A Cloud-Based Fuzzy Multi-Criteria Decision Support System for Procurement Process in Facility Management

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Abstract—**Procurement in facilities management is a complex process for linking different stakeholders together to form an integrated service, it is a crucial process for identifying the best sources of supplier and best suited contractor in improving the efficiency of resources allocation, maintaining equipment reliability and availability to enhance facilities conditions in order to reduce business risks, attract tenants, increase asset and building value. Hence, a building's Return of Investment (ROI) and payback can be incredibly beneficial by enabling the procurement decision to meet its strategic objectives in an economic, efficient and effective manner. However, in current process, procurement is financially consuming and expensive as it requires high demand of manpower and involves enormous amount of paper work for managing requests, quotations, bid requirements and evaluations. Also, there is lack of quantitative measures by incorporating linguistic selection criteria from domain experts in the procurement selection process for improving competitive advantage. Even though applications of digitalization for conveying information to digital format in streamlining internal process have been considered, competiveness and capabilities assessment of current supply base, quantitative and qualitative data analysis on contractor selection and relevant performance feedback is lacking to support the decision-marking. Therefore, in this paper, a cloud-based Fuzzy multi-criteria decision support system (CFMDS) is proposed for integrating with procurement process for performing award analytics to identify the best suited supplier and contractor. The procurement officer can then formulate a follow up plan based on the recommended results.**

I. Introduction

Procurement is an essential component and is the core function to support building facilities management for sourcing vendors, contractors or integrated supplier which provides all required materials, equipment and services in ensuring the functionality of the building to be continued to operate reliably, modernizing services of building to improve safety that is complied with the latest safety standards and regulations, reducing energy costs by introducing new energy saving opportunities as well as to extend building life and sustainability performance. Procurement is the most critical function in supply chain [1] and is the majority spending of an organization [2]. Most of organizations spend more than 30% of their income dollars on purchasing goods and services [3]. It is even possible that about 20% of an organization's purchases constitute 80% of the total purchase value [4]. Echoing to today's dynamic business environment particular for 24-hours operated business buildings require minimum downtime, cost effectiveness and higher quality services, which lead facilities management and support services form a sizeable and majority portion of spend. Traditionally, procurement is financially consuming and expensive; it focuses to improve the efficiency of paper handling activities only. It requires high demand of manpower and involves enormous amount of paper work for managing requests, quotations, bid requirements and evaluations. Procurement has long been considered as a clerical job, optimization and strategic approaches have not been widely considered. Even though applications of digitalization and e-procurement nowadays for conveying information to digital format in streamlining internal process have been taken place, competiveness and capabilities assessment of current supply base, quantitative and qualitative data analysis on vendors and relevant performance feedback is lacking to support the decision-marking.

However, there are many variations relying on the judgments of decision makers in particular decision support from experienced technical experts is usually required for assisting the evaluation of the technical standards and compliances to building systems. Moreover, conventional analysis requires the selection of arbitrary values in pairwise comparison is insufficient and cannot deal with an expert's experience and knowledge when an uncertainty or a linguistic variable environment exists. Therefore, it is imperative to have strategic approach that could continually improve and re-evaluate the purchasing activities of a company with the goals to lower costs, improve quality and reduce risks by analyzing current spend and supply sources, categorizing suppliers, implementing and executing appropriate strategies so as to determine the best sources of supplier and best suited contractor cost-effectively and cost-efficiently. In this paper, a cloud-based multi-criteria decision support system incorporating with Fuzzy-AHP based assessment and Online Analytical Processing (OLAP) has been developed for improving the efficiency and effectiveness of procurement process.

This paper is divided into six sections. Section 2 reviews the literature including the background of facility management, cloud computing application in OLAP, decision support system and the fuzzy analytic hierarchy process. In Section 3, the research design and methodology of the proposed system are described. Section 4 of the paper introduces a case study in which the strategic procurement evaluation in contractor selection in a property management company is assessed,

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evaluated and discussed. This analysis provides insight on various factors in formulating procurement strategies. Section 5 is the results and discussion from implementing the CFMDS. Finally, the conclusions are drawn in Section 6.

