the attitude of users toward the system have been considered more important [Reddick, 2004].

Leukel and Maniatopoulos [2005] pointed out that public e-procurement is different from private e-procurement since public e-procurement involves more bureaucratic processes. The regulations or limitations may vary due to the levels of governments being different. Another specific nature of government procurement is that it involves a variety of business models, commercial technology platforms, and product coding systems [NECCC, 2001]. The integration of the various implementations in government e-procurement is deemed a difficult task. Moreover, the governments sometimes need to take social responsibilities into consideration upon making decisions. Therefore, unlike the e-procurement systems of private enterprises, e-procurement systems in government need to handle the interactions between different levels of governments, between governments and businesses, or even the interactions between businesses with greater care.

Heywood et al. [2001] suggested that e-procurement should focus on e-enabling the purchasing process, using the new information technologies to enable better and cheaper sources of supply, and facilitating innovation and collaboration across the supply chain. It is our belief that cloud computing would help governments to achieve these visions effectively and elevate current public e-procurement systems to an advanced stage.
The methodologies adopted in this research include the study of secondary data such as government white papers, government documents, and reports on the portal of government e-procurement system in Taiwan. The purposes are to understand the flow of government procurement, the current e-procurement systems of Taiwan, and to locate the problems as well as the shortcomings of current systems. In addition, this study conducts a series of interviews to determine the needs of the buyers, the suppliers, as well as the systems service providers so that the components of the cloud e-procurement system can be determined. This section first describes the second generation e-procurement system of Taiwan. The plans, as well as the results of the interviews, are summarized next.

E-Procurement System of Taiwan

The first e-procurement system of Taiwan contained over 40 subsystems. The subsystems, such as the procurement information announcement, e-tendering, the contract agreement, and the auditing and checking systems are working independently. To elevate the performance, as well as to improve the efficiency of the government, the task of the integration of the systems has been outsourced to Chunghwa Telecom. The new generation e-procurement system was announced in effect in 2010. E-procurement system 2.0 consists of six dimensions, which are the portal, the pre-and-post process, e-procurement, purchasing auxiliary, the report center, and the maintenance, respectively [Wu, 2011].

The key objectives of the second generation of e-procurement systems are to realize the policies of regulatory relaxation, to improve the government procurement environment, to provide an open and transparent system, as well as to modify the conventional procurement procedures [PCC, 2011]. For instance, the government procurement of Taiwan is classified into three categories according to the subject (construction, properties, or service) or the type of each case, the amount of the case, or the regulation of the purchasing. Furthermore, for frequent or trivial purchases or the properties that have common requirements or specifications, the government of Taiwan implemented an e-procurement system for Inter-Entity supply contracts to simplify the procedures as well as to reduce the cost. In 2010, more than 90% of the government procurements were completed on an e-procurement system. The amount of the procurements that were through the Inter-Entity supply contract was over 2 billion U.S. dollars and the price was almost 15% cheaper than the market price.

In addition to the procurement system of the central government, the local governments have their own systems. The forms, documents, and even the regulations are different from those of the central government. In the survey of
several annual review reports of local governments and government organizations on e-procurement, the negative feedback included the concern of the security issues, the minute and complicated flow resulting in a waste of time and the cost, especially for a small amount of procurement. In addition, the inter-entity supply contract system does not guarantee the best or the lowest price, which will also lead to a tremendous amount of waste.

The Summary of the Interviews

The objectives of the interviews are mainly to understand the experiences that users have had in government procurement. Secondly, this research tries to locate the difficulties and the bottle necks of the current system. Thirdly, this study collects the requirements and the expectations of users toward e-procurement cloud services.

