CloudDSS: A Decision Support System for Cloud Service Selection

Umut Şener(✉), Ebru Gökalp, and P. Erhan Eren

Informatics Institute, Middle East Technical University, Ankara, Turkey
{sumut, egokalp, ereren}@metu.edu.tr

Abstract. Cloud computing brings in significant technical advantages and enables companies, especially small and medium size enterprises (SMEs), to eliminate up-front capital expenditures. This is due to the various benefits it provides, such as pay-as-you-go service model, flexibility of services, and on-demand accessibility. The proliferation of cloud services leads to their wide spread use and calls for comprehensive evaluation approaches in order to be able to choose the most suitable alternatives. To this end, existing studies in the literature generally provide solutions incorporating a single method for making such decisions. Therefore, this study proposes a more comprehensive solution in the form of a decision support system named as ClouDSS which employs various Multi-Criteria Decision Making (MCDM) methods with the aim of optimizing cloud service selection decisions. ClouDSS has a default decision model, which can be customized according to enterprise-specific requirements, for evaluating the suitability of cloud services with respect to business needs. After presenting the main components of ClouDSS, the employed cloud service selection process is described in order to highlight the associated tasks, including both objective and subjective evaluation approaches. Furthermore, the applicability of the proposed system is demonstrated through a case study.

Keywords: Economics of cloud computing · Service selection · Decision support system · SME · Multi-Criteria Decision Making

1 Introduction

Enterprises have been adopting Cloud Computing (CC) technologies which provide various opportunities such as scalability, flexibility, and on-demand availability. Indeed, CC provides financial benefits including reduced expenditures for existing applications as well as the availability of innovative IT at an affordable operating cost [1]. Among the main drivers of CC are economics and simplification of software delivery and operation [2]. Due to offered benefits such as competitive advantages, significant cost savings, and enhanced business processes, CC is an attractive proposition for many Small and Medium Size Enterprises (SMEs) [3, 4].

Despite the high rate of IT related advances, the growth of CC adoption by SMEs is relatively slow. Since the CC adoption related concerns are multifaceted, the assessment and selection of a variety of available cloud services with similar functions in the market have become a major challenge [1]. Practitioners in SMEs are faced with

C. Pham et al. (Eds.): GECON 2017, LNCS 10537, pp. 249–261, 2017.
DOI: 10.1007/978-3-319-68066-8_19

complex decisions regarding the selection of most suitable CC services for their business activities. This is because the decision includes a comprehensive analysis of all potential criteria influencing the CC service adoption and utilization. These criteria may vary depending on the business structures of SMEs, and may include improved efficiency, increased availability, fast deployment, and elastic scalability, security concern, privacy issues, and information loss [5–7]. Therefore, the CC service selection for SMEs is a complicated decision-making process, which may benefit from multi criteria decision making (MCDM) methods. Although there has been a growing number of studies regarding CC adoption in SMEs [4, 8, 9], a literature review [10] indicates that only few of them are related to the use of MCDM approaches for CC adoption in SMEs.

The decision support system (DSS) concept is described as *"computer based information systems that provide interactive information support to managers during the decision-making process"* [11]. DSSs are interactive and well-integrated systems which provide managers with data, tools, and models to facilitate semi-structured decisions that are unique, rapidly changing, and not easily specified in advance. The information system architecture is relatively less complex for the case of SMEs, but lacks computer aided decision-making capability. Therefore, the development of computerized decision support for SMEs will contribute to their innovation and prosperity [12].

The aim of this study is to analyze existing work related to cloud service selection decisions in SMEs and to develop a DSS providing a collection of MCDM methods for supporting such decisions. Accordingly, the literature is reviewed systematically to identify studies related to the cloud service selection approaches in SMEs. Then, by analyzing the existing studies, and considering the strengths and weaknesses of them, a DSS named as ClouDSS is proposed. The aim of ClouDSS is to provide a comprehensive approach for assessing cloud service alternatives in order to find the best selection for a given company maximizing the economic benefits of CC technologies.

The remainder of the paper is structured as follows: Sect. 2 provides background information which covers economic benefits of cloud computing for SMEs, a brief description of MCDM methods for cloud service selection, and a systematic literature review of existing proposed DSSs for cloud service selection decision of SMEs. Section 3 presents the components of ClouDSS together with the description of the cloud service selection process. Consequently, a case study that demonstrates the applicability of ClouDSS is presented in Sect. 4, followed by the conclusion of the study.