II. Literature Review

A. Faciliity Management

Facility management is defined as the "work undertaken in order to keep, restore or improve every part of a building, its services and surrounds, to a currently accepted standard, and to sustain the utility and value of the building" [5]. It is to ensure that the building and their associated services are in safe conditions, fit for purpose, meet all statutory requirements, maintain the value of physical assets and to carry out work necessary to maintain the quality of the building [6]. According to Freedonia Group Inc., the significance of building maintenance has continued to grow, revenues for building maintenance services in the US market are forecast to advance 4.3% per year to nearly US$176.5 billion in 2017 [7]. Currently, in Hong Kong, the gross value of building maintenance by main contractor in according to the survey results of the Census and Statistics Department (C&S) of the Hong Kong Government has been increasing over the past ten years, about 56.8% from HK$49,390 million in 2007 to HK$77,458 million in 2016 [8]. The works value of building maintenance in year 2016 has been reached about one third of the total sum of construction works in Hong Kong. There were about 40,559 numbers of private buildings in according to the database of private building in Hong Kong of the Home Affairs Department (2017) [9]. In line with the database of mandatory MBIS and MWIS schemes [10], estimated numbers of 30-years old buildings are over 27,000. It is therefore previsied that the facility management market will keep on growing for an increasing in demand to extend the working life of buildings for achieving better sustainability in built environment. However, facility management works are normally dispersed, spreaded over different area of the building and involved various disciplines of service contractors. It is impossible to achieve the goals of optimizing economic effects, quality control and utilize resources simultaneously [11].

Procurement is the most critical function in supply chain [1] and is the majority spending of an organization [2], these give rise to the demand for optimizing saving in procurement process and its importance in measuring business's performance. The driver for procurement by outsourcing or subcontracting is cost saving and it is common for Hong Kong Projects in the considerations of lowering overhead costs, acquiring partner's experience, expertise and equipment as well as to let the company concentrating on his own core competence [12]. The selection of the appropriate contractor or supplier is critical decision-making process that has a great impact to the time, cost and quality of the project especially for capital-intensive construction works [13-15]. Therefore, a strategic scouring and procurement approach in making cost-effective decision is critically essential for enabling the competitive advantage of a company. In order to collect and manage the collected data and knowledge, cloud computing is a promising tool to provide a secure platform to store and analyze the data.

B. E-Procurement

With the rapid growth of the Internet network, traditional paper-based procurement process is revolutionizing to web-electronic-based because of its potential to reduce the total cost of acquisition. E-procurement refers to web-based communication systems for conducting part or all of the purchasing process [16-20]. The emergence of Web-based E-procurement is expected to reduce the order fulfilment cycle time, lower the inventory levels, reduce the administrative cost of procurement, cost of procurement, and enhance the order fulfilment and performance of suppliers [21-22]. The benefit from its implementation over costs reduction arising as a result of 'digitizing' is fewer errors in order transmission [23].

C. Cloud Computing Environement

The size of data sets is growing rapidly due to the emerging development of information technologies and Web-based applications over internet. It causes databased management tools, applications and traditional warehousing solutions having difficulties in scaling up their systems because of the large size of the data as it becomes more and more expensive. The capital expenditure and operational expenditure of computing could be reduced by working in cloud parallel systems running on clusters of commodity servers. Big data become increasingly important as it can be analyzed much quicker and more efficiently. The concept of cloud computing was developed to handle and analyze information on the Internet [24]. The architecture of Cloud Computing environment can be classified into data center, Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) [25]. Cloud computing is a large data base platform "Big Data" and involves a lot of technologies and algorithms. It includes a series of collection, storage, management, processing, analysis, and visualization. By incorporating analysis techniques in the database, useful data and knowledge can be extracted from big data. It gives insight to optimize processes and provides decision-making power by processing and performing analysis to vast amounts of diverse information. In order to handle, analyze and evaluate the collected information for procurement process, artificial intelligence can be applied in the cloud computing environment to select the best sources of supplier and best suited contractor cost-effectively and cost-efficiently.

