

## A QFD Approach for Cloud Computing Evaluation and Selection in KMS: A Case Study

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### Abstract

Cloud computing services are a new information technology trend for business applications in knowledge management systems (KMS). The link between cloud computing services and KMS is a new concept, and methods for selecting multiple choice goals of cloud computing service provider have lacked a formal reference framework. From the perspectives of customer needs and technology requirements, selecting the right cloud computing service supplier for KMS is a key strategic consideration. This paper presents an integrated analytical hierarchy process (AHP), quality function development (QFD) and multi-choice goal programming (MCGP) method to address the cloud computing service provider selection problem in KMS for information service. To show the practicality and usefulness of the proposed method, a case study of a Taiwanese textbook company is presented. This paper shows that the proposed model is a good decision-making tool for the selection of new information technology.

*Keywords:* cloud computing, knowledge management systems (KMS), analytical hierarchy process (AHP), quality function development (QFD), multi-choice goal programming (MCGP).

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## 1. Introduction

The power of information technology (IT) to support knowledge management activities is widely recognized [1]. While cloud services such as webmail, Flickr and YouTube have been widely used by individuals for some time, it is not until relatively recently that organizations have begun to use cloud services as a tool for meeting their IT needs<sup>2</sup>. For a long time, most businesses perceived IT to be the panacea for all issues related to knowledge management systems (KMS). For many firms, cloud computing is an adoptable IT to obtain KMS services over the Internet. For example, a business on the Internet can simultaneously communicate with many customers, and servers can exchange information among themselves<sup>3</sup>. Cloud computing is now one of the new IT trends and will likely have a significant impact on information management in business applications, such as KMS<sup>4</sup>. In addition, the increasing demands on the knowledge resources of KMS are forcing many businesses to consider new information services, such as cloud computing services, to obtain the best KMS support. From the perspectives of customers' needs and technology requirements, selecting the right cloud computing service supplier for KMS is a key strategic consideration.

Cloud computing provides software and hardware resources that are used as the fundamental platform across many host computers, which are connected by the Internet or an organization's internal network. The development of software services (e.g., KMS) has come a long way since the practices employed under quality assurance techniques<sup>5</sup>. For businesses, KMS that include databases, communication, and intelligent systems technologies are the most common examples under a cloud application. The challenge for managers responsible for their business' KMS lies in linking outside cloud computing services to support their KMS to achieve knowledge management objectives. In other words, a knowledge management manager would need to select the best cloud computing service provider to meet their business's competitive strategy.

To improve the competitiveness of businesses, quality function development (QFD) is an adaptation of tools to formulate business problems and possible solutions<sup>6</sup>. As information and communication technologies develop, businesses frequently integrate Internet technology to redesign their processes to achieve a competitive advantage<sup>7</sup>. A number of studies have

explored how to evaluate a specific IT service using QFD approaches<sup>6,8,9</sup>. Liao et al.<sup>3</sup> presented a conceptual framework can link cloud computing services with KMS, when considering customer's requirements and supplier's technology.

In past studied, how to select a suitable cloud computing service supplier for KMS have lacked a formal reference method. This research will fill the gap and presents an integrated analytical hierarchy process (AHP), QFD and multi-choice goal programming (MCGP) method to address the cloud computing service selection problem for KMS. To show the practicality and usefulness of this method, a case study of a Taiwanese textbook company is presented.

The organization of this paper is as follows. Section 2 reviews the relevant literature on cloud computing, KMS and QFD. Section 3 presents the proposed integrated methodology for cloud computing service supplier selection. In Section 4, a case study of a textbook company is presented. Finally, Section 5 provides the concluding remarks and outlines future research directions.

## 2. Review of the literature

### 2.1. Knowledge management systems

Knowledge management provides the reference for directing a business's strategic actions and learning and has thus become increasingly important. Knowledge management refers to the processing of inputs through data, information, and knowledge to wisdom<sup>10</sup>. Since 1987, KMS have become increasingly important because they provide the reference by which a business directs its strategy and generates capabilities to match and enhance its competitiveness in information management<sup>11,12</sup>. For the link between the information management and knowledge management to be successfully directed, there must be an indisputable IT link between a business' strategy and its KMS<sup>13</sup>. KMS involves collecting information and transferring information to demanders. It includes knowledge obtaining, refining, storing and sharing.

No alike general tangible service, knowledge management can effectively increase the value of the products and services in intangible<sup>3,15</sup>. To increase the value of knowledge service in a business's KMS effectively, Liu et al.<sup>14</sup> suggested that the knowledge

management service should include knowledge obtaining, creating, refining, storing, using and sharing. In addition, to integrate knowledge and information flows into an explicit system of transformations, Nonaka<sup>16</sup> and Reinmoeller<sup>17</sup> addressed the transitions of knowledge service and characteristics, such as (1) articulation, from tacit to explicit; (2) combination, from explicit to explicit; (3) internalization, from explicit to tacit; and (4) socialization, from tacit to tacit. The process of knowledge management can be structured into four fundamental elicitation characteristics such as knowledge creation, retention and retrieval of knowledge, sharing and knowledge transfer and application of knowledge<sup>18</sup>. The knowledge management transformations service and characteristics process in applications of organizational systems management is shown in Figure 1.