2 Literature Review

2.1 Economic Benefits of Cloud Computing for SMEs

CC provides the capability to provision on-demand services at a cheaper cost than on-premises alternatives, with reduced complexity, improved scalability, and broader availability. In CC, various services such as computing, storage, and software are available and accessed over the internet.

SMEs have a significant role in terms of supporting national economies. Because small companies have flexible organizational structures which are easily adaptable to new economic conditions or market trends. Although SMEs are capable of creating innovation, their technical capacities constitute a barrier regarding opportunities and profits resulting from economies of scale obtained by large companies [13]. In addition, SMEs have limited financial capabilities, and new expenditures may cause fatal results in business, therefore they try to carry out cost-effective hardware and software investments. CC addresses these issues and provides on-demand and flexible solutions for SMEs, at lower cost levels, thereby reducing potential risks of investments as well as boosting productivity and creativity in businesses.

The economic benefits of CC for SMEs are identified as follows [14]: strategic flexibility (the ability of quick deployment for entering a new market), reduced cost (no up-front and maintenance costs due to pay-per-use), software availability (reduced or no licensing fees), scalability (practically endless resources and automatic scaling based on changing demand), skills and staffing (reduced need for highly-skilled personnel), energy efficiency (reduced utility cost), and system redundancy (data recovery for better action plan in case of system failure). The quick deployment ability of cloud services and reduced Total Cost of Ownership of cloud solutions such as SaaS seem to be more appropriate for SMEs than large organizations [15]. Accordingly, SMEs are in need of selecting and deploying CC solutions based on their specific business requirements.

2.2 Cloud Service Selection by Using MCDM

CC service selection is a complicated decision-making process requiring the use of MCDM approach for identifying the most suitable cloud services among available alternatives [16–18]. As stated in [19], MCDM methods are commonly applied to study complex problems, since they provide a well-structured approach in the operations research domain, and their efficiency is proven in solving complicated and multi-dimensional decision making problems [16]. MCDM includes a set of methods for making comparisons, prioritizing multiple alternatives, and selecting the best-fit choice. Among these methods which include Min-Max, Max-Min, ELECTRE, PROMETHEE, TOPSIS, Compromise Programming, Analytic Hierarchy Process (AHP), Fuzzy AHP, Data Envelopment Analysis (DEA), and Goal Programming, the most widely used one is AHP. It is also quite suitable for cloud service selection decisions [17].

2.3 DSSs Developed for Cloud Service Selection Decision

A systematic literature review conducted by following the method given in Kitchenham [20] is presented in this section. DSSs developed for cloud service selection for SMEs is selected as the research topic and the starting point of the search. The search query is defined as {{“decision” OR “decision-making” OR “DSS” OR “decision support system” OR “Service Selection”} AND “cloud”}. Web of Science (www.webofknowledge.com) and Aisel (aisel.aisnet.org) are selected as databases for the search. In Web of Science, 36 papers are collected, while in Aisel only 33 papers are identified. First of all, SSCI, SCI, and AIS index journals, and conference proceedings, series, meetings, and reviews are selected among the resulting papers. Before reading papers fully, keywords, titles, and abstracts of the studies are checked to assess whether they are related to the research topic. Then, the publication date is selected as between 2000 and 2017. A significant portion of the collected studies is related to the decision of cloud services adoption. They mainly investigate the identification of significant decision criteria instead of proposing a DSS. After this elimination, only eight studies remain and they propose a DSS solution which is based on a single model such as AHP, Fuzzy AHP, and DEA:

- The service selection based on user feedback [21] is proposed as a decision model for cloud selection. However, this model covers the subjective assessment of customers and the assessment of third-party organization. Therefore, this model appears to be inconvenient for SMEs.
- Karim et al. [22] propose an AHP-based decision model for cloud service selection.
- Wilson et al. [23], Godse and Mulik [24], Garg et al. [17] propose a DSS based on AHP ranking. But it does not provide additional assessment methods.
- Whaiduzzaman et al. [16] investigate the available MCDM methods. But, they do not present a decision model or DSS.
- Rehman et al. [25] propose a scenario based MCDM for IaaS selection and compare the results of 7 MCDM methods. However, they utilize matlab functions and usage of the model requires domain knowledge, which can be difficult for SMEs to use.
- Eisa et al. [26] investigate the trends in cloud service selection. They present different online assessment tools such as RightCloudz, Intel Cloud Finder, and Cloudorado. They give a comparison of these tools in terms of their capabilities. MCDM methods are not directly incorporated into their proposed solution.