This study carried out 10 interviews with 15 respondents. The respondents include four users from the buyer side and nine users from the seller side. One respondent is a lawyer who has many years of experience in government procurement dispute settlement. The last respondent is an IT technician from a cloud service provider. The two users from the buyer side include a university employee and a government employee. The nine users from the seller side belong to two companies in the information service industry and have many years of experience in bidding government procurement. The analyses of the interviews are discussed as follows:

● The requirement of clearer definitions of the context. The definitions include the goals, the structures, the policies, and the expected performance. In the seller interviews, surprisingly, only a few users have objections or opinions against the regulations regarding governmental procurement. However, even less users could specifically give answers to the above issues. Users hardly get support thru e-procurement systems due to either not realizing there is such a service or not knowing how to use the service. On the other hand, government employees express that they spend too much time explaining or tutoring on the system. Users recognize the benefits gained from e-procurement simply from how convenient the digitalization may be. The possibilities of the leverage of competitiveness are really not users’ concern.

● The expectations for management environment. In the survey of the experiences in contact with governmental procurement, what concerns the vendors most are the security issues. For instance, the privacy of the vendors, the bidding information, the fairness of the system, etc. Furthermore, users (no matter whether they are buyers or suppliers) complain that the procedures for a small amount of purchasing are too cumbersome. Businesses also complain about the timing of the procurement announcements.

● The services required. In the interviews, the users reveal a contradiction of opinions. On one hand, the users demand a system that will be able to handle the overall processes of e-procurement. On the other hand, users prefer an easy to operate, simple and simplified system. Some users ask for a dual language environment as well.

● The expectations for infrastructures. In the survey of the experiences in contact with governmental procurement, government employees complain that they are seriously bothered by the incompatibility of systems and the inconsistency of data. The suppliers, however, are unhappy with the non-unified documentations, etc. Furthermore, the suppliers suggest that the databases should be shareable among all government divisions but at the same time, that privacy is protected. Fortunately, the shortcomings can be solved under a cloud environment. Stability is another major issue brought out by users.

● The expectations for the systems. As mentioned earlier, the databases are not interconnected between divisions of government; the sellers have to fill out all kinds of information every time they want to participate in the bid. Users expect a friendlier interface and an easy to use system.

THE ARCHITECTURE OF E-PROCUREMENT UNDER CLOUD

The business architecture under the cloud proposed by Motahari Nezhad et al. [2009] is adopted in this research to form the fundamental concept in the development of the architecture of e-procurement under cloud. As indicated in section 2, business context, business services, business processes, and IT services are the four major components in the business architecture under the cloud. This research also defines the four components in the cloud e-procurement environment; the definitions are described in table 1.
### Table 1: The Definitions of E-procurement Environment under Cloud

<table>
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<th>Component</th>
<th>Definition</th>
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| Context     | ✷ Vision: Government, local authorities, suppliers take advantage of effective cost IT services via internet in their procurement.  
             | ✷ Objectives: To gain substantial efficiency in government procurement.  
             | To achieve excellent cost savings in government procurement.  
             | To establish trust of citizens, suppliers, and official organizations.  
             | To take advantage of technology innovations.  
             | ✷ The structures: Cloud services including IAAS, PAAS, SAAS, and DAAS.  
             | ✷ Policies: Seek for common agreement cloud computing rules and norms [Well, 2010].  
             | ✷ Evaluation mechanism: Critical successful factors are defined; SWOT analysis, balanced scorecard, and other tools are adopted to measure the effectiveness of the strategies and performance. |
| Services management | The specific functional and non-functional properties of e-procurement are to be defined and declared.  
                            Users (both public and private) are required to understand their roles and duties. |
| Processes or functions | Functions that cover overall processes of e-procurement are to be defined, selected, and developed. |
| IT services | The IT solutions for e-procurement under cloud environment. |

In fact, the findings of the literature review, as well as the opinions in the interviews, reveal that in the migration of public procurement systems to the cloud, the basic functions or services are not the major concerns. Instead, the infrastructures, security issues, norms, rules, and policies dominate most of the success in the e-procurement under cloud. By incorporating the definitions of the four components with the results of the interviews, as well as the analysis of the secondary data, this research further defines the cloud services for e-procurement. The architecture is given in figure 3.