In a case study of knowledge management,

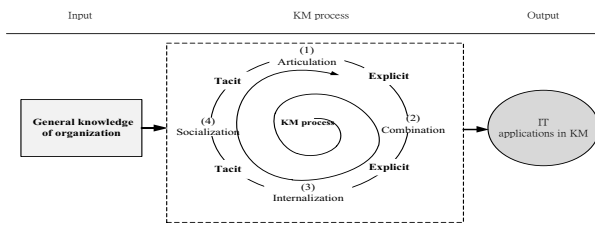


Fig. 1. KM transformations process.

Davenport et al.<sup>19</sup> and Liu et al.<sup>20</sup> noted that to be successful, a business's knowledge management framework must contain a skill and a facility resource of knowledge storage and explanation. Therefore, knowledge management managers must capture the business's knowledge from the soft insights or experiences (e.g., tacit knowledge) and from hard management information (e.g., explicit knowledge). Managers must establish and plan a KMS as (1) a core task of a knowledge management strategic plan is to define how knowledge management aligns with the firm's goal, (2) a task of knowledge management is to identify how employees learn from KMS, (3) as information technology develops, the KMS must be continuously upgraded and developed.

There are three issues in the architecture of KMS: infrastructure services, e.g., storage and communication; knowledge services, e.g., knowledge creation, sharing and reuse; and presentation services, e.g., personalization and visualization<sup>1,3</sup>. Due to the rapid development of IT, many businesses began to widely apply technology-based tools, such as cloud computing, to organize the internal

knowledge innovation activities<sup>21</sup> to achieve these three issues.

## 2.2. Cloud computing service

IT exchange and making business transactions via the Internet and E-mail are very common nowadays<sup>22</sup>. Cloud computing is an emerging application platform that is designed to share data, calculations and services among IT users<sup>23</sup>. The cloud provides flexibility and adapts to the demands for computing resources. Providers use different interfaces to their technology resources (e.g., management information systems, decision support systems and management support systems, etc.) utilizing a variety of structured implementation technologies for customers<sup>23</sup>. Cloud computing services are a new IT paradigm, as opposed to a new technical paradigm, which includes hardware and software infrastructure, or applications that are provided by a cloud computing supplier as a service to its customers<sup>24</sup>.

Cloud computing services are a viable alternative for today's businesses and provide a new paradigm to the application of IT to knowledge management. There are three main types of services offered by cloud computing<sup>3,25</sup>:

- (1) Infrastructure service— products include the far delivery (e.g., by the Internet) of a full computer infrastructure, such as virtual computers, servers, storage devices, etc;
- (2) Platform service— hardware, an operating system, a database, middleware, Web servers, and other software. In addition, these services require a team of network and system management experts and databases to keep everything online;
- (3) Software service— this service delivers applications via the Internet.

## 2.3. Knowledge management and cloud computing

In recent years, knowledge management has been recognized as a core business concern and many knowledge management related approaches have been proposed to enhance the performance of cloud computing services. Knowledge management is a key factor in improving the operational performance of a business. However, the high cost of knowledge technology will continue to place a great deal of pressure on the information technology costs of business (e.g., KMS' costs). From the perspectives of economics, convenience

and simplification, cloud computing could provide many businesses the opportunity to affordably take advantage of new developments in knowledge management<sup>25</sup>. Cloud computing services provide instant access to global service platforms, expanded hardware or software capacities and licenses, cost reductions, and simplified scalability in knowledge management. In contrast, organizational knowledge management automatically reduces business expenses and offer businesses more powerful functional capabilities.

Liao et al.<sup>3</sup> developed a novel conceptual framework for a cloud computing service architecture for knowledge management applications. The conceptual framework addresses the needs of employees, administrative staff, managers and developers that use knowledge management service for business management. Using this model, the cloud can be used to achieve an organization's knowledge management goals in a cost-effective manner. The model illustrates how cloud computing services, including infrastructure service, platform service and software service, can be utilized and the processes involved in organizational utilization of the KMS. The model links the cloud computing services and the knowledge management architecture for knowledge management's managers. The links are infrastructure services between cloud computing and knowledge management, such as storage and communication; knowledge services, such as knowledge creation, knowledge sharing, knowledge reuse, and presentation services, such as personalization and visualization<sup>1</sup>.

#### 2.4. Quality function development

Quality, in its simplest form, can be defined as meeting the customer's expectations or compliance with the customer's specifications<sup>26,27</sup>. Today, the meaning of the word 'quality' can be different in different contexts, such as in information technology, where the quality of information technology service still exists for quality management problems<sup>28</sup>. KMS are an information technology service problem, the QFD can be applied to analyze and assess the relationships between KMS and cloud computing services. For example, Chen and Huang<sup>9</sup> applied fuzzy QFD to analyze and assess the relationships between knowledge management processes and information technology services. QFD methodology has introduced two innovations into the traditional product/service development processes. First, the application of QFD requires that the customer be carefully

considered during the development process<sup>29</sup>. Second, the QFD approach has introduced the collaboration between different business areas as a prerequisite for product/service design<sup>30</sup>. Chan and Wu<sup>31</sup> view QFD as an implement to translate customer needs into technical requirements. In contrast, QFD is an overall concept that provides a means of translating customer requirements into the appropriate technical requirements for each stage of product/service development, e.g., marketing strategies, systems evaluation, service design and process development<sup>8</sup>. The success of QFD applications can be attributed to its benefits, which include higher customer satisfaction, greater customer focus, shorter lead time, and knowledge preservation<sup>14,32</sup>. The major benefits are QFD helps businesses to identify the key trade-offs between what the customer demands and what technology the business can afford to produce. In addition, QFD brings together all of the data required for the development of a good product, and the development team quickly sees where additional information is needed during the process. Moreover, the information is better used and documented. Thus, QFD can be applied to plan and design new services, such as cloud computing services for KMS requirements. Considering the new services of cloud computing available to meet a business's KMS requirements, this study will adopt the QFD method to select the best cloud computing service supplier<sup>33,34,35,36,37</sup>.