As a result of the systematic literature review, it can be concluded that there is a limited number of studies proposing DSS for cloud service selection. The analysis of existing studies reveals that they provide solutions utilizing a maximum of two decision models and their structures are not customizable according to enterprise specific requirements. Therefore, in order to provide a more comprehensive solution, this study proposes a customizable DSS for selecting the most suitable cloud services. The system is intended to be also accessible for users with limited domain knowledge regarding CC and decision making approaches. The proposed solution is described next.

3 Development of ClouDSS

The system architecture of ClouDSS comprises three main components of a typical DSS: Data Management, Model Management, and Knowledge Management, as shown in Fig. 1. The proposed ClouDSS is designed as a DSS for cloud service selection process which contains a set of semi-structured decisions requiring individual judgment. It focuses on determining the best cloud service alternative based on both objective and subjective evaluation by using MCDM methods including AHP, Fuzzy AHP, linear optimization, goal programming, etc. The unique aspect of ClouDSS is that it provides various techniques within a single system, and Decision Makers (DMs) can access the system over the internet for making cloud service selection decisions efficiently and comprehensively.

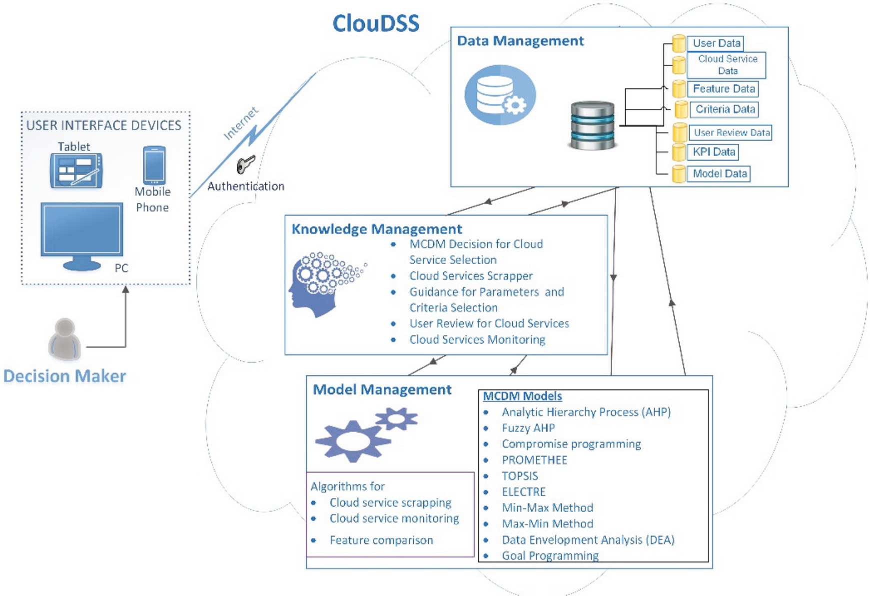

Fig. 1. System architecture of ClouDSS.

3.1 Identification of the Criteria Set for MCDM

The criteria set for adopting a cloud-based enterprise solution has already been identified in our earlier study [27], based on an extensive literature search. In that study, the factors are ranked by employing the AHP method with 20 experts. Based on these results, the highest ranking factors are chosen as the assessment criteria set to be used in ClouDSS (Table 1). Each criterion consists of several attributes that enable DMs to evaluate cloud service alternatives. While the default assessment criteria set consists of five main items including functionality, security & privacy, performance, usability and economic value, additional criteria can be chosen from an extended collection available in ClouDSS.

3.2 Cloud Service Selection Process in ClouDSS

The cloud service selection process and the interrelated set of tasks performed in conjunction with the ClouDSS modules are shown in Fig. 1. The DM accesses ClouDSS after registering and entering the company information such as company size, sector, number of employees, and business structure. After the user is authenticated successfully, the DM selects the type of cloud service, such as Enterprise Information Systems, Enterprise Content Management Systems. The DM can make an objective evaluation by obtaining a feature comparison table for the cloud service alternatives, including objective parameters such as languages provided, hourly pay-as-you-go (yes/no), and SLA level. The DM can also make a subjective evaluation, which means finding the best-fit cloud service alternative by weighing multiple criteria based on his

Table 1. Default assessment criteria set of ClouDSS.