D. Multi-Criteria Decision Marking

Supplier or subcontractor selection in procurement process is a complex multi-criteria decision process and requires the evaluation of alternative criteria, this is classified as multi-criteria decision analysis or multi-criteria decision making (MCDM) [26]. It can be defined as the combination and optimization of conflicting objectives in terms of cost, technical and associates in supporting the decision makers for identifying the best sources of supplier and best suited contractor. There are several methods have been researched and developed for performing multi-criteria decision-marking include Knowledge-based [27], neural network [28], Analytic

Hierarchy Process [29], Fuzzy Logic [30]. The most extensively used MCDM method is the AHP decision-making aiding method by Saaty in 1980, AHP has been put in applications to different kinds of problems [31-34]. It enables decision makers to deal with complex and unstructured problems in a form of hierarchy for determining the priorities in a systematic manner. However, in real-life decision situation, uncertainly, imprecision and vagueness or fuzziness of experts' opinion is the prominent feature. It is therefore cannot be precisely to obtain information to tackle them with crisp numbers by AHP. In the theory of fuzzy sets, it uses membership functions and the fuzzy numbers to deal with vague or not well-defined information. Fuzzy-AHP method can handle this impreciseness of expert's judgments or opinions efficiently through the application of fuzzy set theory and hierarchical structure analysis could allow more accurate results of the multiple criteria decision-making process.

E. Fuzzy Analytic Hierarchy Process

Fuzzy Analytic Hierarchy Process is a combiner of fuzzy logic and Analytic Hierarchy Process. The Analytic Hierarchy Process (AHP) provides an effective method to deal with complex decision-making and can assist in identifying and weighting criteria [35]. It is a theory of measurement through pair-wise comparisons and derives priorities among all the criteria and sub-criteria within each level of the hierarchy following on the judgements of experts. Finally, the AHP combines the criteria weights and the options scores, a global score for a consequent ranking can then be determined. The higher the weight is, the more important the corresponding criterion is and the higher the score, the better the performance of the option. However, AHP cannot completely reflect the importance of data collected since there are typically multiple conflicting criteria that need to be evaluated in expert's preference [36]. It is difficult to use precise and definite value to present the linguistic judgements as AHP method cannot determine cognitive factors of human thinking. Fuzzy-AHP is the extension of Saaty's theory and many researchers have addressed that Fuzzy-AHP shows the capability for handling imprecise and linguistic thinking under human's judgement efficiently [37].

III. METHODOLOGY

In this paper, a cloud-based fuzzy multi-criteria decision support system (CFMDS) is proposed for integrating with procurement process to select the most suitable supplier or subcontractor. Fig. 1 shows the system architecture of CFMDS which consists of two modules: (i) Cloud-based Online Analytical Processing Data Storage and Management Module, and (ii) Fuzzy-AHP based Performance Assessment Module; this is related to the system setting, computations of Fuzzy-AHP and assessment.

1) Cloud-based Online Analytical Processing Data Storage and Management Module

There is a large amount of data collected which is related to the formulation of a procurement strategy, it consists of the major elements in procurement management and the objectives of evaluating supplier and subcontractors in supporting the decision-making in facility management. Procurement management basically covers the procuring entities, suppliers, contractors, maintenance and engineering expertise, that are used to establish the hierarchy structure and are correlated with each other in facility management and operation. On the other hand, according to a company's specific culture and business objectives, the objectives of procurement strategy development can be affected. There are three directions to consider in the development of a procurement strategy, i.e. technical aspect, performance aspect, and cost aspect. This information provides