In the QFD process, the customers' requirement planning matrix, also called the "House of Quality (HOQ)" because of its typical shape, is used to exhibit the relationship between the voice of the customers (WHATs) (e.g., customer requirements for the KMS) and the quality characteristics (HOWs) (e.g., technical requirements of the services for the KMS)<sup>31,33</sup>. The main goals of the HOQ are to translate the needs of the customer into service requirements<sup>34,38</sup>. The HOQ is comprised of several so-called rooms, each containing information about the service. The basic HOQ format is comprised of seven major components: (1) customer requirements (CRs), (2) the importance of CRs, (3) design requirements (DRs), (4) relationship matrix for CRs and DRs, (5) correlations among DRs, (6) analysis of competitors, and (7) prioritization of the design requirements. The HOQ is thus adopted by the design work team (or expert) to transform the customer's requirements and needs into product/service characteristics. The basic structure of the HOQ is shown in Figure 2.

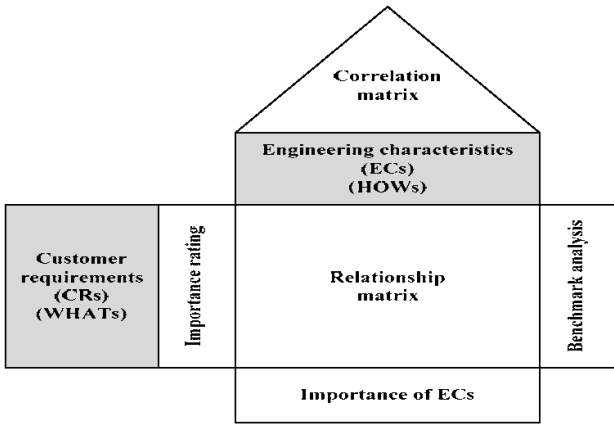


Fig. 2. The house of quality (HOQ).

### 3. The proposed methodology

The proposed approach is based on a translation of HOQ principles from the knowledge management services requirements to the management of cloud computing services. In our approach, a customer's knowledge management service requirements in terms of cloud computing performances (WHATs) are correlated with eight viable technical or management service actions that could be undertaken by the firm's top management to improve knowledge management processes (HOWs). The method shows the applicability of the QFD methodology, especially the HOQ, to identify the technical requirements of a viable service to achieve a defined set of customer requirements. The AHP was used to prioritize customer requirements.

The proposed method to integrate the AHP and QFD for a cloud computing service selection problem comprises the following steps:

*Step 1.* Identify the customer needs and the technical requirements of the service.

*Step 2.* Determine the central relationship matrix using the expertise of the QFD team.

*Step 3.* Use AHP to calculate the degree of importance (e.g., weights) for each customer requirement,  $w_i$ .

*Step 4.* Calculate the relative importance,  $RI_j$ , and priority weights of technical requirements for cloud computing (TC),  $RI_j^*$ , using equations (1)-(2):

$$RI_j = \sum_{i=1}^n w_i \times R_{ij}, \quad j = 1, \dots, m, \quad (1)$$

where  $R_{ij}$  is the relationship matrix giving the relationship between the  $j$  th TC and the  $i$  th CRs. Again,  $RI_j^*$  is the degree of importance for the TC of the  $j$  th service ( $j = 1, \dots, m$ ).

$$RI_j^* = RI_j + \sum_{k=j} T_{kj} \times RI_k, \quad j = 1, \dots, m, \quad (2)$$

where  $T_{kj}$ ,  $j, k = 1, \dots, m, k \neq j$ , expresses the correlation between the  $k$  th and the  $j$  th "hows."

*Step 5.* Normalize the degrees of importance of the technical requirements for the service ( $NRI_j^*$ ).

*Step 6.* Using AHP, determine the pairwise comparison matrices for each technical requirement for the service.

*Step 7.* For each cloud computing service candidate, evaluate the weight,  $e_{ij}$ , for each technical requirement of the service.

*Step 8.* Use equation (3) to calculate the overall score (or weight).

$$S_j = \sum_{i=1}^m NRI_j^* \times e_{ij}, \quad i = 1, \dots, n \quad (3)$$

where  $S_j$  is the overall score for the  $j$  th cloud computing service alternative; and  $e_{ij}$  is the weight of the  $j$  th alternative for the  $i$  th technical requirement for the service.