Criteria ID	Assessment criteria	Attributes
AC1	Functionality	Operations and functions set
		Requirement set (memory, CPU, bandwidth)
		Fitness for business purposes
		Data migration and export capabilities
		Business partners' requirements
AC2	Security & privacy	Conformance (legal requirements/standards)
		Reputation (trust toward providers)
		Enterprise specific requirements (encrypted data storage, enhanced security level, PII controls)
		Disaster recoverability
		Ease of monitoring
AC3	Performance	System uptime
		Reliability
		Response time
		Elasticity
AC4	Usability	User-friendly interface
		Ease of use
AC5	Economic value	Price of the product
		Additional operating cost of the product
		Cost of the downtime
		Total cost of ownership (i.e. implementation cost, personnel training cost, licensing fees, etc.)

intuition, judgement, and experience regarding cloud services. If the DM wants to make an objective comparison, he selects the set of features in order to compare the service alternatives to be shown in the comparison table. He also selects a suitable user profile for user reviews matching his own requirements, such as user experience, user review rating, and company size the user works at, and the system displays the reviews. As a result, he obtains the feature comparison table which is in a matrix form showing features versus service alternatives. Reviews of other users are also shown at the end of the table for each cloud service. Once the DM makes the cloud service selection decision based on this table, the option of making additional subjective evaluation before making the final decision is also offered to the DM. If he selects this option, MCDM is performed after the selection of model (the default model is AHP), criteria from the criteria set (the default criteria are functionality, security &privacy, performance, usability, and economic value), and service alternatives from the cloud services set. Then, the system requests the user to perform a pair-wise comparison of the selected criteria followed by a comparison of alternatives for each selected criteria. For example, if the best-fit solution is to be chosen among seven alternatives by using the default criteria set containing the five criteria, six pairwise comparison matrices are requested to be filled by the DM (one for pair-wise comparison of criteria and five for pair-wise comparison of alternatives for each criteria). Upon completion of comparisons, ClouDSS displays the results report including the scores for each alternative and offers to perform additional assessments by using different models. If the DM selects an additional assessment, available models are displayed for selection. After selecting the additional model, the assessment is conducted and the resulting report is obtained. As a result, the process is concluded by making the cloud service selection decision. ClouDSS consists of five modules as described below.

MCDM for Cloud Service Selection: This module includes algorithms implementing MCDM Models such as AHP, Fuzzy AHP, DEA and Goal-Programming to provide optimized decision making.

Cloud Services Information Fetcher: This module includes APIs developed for extracting up-to-date information about cloud services by constantly checking their provider's websites to find out if there is any new information. The collected data is stored as cloud services data.

Guidance for Parameters and Criteria Selection: This module is responsible for providing assistance to DMs with specifying parameters used for objective evaluation and criteria for subjective evaluation. This module also represents parameters and criteria in a uniform way so that users with little knowledge about cloud technologies can easily understand and specify their requirements.

User Review for Cloud Services: This module aims to manage user review data related to cloud services. IT experts or other DMs using the services provide reviews for cloud services, which are rated by other DMs based on usefulness and correctness.

Cloud Services Monitoring: Some quantitative Key Performance Indicator (KPI) values regarding performance and reliability of cloud services, such as response time and system up-time, are obtained, monitored and managed by this module which regularly checks cloud providers. The real-time values obtained periodically for this kind of KPIs are stored as KPI data. The DM can select the time interval in which the values are collected. ClouDSS gives real-life measures for these KPIs in order to increase the decision quality. However, for some cloud services, it is not possible to monitor them as they may not have interfaces for monitoring purposes.

4 Case Study

The applicability of ClouDSS is presented by employing a usage scenario in this section. The SMEs need to assess the different aspects of the alternative cloud solutions before implementing; therefore they need a set of methods in order to evaluate the different aspect of the alternatives and to select the best-fit solution among them.