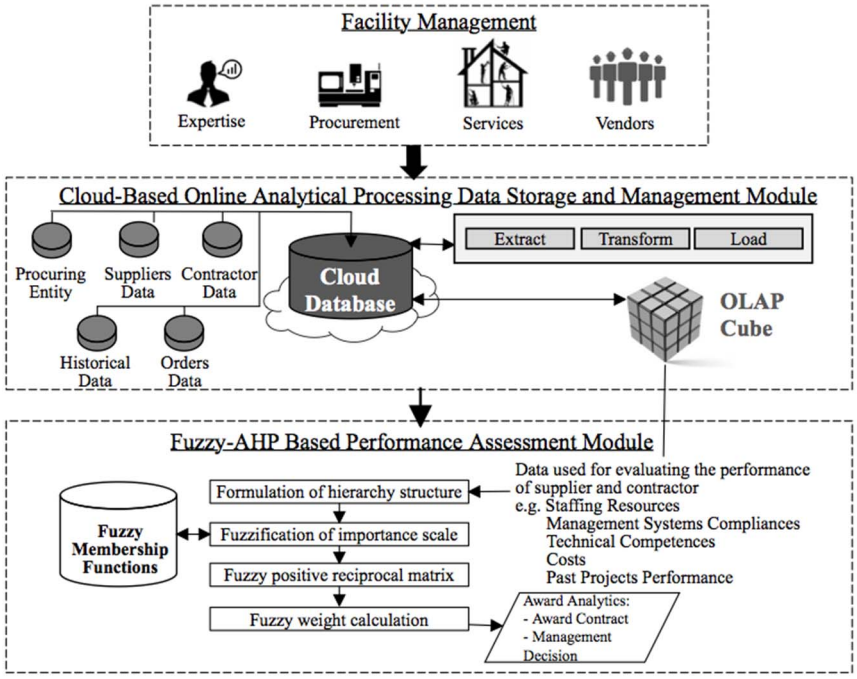

Fig. 1. System Architecture of CFMDS

a clear scope for developing the procurement strategy, and also supports the performance assessment. The procurement and engineering staff can access to the cloud database at any time elsewhere in the world. The information is parsed to JSON or XML data format to develop a cloud-based system through the processing of extract, transform, and load (ETL) to the collected data. Online analytical processing (OLAP) cube is hosted in the cloud platform and it is data structure that overcomes the limitations of relational databases by providing rapid analysis of data. OLAP can display and sum large amounts of data while also providing users with searchable access to any data points. This way, the data can be rolled up, sliced, and diced as needed to handle the widest variety of questions that are relevant to a user's area of interest. Through the development of the cloud database, procurement officer and facility management officer are then able to aggregate and standardize data from various sources and hence improve the data integrity within the facility management and operation. Although the multi-dimensional structure of the OLAP can retrieve summarised value existed in the cube to enable users for increasing the information and understanding on the evaluation and selection of suppliers and subcontractor. However, it does not have the ability to make decisions in the situation when complex multi-criteria, uncertainly or linguistic variable environments need to be considered. Therefore, useful data are passed to the fuzzy-AHP based performance assessment module for evaluating the service quality and performance of suppliers and contractors.

2) Fuzzy-AHP Based Performance Assessment Module

In the fuzzy-AHP based performance Assessment module, the quantitative value of the input parameters for evaluating the performance of suppliers and contractors, such as organization, technical competence, compliances of management system, past project performance are first converted into trapezoidal fuzzy members as a pair-wise comparison scale for representing the judgements by domain experts and deriving the priorities of different selection criteria and attitudes. The goal is to select the most suitable supplier or contractor to suit the needs of facility management and operations. A fuzzy-AHP approach is proposed as the performance assessment module to evaluate and select the most suitable supplier and contractor. Facility management personnel could then formulate a follow-up plan to minimize the risks and costs.

Step 1: Representation of Structure by a Hierarchy Chart

The objective and problem under consideration can be represented in a hierarchy chart. Interrelated decision criterions are at the lower level and a unique objective is at the highest level. Interrelated criterions are defined by technical personnel and experts whose have the whole big picture of the existing problems in mind and responsible for decision-making, various attributes are then used to compare the performance and importance that affect the decision-making process.

Step 2: Define the Fuzzy Weights of Judgements

Uncertainly, Vagueness, impreciseness or fuzziness of experts' judgements are transformed to linguistic scale by applying trapezoidal membership functions. Linguistic importance scale and linguistic performance scale are shown in Table I and Table II.