*Step 9.* According to the overall scores obtained from Step 8 for each cloud computing service candidates in Table 4 is used as weight values to build the multi-choice goal programming (MCGP) achievement model to fine the best candidate selection. Chang<sup>38</sup> presented a MCGP method to solve multiple goals choice problems, and it can be expressed as follows:

#### MCGP model

$$\text{Min } \sum_{i=1}^n (\alpha_i d_i^+ + \beta_i d_i^-) \quad (4)$$

$$\text{s.t. } f_i(X) - d_i^+ + d_i^- = g_{i1} \text{ or } g_{i2} \text{ or } \dots \text{ or } g_{im}, \quad (5)$$

$$d_i^+, d_i^- \geq 0, \quad i = 1, 2, \dots, n,$$

$$X \in F \quad (F \text{ is a feasible set}),$$

where  $f_i(X)$  is the linear function of the  $i$  th goal, and  $g_i$  is the aspiration level of the  $i$  th goal and  $g_{ij}$  ( $i = 1, 2, \dots, n$  and  $j = 1, 2, \dots, m$ ) is the  $j$  th aspiration level of the  $i$  th goal,  $g_{ij-1} \leq g_{ij} \leq g_{ij+1}$ . In addition, parameters  $\alpha_i$  and  $\beta_i$  are the weights reflecting preferential and normalizing purposes attached to positive

and negative deviations of  $i$  th goal, respectively;  $d_i^- = \max(0, g_i - f_i(X))$  and  $d_i^+ = \max(0, f_i(X) - g_i)$  are, respectively, under- and over-achievements of the  $i$  th goal.

#### 4. A case study

This section presents a case study that was applied to Hwa Tai Publishing (HTP) to select the best cloud computing service supplier for KMS by using the proposed QFD methodology. The characteristics of management and marketing information service have some specialized customer (e.g., college students and teachers) information requirement problems (e.g., information or knowledge obtainment etc) compare with other types of HTP. How to offer an efficient responding knowledge service system to customers is the major success factor in customer relationship management for HTP.

##### 4.1. The HTP

This paper considers an empirical example of a HTP, which supply information service in its own member system in Taiwan. Founded by M. C. Wu, chief executive officer (CEO) in 1974, HTP started as a small association. Up to now, HTP acquired 16 centers and became the largest textbook publisher of college; it publishes many commerce and management publications in Taiwan. The major data of HTP in 2012 is shown in Table 1.

**Table 1.** The data of HTP in 2012

Item	Numbers / Characteristics
Total sales volume	NT\$ 270 million
Number of employees	134
Product lines in information service	6
Charge range	NT\$ 450 ~ 1700
Place category	3
-Center stores	27
- Internet market	1
- Agency	21
IT tools for customer service	Blog, MSN, Facebook, E-learning, E-mail...

##### 4.2. Organization strategy

The strategy of HTP aims to maintain its position as the leading commerce and management information service in Taiwan. The chief executive officer claimed that this objective could be achieved through a policy reaching a high level of market penetration of its services. HTP strategy was built upon three key operational strengths:

organizational capabilities, marketing capabilities, and service capabilities.

**Organizational capabilities:** To achieve higher organizational efficiencies, HTP developed an integrated information and management system. Acquired information would be used to plan the service program and meet the customer requirements.

**Marketing capabilities:** HTP made a significant investment in building and maintaining its brand; furthermore, increase the brand awareness in Taiwan educational system. HTP owns one of the largest commerce and management information services in Taiwan with total 134 sales personnel and over 49 major points of sale. These marketing and service activities were coordinated through a central commerce and management information service management system.

**Service capabilities:** Customer demands for information never end, which makes information technology service a key role in marketing. Therefore, HTP has to choose an optimal platform for transportation information service to provide valuable knowledge for customer (e.g., commerce and management professors, students and researcher, etc).

##### 4.3. SWOT analysis

Currently, HTP has faced with two major issues: (1) Due to the recession birth rate of the population in Taiwan, the market of textbook publishing recedes as well. Consequently, to effectively develop a new product and expand customer sources is a key issue. (2) With the rise of information standard, customers tend to satisfy their demands via information technology services (e.g., Internet). Thus, how transportation information service functions and quality can meet customer demand is another imperative issue that HTP needs to handle. As a results, a strengths, weaknesses, opportunities, and threats (SWOT) analysis will be performed by expert team, which is familiar with the operation of the industrial. The SWOT is an important support tool for decision maker, and is commonly used as a means to systematically analyze a business internal and external environment. Using SWOT factors and alternative strategies, four sub-factors were developed as follow (also see Table 2):

- Selection a strong information technology service suppliers;
- Increasing image recognition and loyalty;
- Investing in E-books market;
- Subcontracting.

Considering the business mission and resource of HTP under SWOT analysis, Mr. Wu decided that a top

**Table 2.** SWOT analysis matrix for HTP

External factor	Internal factors	
	<b>Strengths-(S)</b>	<b>Weaknesses-(W)</b>
	-Research -Income generating capacity -Expert management staff	-Delay in innovation applications -Weak image
<b>Opportunities-(O)</b>	<b>(SO) Strategy</b>	<b>(WO) Strategy</b>
-New IT applications -Internet incentives - E-markets	Selection a strong IT service suppliers	Increasing image recognition and loyalty
<b>Threats-(T)</b>	<b>(ST) Strategy</b>	<b>(WT) Strategy</b>
-Threat of E-books -Economic and political uncertainty -Current and possible problems in birth rate	Investing in E-books market	Subcontracting

priorities strategy is to select a strong information technology service supplier.