A small company considers implementing a cloud-based Enterprise Content Management (ECM) solution. This decision is made by following the subjective evaluation path described in Fig. 2. Six Decision Makers (DMs) in a given SME try to determine the best alternative among three cloud service alternatives X, Y, and Z, with respect to the requirement set provided in Table 1. Decision makers employ pairwise

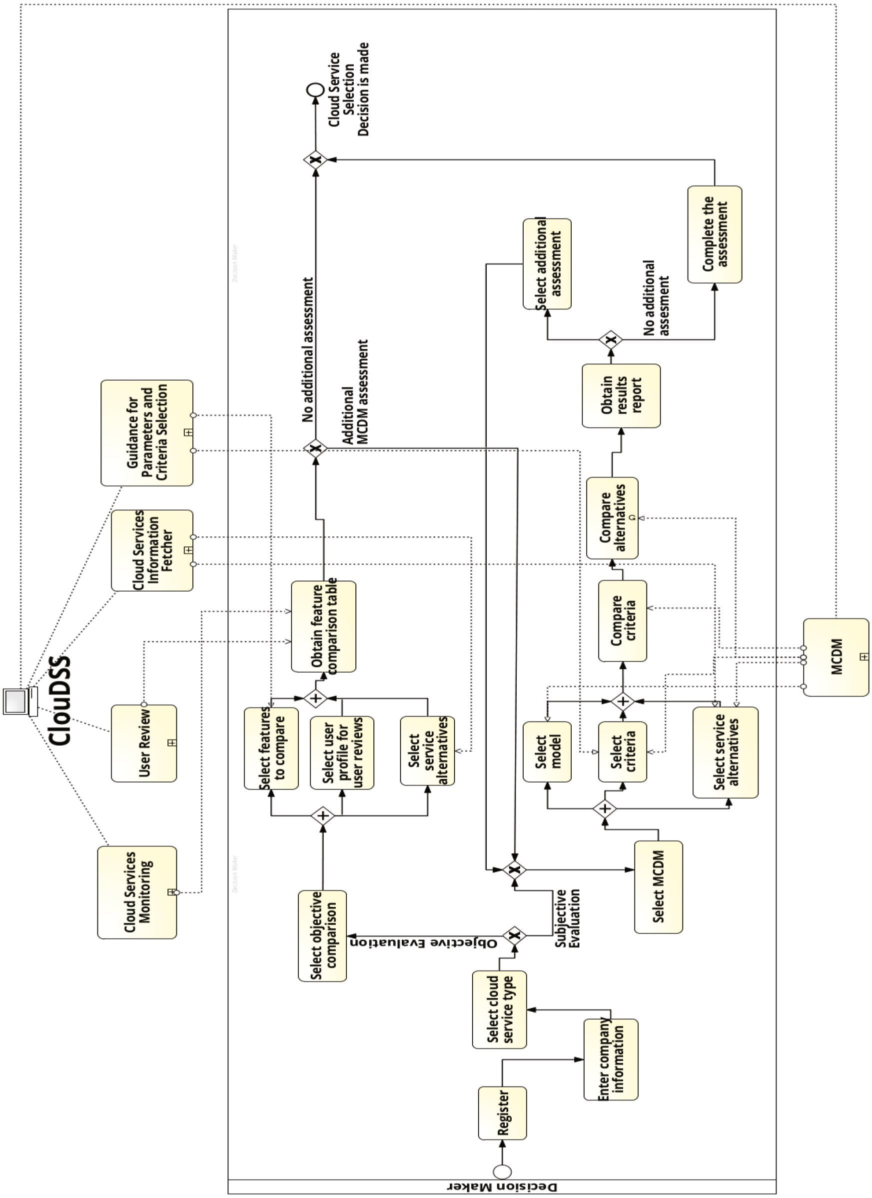

Fig. 2. Cloud service selection process in ClouDSS.

Table 2. The weights of the products based on each criterion.

	AC1	AC2	AC3	AC4	AC5	Overall	Priority
Alternative X	0.36	0.53	0.47	0.37	0.37	0.42	1
Alternative Y	0.35	0.32	0.22	0.20	0.39	0.30	2
Alternative Z	0.29	0.14	0.31	0.43	0.25	0.28	3

comparisons of the AHP methodology to obtain the following: (i) Prioritize the assessment criteria independently, (ii) Prioritize the feasible products independently, (iii) Merge the results of the prioritization to identify the best solution.

The default decision model in ClouDSS is AHP. The decision criteria together with their descriptions are provided by the ClouDSS user interface. If the company has additional requirements apart from the criteria in the default decision model, the decision model can be enhanced by selecting those items from the criteria pool in ClouDSS. After finalizing the decision criteria, the ClouDSS construct judgment matrix is formed based on the AHP method.