TABLE I. LINGUSTIC IMPORTANCE SCALE

Linguistic Variable	Explanation	Fuzzy No.
Equally Important (EI)	Activities contribute equally to the objective	1,1,1,1
Low Important (LI)	Judgement slightly inferior to one criterion to another	0,0,2,4
Moderate Important (MI)	Judgement strongly inferior to one criterion to another	2,4,4,6
High Important (VI)	Judgement slightly favour one criterion over another	4,6,6.8
Very High (VHI)	Judgement strongly favour one criterion over another	6,8,10,10

TABLE II. LINGUSTIC PERFORMANCE SCALE

Linguistic Variable	Explanation	Fuzzy No.
Fair (FI)	Performance contribute equally to the objective	1,1,1,1
Weak (WI)	Barely achieves performance standards	0,0,2,4
Good (GI)	Achieves performance standards	2,4,4,6
Very Good (VGI)	Exceeds performance standards	4,6,6.8
Excellent (EXI)	Significantly exceeds performance standards	6,8,10,10

Step 3: Pairwise Comparison between Criterions at each level

The linguistic evaluation of experts' judgements for each criterion is transformed into a pairwise comparison. A positive square pairwise comparison Matrix $\tilde{A}$ is then created, the intensities of importance or performance from activity i to j denoted by components of comparison matrix a_{ij} ($i < j = 1, 2, 3, \ldots n$), where components $a_{ji} = 1/a_{ij}$ are denoted as the reciprocal numbers

Step 4: Consistency of Pairwise Comparison Matrix

Since components of comparison matrix are obtained by comparisons between two elements, consistency is not guaranteed. The Consistency Index (C.I.) is defined as below [35]:

$$\text{C.I.} = \frac{\lambda_A - n}{n-1} \quad (1)$$

Where n is the order of matrix, and λ_A is its maximum eigenvalue. The Consistency Ratio (C.R.) is defined as C.R. = C.I. /R.I., the decision-making can be deemed within acceptable consistency if C.R. < 0.1 and the judgments are considered inconsistent for C.R. ≥ 0.1. The Random Indices are given in Table III.

TABLE III. VALUES OF RANDOM INDICES

n	3	4	5	6	7	8	9	10
R.I.	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Step 5: Calculation of Overall Fuzzy and Defuzzification

The fuzzy weight of each criterion is then defuzzified and converted to crisp scores by the centroid method. With repetition, relative fuzzy weight and normalized weight of each criterion can be formulated. By aggregating the results for each level of hierarchy chart, the overall fuzzy and normalized weights with respect to the ultimate objective could be found.

IV. CASE STUDY

This section covers the company background, problems in the company and implementation of CFMDS in the company.

A. Background and Problems in ABC Company

ABC Company is a property management company that is currently managing a 50-storey commercial building in the Kowloon district in Hong Kong. Their daily jobs involve a variety of administrative tasks, including managing requests, quotations, bid requirements and evaluations, order issuance to awarded suppliers and contractors for handling facility maintenance, supervising building repairs and controlling expenses. Currently, procurement account for facility management is the majority expenditure and procurement activities are handling mainly by paper-based and conversation-based operations. Therefore, there is a need to develop a cost-effective procurement management system that could continually improve and re-evaluate the purchasing activities with the goals to lower costs, improve quality and reduce risks by selecting suitable supplier and contractor for maintaining building facilitates reliably and economically.

B. Implementation of CFMDS

The success of the project execution and the long-term business reputation in facility management depends on the quality of the contractor selected and how well the contractor performs to operation needs of the building. The CFMDS consists of cloud-based data management; structure of the data warehouse is shown in Fig.2. The proposed system is able to reduce subjective knowledge and the output of the Fuzzy-AHP is developed to recommend a best suited vendor in assisting the decision-making process. In this case, the Property Manager is required to select an appropriate one from the three contractors: Contractor "SC1", Contractor "SC2" and Contractor "SC3" for carrying out an improvement works to existing power supply distribution switchboards where were installed for more than 25 years ago, there are no spare parts could be available in the market due to most of the parts have already been obsoleted. The proposed methodology allows experts to rank and access the performance of each contractor. The evaluation process will be based on the hierarchy of criteria that are consulted with facility management personnel and experts. The hierarchy structure can then be built in accordance to the linguistic variables in terms of importance of each criterion. The advantage of fuzzy set theory facilitates the assessment to be made in a linguistic, quantitative and qualitative manner.