Consequently, HTP plans to promote their customer service using IT system (e.g., Internet) to improve service quality and increase the spread of knowledge to meet customer requirements. HTP wishes to adopt a KMS to simplify customer service, and thereby increasing the productivity of knowledge sharing and customer satisfaction. However, given the cost of KMS and the difficulties associated with their management, Mr. Kevin Wu, the chief executive officer of HTP, is considering outsourcing the tasks of the KMS. The choice of a cloud computing service supplier becomes a critical issue due to the costs of IT management and quality of customer service.

#### 4.4. Applying QFD to this case

According to the decision-making by Mr. Wu, the CEO of HTP, they first established an information technology service evaluation team. The DM group was comprised of four members: the chief executive officer, chief information manager, marketing manager, and chief finance officer. In addition, nine experts from transportation business and academic institutions were invited to participate in the group and provide their opinions. Using the modified Delphi technique, four cloud computing service suppliers were considered to perform the desired tasks. The four cloud computing service alternatives were IBM ( $S_1$ ), HiNet hicloud ( $S_2$ ), CONNEXION ( $S_3$ ) and EASPNNet ( $S_4$ ) in Taiwan.

Nevertheless, HTP lacks an evaluation and selection method to determine the optimal cloud computing service supplier for its KMS. For establish a reliable KMS, QFD approach was introduced to select a cloud computing service supplier due to the major advantage of using QFD and have been discussed in previous section. In addition, the key criteria of selecting cloud computing service supplier from customer requirements and technical requirements are not well-established. Thus, from literature review, the DM group adopted the proposed criteria by Liao et al.<sup>3</sup> to evaluate the cloud computing services for KMS. In other words, all customer requirements mentioned in capture the voice of the customer will adopt in this study.

Liao et al.<sup>3</sup> identified customer requirements for the knowledge management process in cloud computing as knowledge creation, refining, sorting, sharing, using and storing such as customer requirements for KMS in a cloud computing environment. In addition, the technical requirements for the services of the KMS in a cloud computing environment are including eight technical requirements such as virtual computers, middleware, storage devices, an operating system, database, Web servers and business programs. The objective is to select the best of the four cloud computing suppliers.

This paper applied the original structure of the HOQ (see Figure 1) to integrate the voice of customer requirements and technical requirements of the services for the KMS. The AHP-HOQ specific structure is shown in Figure 3 and is adopted here. The main objective of this application is to explain the HOQ for the cloud computing service selection problem.

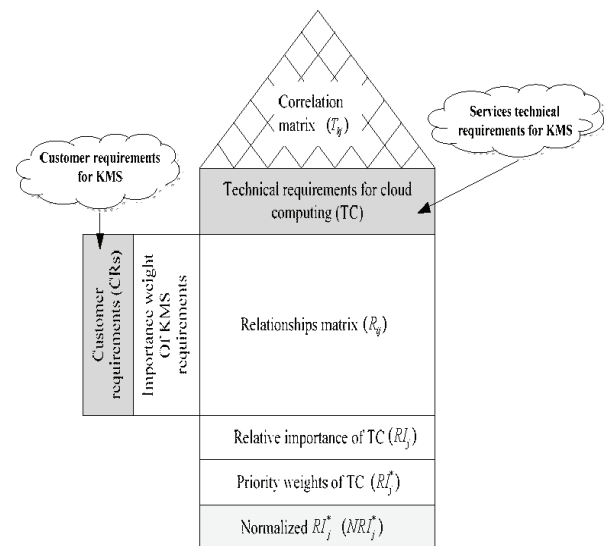


Fig. 3. The AHP-HOQ for the cloud computing selection problems.

The idea of AHP is based on the assumption that a DM is more able to compare two issues than make a decision among many elements<sup>39,40</sup>. Based on AHP method, the voice of customer requirements questionnaire was designed, and survey to DM group and experts.

According to the response from each DM and nine experts, it can calculate the aggregated pairwise relation importance in customer requirements. As a result, the decision matrix, constructed to measure the relative degree of importance for each customer requirements, is shown in equation (4). From AHP, geometric average approach is applied to derive the equation (4) weights. For example, the  $C_1$  (i.e., knowledge creation) weight is calculated as  $(1 \times 5 \times 3 \times 4 \times 6 \times 7)^{1/6} = 3.689$ . Similarly, all other elements of customer requirement weights can be obtained as  $C_2 = 0.681$ ,  $C_3 = 2.289$ ,  $C_4 = 1.165$ ,  $C_5 = 0.357$  and  $C_6 = 0.417$ . Subsequently, sum the weights from  $C_1$  to  $C_6$ , the total weight are 8.599 and the  $C_1$  normalized weight is calculated as  $(3.689/8.599) = 0.429$ . Therefore, the weights of this decision matrix are  $[0.429, 0.079, 0.266, 0.135, 0.042, 0.049]^T$ . To check the level of inconsistency, the following characteristics of the decision matrix were obtained: eigenvalue ( $\lambda_{\max} = 6.412$ ), consistency index (CI) = 0.082 and consistency ratio (CR=CI / RI) = 0.067; where RI is the average random index obtained by different orders of the pairwise comparison matrices. If CR is less than 0.1, the judgments are consistent, and the derived weights can be used. The QFD team then puts the weights into the transformation matrix shown in Fig. 4, the QFD matrix for a cloud computing selection problem.