The judgment matrix consists of the pairs that the decision makers compare. In this case, six experts compare each item of the comparison pairs to each other, and express their individual rankings for the comparison by using Saaty's Scale [28]. This scale allows the decision makers to convert their linguistic judgment into a numerical measure which represents the relative importance of items in each pair. The scale is from "1", which represents "equally important", to "9" which represents "extremely important".

ClouDSS checks the consistency of each judgment matrix in order to prevent inconsistent judgments of the experts, and once the consistency ratio is calculated as over 10%, a notification is sent to the corresponding user to revise his judgment. After the consistency check, the weight of each criterion is determined. The resulting weights obtained by combining the comparison results of six DMs are given in Table 2. According to the AHP ranking, the highest weight is assigned to X. But the weights of Y and Z are very close to each other. Therefore, the company may prefer to conduct an additional analysis such as DEA, in order to evaluate them, as described next.

The DM investigates the most cost-effective product among the three different cloud-based enterprise solutions given above, and can employ Input-oriented DEA decision model to select the best alternative. That means, it is investigated whether the selected product can still increase its output (i.e., net income, etc.) or decrease its input when compared to the "ideal" cloud product (Table 3).

- Input 1: Amount of Subscription Payment per Year
- Input 2: Number of IT Personnel Hired

Table 3. The input and output of the DEA model.

Cloud alternatives	Input 1 (million $)	Input 2	Output 1 (thousand)	Output 2 (thousand $)	Output 3
Alternative X	2	50	10	100	24
Alternative Y	1.6	44	8	80	16
Alternative Z	1.2	30	6	90	12

- Output 1: Average Number of Customers of the Enterprise
- Output 2: Expected Net Income from Investment
- Output 3: Expected Number of Business Partnership

According to the given inputs and outputs, for calculation efficiency of the Alternative X, the following linear optimization model is constructed.

Linear Optimization Model for Alternative X efficiency:

$$\text{Minimize}\,\theta;\ \text{minimize input resources} \tag{1}$$

Constraints:

$$2\lambda_{A1} + 1.6\lambda_{A2} + 1.2\lambda_{A3} < = 2^{*}\theta \tag{2}$$

$$50\lambda_{A1} + 44\lambda_{A2} + 30\lambda_{A3} < = 50^{*}\theta \tag{3}$$

$$10\lambda_{A1} + 8\lambda_{A2} + 6\lambda_{A3} > = 10 \tag{4}$$

$$100\lambda_{A1} + 80\lambda_{A2} + 90\lambda_{A3} > = 100 \tag{5}$$

$$24\lambda_{A1} + 16\lambda_{A2} + 12\lambda_{A3} > = 24 \tag{6}$$

$$\lambda_{A1} + \lambda_{A2} + \lambda_{A3} = 1 \tag{7}$$

$$\lambda_{A1}, \lambda_{A2}, \lambda_{A3} > = 0 \tag{8}$$

Once this model is solved for Alternative X, $\lambda_{A1} = 1$, $\lambda_{A2} = 0$, $\lambda_{A3} = 0$, and; the efficiency coefficient of Alternative X is calculated as “1”, which means Alternative X is found as the efficient product. Similarly, each product efficiency can be calculated by the DEA method.

As a result, Alternative X has the highest rank among others in AHP and it is also found as efficient according to DEA. Therefore, the decision to choose Alternative X, as suggested by AHP is further verified by DEA as an efficient selection.

5 Conclusion

CC provides significant benefits to SMEs both financially and technically. There are various aspects of CC which are important for its adoption. Accordingly, the selection of suitable cloud services turns into a complex decision problem requiring a comprehensive approach for making an optimal decision. Furthermore, each SME may be operating under a unique set of circumstances which makes this decision even more difficult. Therefore, a DSS that is capable of collecting relevant data as well as providing a set of suitable methods becomes important in helping SMEs with cloud service selection decisions. To this end, this study proposes ClouDSS which is a DSS for cloud service selections.

The conducted systematic literature review reveals that there is a limited number of studies proposing DSS for cloud service selection. Upon analyzing them, the system architecture for ClouDSS is constructed in order to provide a more comprehensive solution. Its system architecture containing data, model and knowledge management components is described. Furthermore, the cloud service selection process by using ClouDSS is presented in order to delineate the set of corresponding tasks. The applicability of the proposed system is demonstrated by providing a case study.