Data collection is conducted through interview with the property manager, engineers and technicians whose have the whole big picture of the existing conditions in mind to determine the dominant factors. The five proposed dominant criterions are "Staffing Resources (C1)", "Management Systems Compliances (C2)", "Technical Competences (C3)" , "Costs (C4)" and "Past Projects Performance (C5)", relative weights in linguistic importance and performance scale are provided in Table I and Table II. The criterion of Staffing Resources is key aspect to ensure the contractor can provide adequate supervision and has suitable labour resources available to service the project for ensuring timely completion of each milestone. Management System Compliance refers to the implementation of quality assurance management system and safety assurance management system to ensure the contractor has deployed an active control of quality assurance and safety measurement, also have all required licenses and insurances. Technical competences are related to the contractor whether their managerial staff and workers have appropriate qualifications, trainings and experience that are competent to the specified type of works. Past Projects Performance refer as the reference checks to verify the contractor's reputation for project management, whether the contractor is able to complete past projects on time and any concerns or complaints from past projects. The hierarchy of data structure is shown in Fig. 3. By migrating supplier and contractor data for constructing Azure SQL Database through date migration, file upload, data transform, data staging, data validation and data mapping under the import / export framework (DIXF) and establishing the OLAP cube. The cube is hosted in the cloud platform and can provide rapid analysis of data. OLAP can display and sum large amounts of data while also providing users with searchable access to any data points for delivering decisive insight across data sources.

Procurement and facility management personnel can use the operation functions of OLAP for viewing the details of data systematically and useful data are passed to the fuzzy-AHP based performance assessment module for evaluating the service quality and performance of suppliers and contractors. Maintenance personnel and experts' judgements for each criterion in linguistic terms is transformed into pairwise comparisons and shows in Table IV. This linguistic evaluation

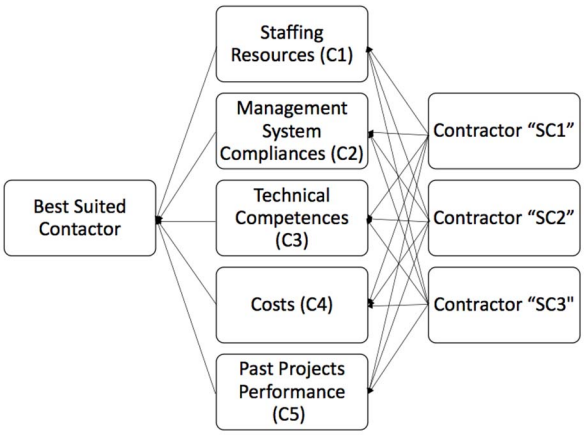

Fig. 2. Hierarchy Structure of CFMDS

is then transformed as the ratios of two fuzzy members into a pairwise comparison matrix. The consistency ratios for each hierarchy are calculated with (1) and Table III. For example, the calculated maximum eigenvalue for upper weights of pairwise comparison matrix for Criteria is $\lambda_A = 5.286$ as shown in Fig.4. Using the formula (1), C.I. is calculated = 0.0715. Dividing it by RI5, C.R. is calculated = 0.064, which is smaller than the threshold of 0.1. With repetition, calculated CRs are ranged from minimum of zero to maximum of 0.064 < 0.1, therefore the judgments on Criteria are considered consistent. The fuzzy weight of the criterion is then defuzzified and converted to crisp scores by the centroid method. Relative fuzzy weight and normalized weight of each criterion can be formulated and shows in Table V.

The same approach is adopted to determine the weights of the contractors with respect to each criterion, linguistic performance scale for contractors is shown in Table VI and transform to pairwise comparison matrixes, the CRs are calculated in accordance with (1) and Table III with values ranged from minimum of zero to maximum of 0.0462 < 0.1, therefore all the judgments are considered consistent in all the cases. By aggregating the results for performance of each contactor, the normalized weights of each contractor and each criterion weights of each contractor are shown in Table VII and the finalized scores are presented in Table VIII. It is revealed that contractor "SC3" has the highest total score. Therefore, it is suggested that this contractor is the best suited one for carrying out the improvement works.