$$D = \begin{bmatrix} 1 & 5 & 3 & 4 & 6 & 7 \\ 0.200 & 1 & 0.167 & 0.500 & 2 & 3 \\ 0.333 & 6 & 1 & 3 & 4 & 6 \\ 0.250 & 2 & 0.333 & 1 & 5 & 3 \\ 0.167 & 0.500 & 0.250 & 0.200 & 1 & 0.500 \\ 0.143 & 0.333 & 0.167 & 0.333 & 2 & 1 \end{bmatrix} \quad (6)$$

The next step of the QFD team is to rank the four cloud computing service candidates based on the eight

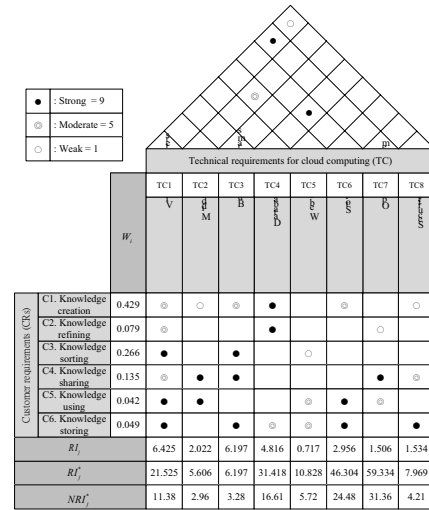


Fig. 4 QFD matrix for a cloud computing selection problem.

conflicting TC (see Table 4). The AHP prioritizes the customer's requirements by assigning a relative degree of importance to each customer requirement. Using AHP questionnaire survey to each decision-making, the eight pairwise comparison matrices are based on the information in each of TC matrices were concluded as matrix 1 to matrix 8. Similarly, following the calculation approach by equation (4), the results of eight matrices' weights are shown in Table 2.

Matrix 1: The "virtual computers" criterion

$$A_1 = \begin{bmatrix} 1 & 0.333 & 5 & 7 \\ 3 & 1 & 5 & 6 \\ 0.2 & 0.2 & 1 & 2 \\ 0.143 & 0.167 & 0.5 & 1 \end{bmatrix}, \quad (7)$$

and the weights of  $A_1$  are calculated as

$$(1 \times 0.333 \times 5 \times 7)^{1/4} = 1.848,$$

$$(3 \times 1 \times 5 \times 6)^{1/4} = 3.080,$$

$$(0.2 \times 0.2 \times 1 \times 2)^{1/4} = 0.532 \text{ and}$$

$$(0.143 \times 0.167 \times 0.5 \times 1)^{1/4} = 0.330, \text{ respectively.}$$

**Table 3.** Overall score of the cloud computing services candidates

Technical requirement	Weight	Importance weight for cloud computing services				CI	CI/RI	Inconsistency (%)
		$S_1$	$S_2$	$S_3$	$S_4$			
1. Virtual computers	11.38	0.319	0.532	0.092	0.057	0.0672	0.0747	7.47
2. Middleware	2.96	0.402	0.213	0.327	0.058	0.0640	0.0711	7.11
3. Business programs	3.28	0.074	0.520	0.105	0.300	0.0760	0.0844	8.44
4. Database	16.61	0.267	0.550	0.054	0.128	0.0722	0.0802	8.02
5. Web servers	5.72	0.319	0.532	0.092	0.057	0.0672	0.0747	7.47
6. Storage devices	24.48	0.514	0.090	0.331	0.065	0.0447	0.0497	4.97
7. Operating system	31.36	0.483	0.086	0.355	0.077	0.0846	0.0940	9.40
8. Security	4.21	0.631	0.173	0.154	0.067	0.0760	0.0844	8.44
Overall score		<b>41.70</b>	<b>26.20</b>	<b>23.65</b>	<b>8.56</b>			

Subsequently, sum the weights (1.848+3.080+0.532+0.330), the total weight are 5.790 and the  $A_1$  normalized weight is calculated as (1.848/5.790, 3.080/5.790, 0.532/5.790 and 0.330/5.790, respectively. Therefore, the weights of this decision Matrix 1 are [0.319, 0.532, 0.029, 0.057]<sup>T</sup>.

Using the same calculation process of Matrix 1, we can obtain the weights of from Matrix 2 to Matrix 8 as follows.

Matrix 2: The “middleware” criterion

$$A_2 = \begin{bmatrix} 1 & 2 & 2 & 4 \\ 0.500 & 1 & 5 & 5 \\ 0.500 & 2 & 1 & 7 \\ 0.250 & 0.200 & 0.143 & 1 \end{bmatrix}, \quad (8)$$

and the weights of  $A_2$  are [0.402, 0.213, 0.327, 0.058]<sup>T</sup>.

Matrix 3: The “business programs” criterion

$$A_3 = \begin{bmatrix} 1 & 0.200 & 0.500 & 0.250 \\ 5 & 1 & 4 & 3 \\ 2 & 0.250 & 1 & 0.200 \\ 4 & 0.333 & 5 & 1 \end{bmatrix} \quad (9)$$

and the weights of  $A_3$  are [0.074, 0.520, 0.105, 0.300]<sup>T</sup>.