The architecture proposed by this research will support the achievement toward the vision and objectives defined in table 2. The structure of the architecture consists of four layers. The first layer is the interface, the portal, and the Web layer. This layer provides all users (government, local governments, local authorities, suppliers, or even visitors or researchers) an entrance to implement or to navigate government procurement systems. Services on this layer must provide full and friendly interface support. The second layer is the software services (SaaS) layer in the cloud environment. The services are classified into three categories. The processes and functions are the general and necessary processes that provide a seamless and complete flow for procurement transactions. The services for government preparation for procurement, the e-tendering, e-bidding, contract and authorization, and e-payment are defined in this category. The management category is responsible for the improvement of transparency, the evaluation of performance, as well as the sharing of knowledge. The policy category is to regulate the norms and rules. The detail services of each category are listed in table 2. The third layer is the database layer. The database services include the storage of all transactions, the historical data, the standard for data exchange, and the integration of data. This layer will ease the difficulties of non-shareable data between government divisions or organizations and eliminate the redundant procedures as previously mentioned. The last layer is the computing and networking framework. Government and suppliers consider virtual infrastructure as services. Services on this layer include the provision of virtual hardware, network, storage, computing power, etc. This layer plays an important role in the support of the entire architecture. The platforms, as well as the infrastructures of governments and suppliers are integrated. The protocols will be unified as well.
Public e-procurement was heralded for over a decade as offering governments significant opportunities for the purchasing functions and the procurement process. This study explores the advance of public procurement by reviewing new information technologies. The ultimate objectives of the research are to understand the flow of current public procurement and locate the bottle necks of the system; to organize the cloud services that are required for e-procurement; and finally, to propose the framework of e-procurement under cloud for Taiwan.

In this paper, the cloud services are generated and proposed from three phases:

- The results of literature survey. The framework proposed by [Motahari Nezhad et al., 2009] was adopted as the blueprint to plan the architecture of this research.
- The analysis of users’ requirements. The experiences, the barriers, and the expectations of the users are collected and analyzed to generate the services that are necessary for a public procurement environment under cloud.

**CONCLUSIONS**
The basic cloud architecture, which includes the infrastructure (IaaS), the applications (SaaS), the databases (DaaS), and the platforms (PaaS).

- The analysis of this research confirmed that the four components proposed by [Motahari Nezhad et al., 2009] including context, processes, services, and IT services, are applicable to public procurement in the framework of e-government as well. To plan the environment of e-procurement under the cloud, the governments have to clearly identify the goals and visions of the system. The functions have to be defined in detail, the services that will fulfill the objectives of the functions are then provided in whole. The infrastructures, platforms, databases, and software applications will, however, take a ride on the advance of technologies to build the foundations of the entire architecture.

The architecture of e-procurement under cloud for Taiwan proposed in this research will lead the government of Taiwan to enter a new era of e-procurement. The architecture guarantees the following merits:

- The architecture has clear visions and objectives. Thus, government has a more definite and correct direction in the development of strategies, amending the inappropriate or outdated laws, editing yearly budget, and the integration of public and private resources.
- The architecture proposed in this research emphasizes not only a seamless public procurement flow or system but focuses mainly on the provision of innovative services. The concept of innovative service is customer or user oriented. Therefore, the services are easily adopted.
- With a single portal, the information will be broadcasted in time. Plus the policy service layer promises the transparency of the procurement process and mutual trust will be established easily.
- The architecture is designed based on the concept of cloud computing. Government, local governments, local authorities, suppliers, or even citizens and researchers will share the infrastructures, databases, and software applications. Tremendous cost will be saved under this design.

Current research focuses on the skeleton of the cloud environment for public procurement. The difficulty encountered during the research is that the word “cloud computing” is new to almost all end users. Users may not realize how to take advantage of the nature of cloud computing. The results generated from interviews require more in-depth investigations. To improve, as well to present a robust architecture, more interviews will be arranged in future works. The opinions of users or vendors, especially from large enterprises or international corporations, will gain more attention in this phase. In addition, a large scale of questionnaire investigations will be conducted to gain a more general idea from users and the focus of the next phase will be more specific services on the cloud. Furthermore, this research will carry out a survey on the market and investigate the services that are appropriate to realize the architecture this research proposes.

REFERENCES


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