TABLE IV. PAIRWISE IMPORTANCE COMPARISON FOR CRITERIA

Criteria	C1	C2	C3	C4	C5
C1	-	VHI / VI	VHI / MI	VHI / VI	VHI / VI
C2		-	VI / MI	VI / VI	VI / VI
C3			-	MI / VI	MI / VI
C4				-	MI / VI
C5					-

TABLE V. FUZZY AND NORMALIZED WEIGHTS FOR CRITERIA

Criteria	Fuzzy Weight	Normalized Weight
C1	(0.2, 0.272, 0.349, 0.390)	0.303
C2	(0.2, 0.184, 0.172, 0.127)	0.171
C3	(0.2, 0.149, 0.124, 0.078)	0.138
C4	(0.2, 0.191, 0.191, 0.192)	0.193
C5	(0.2, 0.204, 0.164, 0.214)	0.195

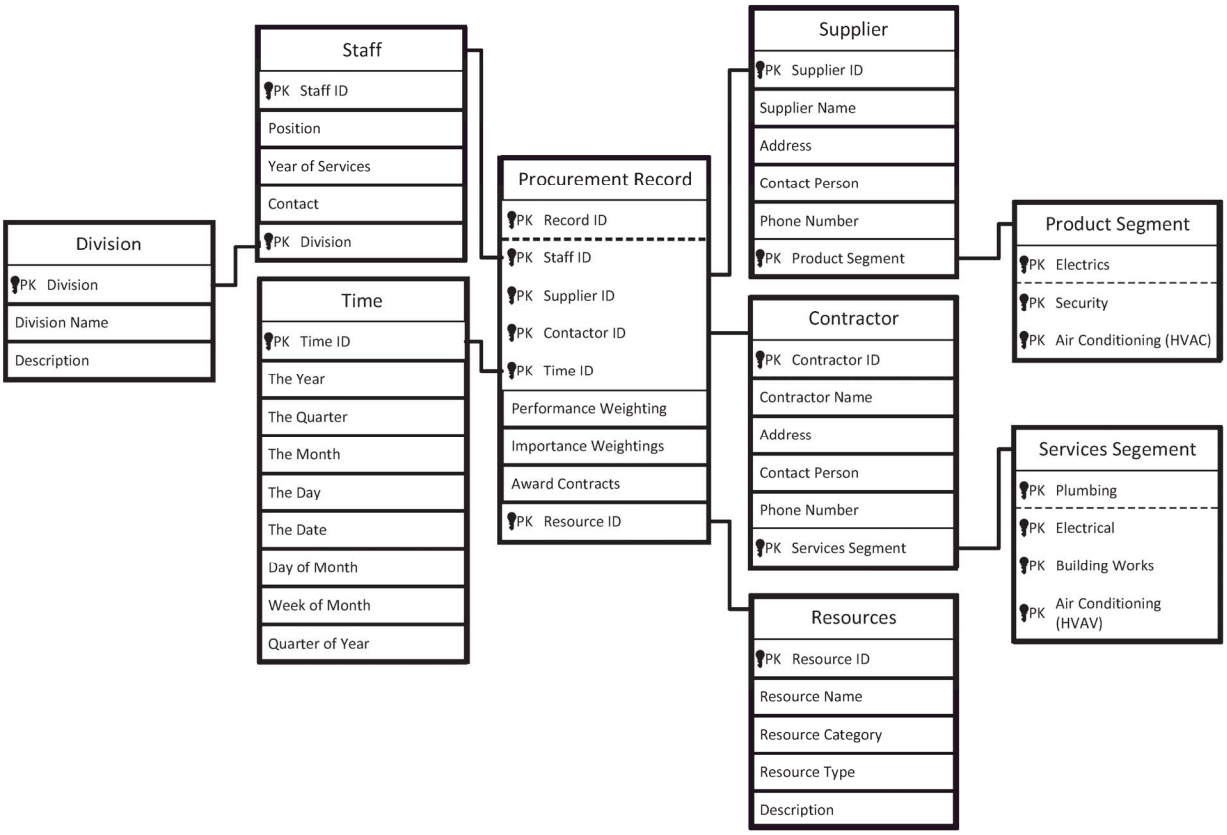

Fig. 3. System Architecture of Database

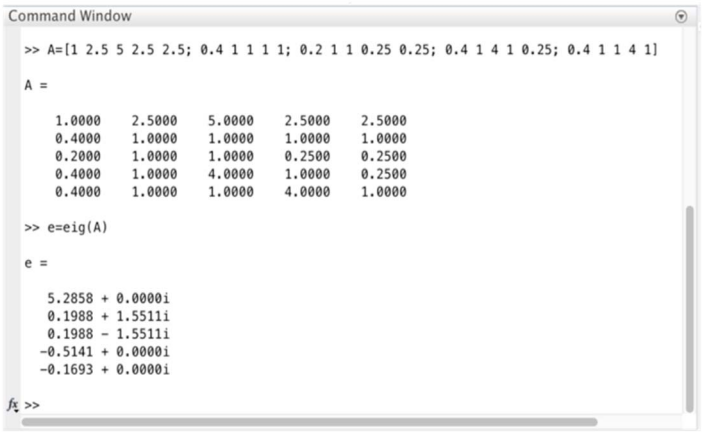

Fig. 4. Calculated Eignvalues for Upper Weights of Pairwsie Comparsion Matrix for Criteria (MATLAB 2017a)

TABLE VI. LINGUISTIC PERFORMANCE SCALE FOR CONTRACTORS

Criteria	SC1	SC2	SC3
C1	WI	GI	GI
C2	GI	GI	VGI
C3	EXI	VGI	GI
C4	VGI	GI	EXI
C5	VGI	EXI	GI

TABLE VII. NORMALIZED WEIGHTS OF EACH CONTRACTOR TO CRITERIA

Contractor	C1	C2	C3	C4	C5
SC1	0.160	0.268	0.458	0.312	0.330
SC2	0.420	0.268	0.330	0.207	0.458
SC3	0.420	0.464	0.213	0.482	0.213

TABLE VIII. AGGREGATED RESULTS FOR EACH CONTRACTOR TO CRITERIA

Criteria	Weights	Scores with respect to related criteria		
		SC1	SC2	SC3
C1	0.303	0.160	0.420	0.420
C2	0.171	0.268	0.268	0.464
C3	0.138	0.458	0.330	0.213
C4	0.193	0.312	0.207	0.482
C5	0.195	0.330	0.458	0.213
Total		0.282	0.348	0.370

V. RESULTS AND DISCUSSION

The results generated from the system can assist ABC Property Management Company in centralizing purchasing with common supply base and optimizing procurement process in an efficiently and cost-effectively manner. Since the costs are factored in the CFMDS structure, the experts and managers are able to control the cost for facility management The results of applying the CFMDS show that it is not only can reduce the subjectivity associated with expert's assessment, but also be used to assist the Property Manager / Engineers in making strategic procurement decisions for performing award analytics to identify the most suitable contractor, e.g. contractor with highest in total score, or if contractor