Matrix 4: The “database” criterion

$$A_4 = \begin{bmatrix} 1 & 0.333 & 5 & 3 \\ 3 & 1 & 6 & 5 \\ 0.200 & 0.167 & 1 & 0.250 \\ 0.333 & 0.200 & 4 & 1 \end{bmatrix} \quad (10)$$

and the weights of  $A_4$  are [0.267, 0.550, 0.054, 0.128]<sup>T</sup>.

Matrix 5: The “Web servers” criterion

$$A_5 = \begin{bmatrix} 1 & 0.333 & 5 & 7 \\ 3 & 1 & 5 & 6 \\ 0.200 & 0.200 & 1 & 2 \\ 0.143 & 0.200 & 1 & 1 \end{bmatrix} \quad (11)$$

and the weights of  $A_5$  are [0.319, 0.532, 0.029, 0.057]<sup>T</sup>.

Matrix 6: The “storage device” criterion

$$A_6 = \begin{bmatrix} 1 & 5 & 2 & 7 \\ 0.200 & 1 & 0.167 & 2 \\ 0.500 & 6 & 1 & 4 \\ 0.143 & 0.500 & 0.250 & 1 \end{bmatrix} \quad (12)$$

and the weights of  $A_6$  are [0.514, 0.090, 0.331, 0.065]<sup>T</sup>.

Matrix 7: The “operating system” criterion

$$A_7 = \begin{bmatrix} 1 & 5 & 2 & 4 \\ 0.167 & 1 & 0.143 & 2 \\ 0.500 & 7 & 1 & 4 \\ 0.250 & 0.500 & 0.250 & 1 \end{bmatrix} \quad (13)$$

and the weights of  $A_7$  are [0.483, 0.086, 0.355, 0.077]<sup>T</sup>.

Matrix 8: The “security” criterion

$$A_8 = \begin{bmatrix} 1 & 5 & 4 & 7 \\ 0.200 & 1 & 2 & 2 \\ 0.250 & 1 & 1 & 4 \\ 0.143 & 0.500 & 0.250 & 1 \end{bmatrix} \quad (14)$$

and the weights of  $A_8$  are  $[0.631, 0.173, 0.154, 0.067]^T$ .

From the results presented in Table 3,  $S_1 \gg S_2 \gg S_3 \gg S_4$ . It is clear that  $S_1$  has precedence over  $S_2$ , which is more important than  $S_3$  and  $S_4$ . The  $S_1$  cloud computing service has the highest overall score and be select under AHP.

According to the sales record in the last five years, marketing forecast and company KMS selection strategic by HTP, the CEO and top managers of HTP have established five goals as follows:

- (1) The total benefit of KMS application is set between US\$32000 and US\$54000 thousand dollars per month; and the more the better.
- (2) The total software cost of KMS service is set between US\$250 and US\$480 thousand dollars per month; and the less the better.
- (3) The total hardware cost of KMS procurement is set between US\$300 and US\$430 thousand dollars per month; and the less the better.
- (4) For achieving the operation skill level, the training time (weeks) from cloud computing service candidate is set between 3 and 6 weeks; the more the better.
- (5) The selection highest weighted of cloud computing service candidate; and the more the better.

The coefficients of variables in KMS project selection profiles shown in Table 4 represent the data set for each candidate.

The functions and parameters related to HTP's KMS service selection problems using an integrated AHP and MCGP approach, this problem can be formulated as follows:

#### MCGP model

Min  $Z =$

$$(d_1^+ + d_1^- + e_1^+ + e_1^-) + (d_2^+ + d_2^- + e_2^+ + e_2^-) + (d_3^+ + d_3^- + e_3^+ + e_3^-) + (d_4^+ + d_4^- + e_4^+ + e_4^-) + d_5^+ + d_5^- \quad (15)$$

$$\text{s.t. } 32000x_1 + 54000x_2 + 39000x_3 + 45000x_4$$

$$-d_1^+ + d_1^- = y_1 \quad \text{For benefit of KMS service goal} \quad (16)$$

$$y_1 - e_1^+ + e_1^- = 5200 \quad \text{For } |y_1 - g_{1,\max}| \quad (17)$$

$$3400 \leq y_1 \leq 5200 \quad \text{For bound of } y_1 \quad (18)$$

$$480x_1 + 315x_2 + 360x_3 + 250x_4$$

$$-d_2^+ + d_2^- = y_2 \quad \text{For software cost goal} \quad (19)$$

$$y_2 - e_2^+ + e_2^- = 250 \quad \text{For } |y_2 - g_{2,\min}| \quad (20)$$

$$250 \leq y_2 \leq 360 \quad \text{For bound of } y_2 \quad (21)$$

$$430x_1 + 300x_2 + 430x_3 + 370x_4$$

$$-d_3^+ + d_3^- = y_3 \quad \text{For hardware cost goal} \quad (22)$$

$$y_3 - e_3^+ + e_3^- = 300 \quad \text{For } |y_3 - g_{3,\min}| \quad (23)$$

$$300 \leq y_3 \leq 430 \quad \text{For bound of } y_3 \quad (24)$$

$$4x_1 + 6x_2 + 3x_3 + 5x_4$$

$$-d_4^+ + d_4^- = y_4 \quad \text{For training time goal} \quad (25)$$

$$y_4 - e_4^+ + e_4^- = 6 \quad \text{For } |y_4 - g_{4,\max}| \quad (26)$$

$$3 \leq y_4 \leq 6 \quad \text{For bound of } y_4 \quad (27)$$

$$41.70x_1 + 26.20x_2 + 23.65x_3 + 8.56x_4$$

$$-d_5^+ + d_5^- = 1 \quad \text{For maximize candidate weight} \quad (28)$$

$$d_i^+, d_i^- \geq 0, i = 1, 2, \dots, 4, \text{ Deviation from the target} \quad (29)$$

$$e_i^+, e_i^- \geq 0, i = 1, 2, 3. \text{ Deviation from the target} \quad (30)$$

The MCGP model was solved using LINGO software<sup>41</sup>, the optimal solutions obtained  $x_2 = 1$  and  $x_1 = x_3 = x_4 = 0$ . Therefore, based on involvement quantitative measures in the best interest of the HTP, KMS service candidate  $S_2$  should be selected. This is a different result due to the AHP-MCGP method considered qualitative and quantitative selection criteria. Table 5 shows the results for KMS service candidate selection comparisons with AHP and AHP-MCGP methods.

**Table 4.** KMS project towards resource utilization

KMS candidates	Benefit (\$000)	Software cost (\$000)	Hardware cost (\$000)	Training time (weeks)
$x_1 (S_1)$	32000	480	335	4
$x_2 (S_2)$	54000	315	300	6
$x_3 (S_3)$	39000	360	430	3
$x_4 (S_4)$	45000	250	370	5

The MCGP model was solved using LINGO software [41], the optimal solutions obtained  $x_2 = 1$  and  $x_1 = x_3 = x_4 = 0$ . Therefore, based on involvement quantitative measures in the best interest of the HTP, KMS service candidate  $S_2$  should be selected. This is a different result due to the AHP-MCGP method considered qualitative and quantitative selection criteria. Table 5 shows the results for KMS service candidate selection comparisons with AHP and AHP-MCGP methods.

best cloud computing service supplier for a business' KMS. The proposed QFD method facilitates efficient communication between the customers (e.g., KMS service requirements) and suppliers (e.g., KMS technical requirements). The contribution of this study is proposed a practical application case and it will provide a reference formwork for publisher organization or company in cloud computing service selection.

Furthermore, there are three meaningful managerial can be learn by publisher organization or textbook

**Table 5.** Comparison of KMS service selection methods

Methods	Multi-choice aspiration levels	Selection criteria		The best selection
		Qualitative	Quantitative	
AHP (Using weights ranking)	No	Yes	No	$S_1$
AHP+ MCGP (Using LINGO)	Yes	Yes	Yes	$S_2$

## 5. Conclusions and suggestions

New information technology, such as cloud computing services, is a powerful enabler for the success of a business's knowledge management strategy. A cloud computing service can be adopted by a business for its knowledge management via the Internet. Because it involves many factors, therefore selection an IT service supplier for KMS (e.g., textbook information service) is a very important and complex decision-making problem. The link between cloud computing services and KMS is a new concept and how to select a cloud computing service supplier have lacked a formal reference framework. Selecting the right cloud computing service supplier for KMS is a key strategic consideration. To the author's knowledge, no one has applied AHP-QFD method in cloud computing service supplier selection problem for KMS. This paper an integrated AHP-QFD approach, which considers customer requirements and technical requirements for the service, was proposed to select the

publishing company from this case study:

- (1) Cloud computing service will be a new consideration for IT service outsourcing strategy.
- (2) The publishing member would pay higher attention to the new IT application to satisfy customer demands.
- (3) Cloud computing service will be the future trend; how to apply cloud computing to business information service system with the aim of increasing competitiveness would be a key issue.

We believe that cloud computing represents the next generation in information services. Although this case study has demonstrated the usefulness of the proposed approach in developing a business KMS, it may be valuable for a company to use other methods, such as the analytic network process (ANP) or fuzzy techniques for order preference by similarity to ideal solution (TOPSIS) (e.g., Liao and Kao<sup>42</sup>) and matter-element analysis (MEA) (e.g., Zhang et al.<sup>43</sup>) in our future research. The researchers plan to integrate other methods with QFD and multi-segment goal programming (e.g., Liao<sup>44,45</sup>) to enhance cost-effectiveness of KMS. In addition, we will

consider KMS and the transport's competitive advantage or supply quality for transportation organization. Finally, we hope that this research will inspire future studies in transportation problems.

## Appendix A

### List of acronyms

AHP	Analytical hierarchy process
ANP	Analytic network process
CEO	Chief executive officer
CI	Consistency index
CR	Consistency ratio
CRs	Customer requirements
DM	Decision maker
DRs	Design requirements
HOQ	House of quality
IT	Information technology
KMS	Knowledge management systems
HTP	Hwa Tai Publisging
RI	Random index
MCGP	Multi-choice goal programming
MEA	Matter-element analysis
QFD	Quality function development
SWOT	Strengths, weaknesses, opportunities, and threats
TC	Technical requirements for cloud computing
TQM	Total quality management

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