with specified compliance of project is required, contractor with highest score in matching for that performance criterion can be identified. Through enabling the effective use of data form knowledge-based CFMDS, supplier and contractor data are acquired in real-time basis. It facilitates the analysis by reviewing and comparing the historical purchasing record. This also enables an advantage in streamlining negotiations with supplier and contractor for a more competitive offer. Therefore, it is not merely to improve the efficiency and transparency of procurement process in facility management, but also extracts more values by having the best combination of purchase through experts' evaluation, price comparison and award analytics for minimizing all incurred cost, in parallel to identify any potential savings to the whole operation.

VI. CONCLUSIONS

Procurement in facility management is an important process and business performance is greatly affected due to inefficient and inconsistent planning. Therefore, a cloud-based fuzzy multi-criteria decision support system (CFMDS) integrated with OLAP cube is designed for enhancing strategic planning of procurement activities. Through applying data acquisition and management in a real-time basis and the fuzzy analytic hierarchy process, it standardizes the process and ensures the execution of the best purchase aligned to company's strategic objectives, improves visibility and categorization to supplier and contractor characteristics, product and performance master information. It also increases productivity through reducing manual efforts associated with procurement process. The CFMDS has the ability to handle vague and imprecise information in assisting the implementation of strategic planning efficiently and effectively. The Property Manager, procurement officers and maintenance personnel can manage and analysis the data for selecting the most appropriate strategy systematically and thus assist the company to develop competitive advantages.

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