ClouDSS provides a set of assessment methods within a single system without the need of expertise or knowledge in the domain of cloud technologies and decision making approaches. The main contribution of the study is that it proposes a comprehensive DSS while a limited number of existing studies provides solutions utilizing a maximum of two decision models. ClouDSS offers both objective and subjective evaluation approaches for cloud service selection decision. For subjective evaluation, 10 MCDM methods are available to support decisions for identifying the best alternatives according to enterprise-specific requirements. Another significant contribution is that it provides customization of criteria for subjective evaluation and parameters for objective evaluation, as well as the capabilities for searching and filtering of cloud service alternatives and user reviews. Furthermore, it collects real-life measurements for quantitative KPIs and up-to-date service information in order to increase the decision quality. Finally, it also provides guidance to DMs for specifying parameters and criteria through easy to understand representations. While ClouDSS has been designed by considering the needs of SMEs, the solution is suitable for use in large enterprises as well.

As part of future work, additional case studies are planned in order to further assess the applicability of ClouDSS. Furthermore, its usability will be investigated by conducting System Usability Scale (SUS) tests with DMs who are planning to adopt a cloud service.

References

1. Sultan, N.A.: Reaching for the "cloud": how SMEs can manage. Int. J. Inf. Manage. **31**, 272–278 (2011)
2. Erdogmus, H.: Cloud computing: does Nirvana hide behind the Nebula? IEEE Softw. **26**, 4–6 (2009)
3. Dillon, S., Vossen, G.: SaaS Cloud computing in small and medium enterprises: a comparison between Germany and New Zealand. Int. J. Inf. Technol. Commun. Converg. **3**, 1–16 (2009)
4. Carcary, M., Doherty, E., Conway, G., McLaughlin, S.: Cloud computing adoption readiness and benefit realization in Irish SMEs—an exploratory study. Inf. Syst. Manag. **31**, 313–327 (2014)
5. Dutta, A., Peng, G.C.A., Choudhary, A.: Risks in enterprise cloud computing: the perspective of IT experts. J. Comput. Inf. Syst. **53**, 39–48 (2013)
6. Tse, D.W.K., Chen, D., Liu, Q., Wang, F., Wei, Z.: Emerging issues in cloud storage security: encryption, key management, data redundancy, trust mechanism. In: Wang, L.S.-L., June, J.J., Lee, C.-H., Okuhara, K., Yang, H.-C. (eds.) MISNC 2014. CCIS, vol. 473, pp. 297–310. Springer, Heidelberg (2014). doi:10.1007/978-3-662-45071-0_24
7. Wu, W.-W., Lan, L.W., Lee, Y.-T.: Factors hindering acceptance of using cloud services in university: a case study. Electron. Libr. **31**, 84–98 (2013)

8. El-Gazzar, R.F.: A literature review on cloud computing adoption issues in enterprises. In: Bergvall-Kåreborn, B., Nielsen, P.A. (eds.) TDIT 2014. IAICT, vol. 429, pp. 214–242. Springer, Heidelberg (2014). doi:10.1007/978-3-662-43459-8_14
9. Oliveira, T., Thomas, M., Espadanal, M.: Assessing the determinants of cloud computing adoption: an analysis of the manufacturing and services sectors. Inf. Manag. **51**, 497–510 (2014)
10. Yang, H., Tate, M.: A descriptive literature review and classification of cloud computing research. Commun. Assoc. Inf. Syst. **31**, 35–60 (2012)
11. O'Brien, J.A., Marakas, G.: Introduction to Information Systems. McGraw-Hill, Inc., New York (2005)
12. Szabo, S., Ferencz, V., Pucihar, A.: Trust, Innovation and Prosperity. Qual. Innov. Prosper. **17**, 1–8 (2013)
13. Al-Isma'ili, S., Li, M., Shen, J., He, Q.: Cloud computing adoption decision modelling for SMEs: a conjoint analysis. Int. J. Web Grid Serv. **12**, 296 (2016)
14. Talukder, A.K., Zimmerman, L., Prahalad, H.A.: Cloud economics: principles, costs, and benefits. In: Antonopoulos, N., Gillam, L. (eds.) Cloud Computing. Computer Communications and Networks, pp. 343–360. Springer, London (2010). doi:10.1007/978-1-84996-241-4_20
15. Seethamraju, R.: Adoption of software as a service (SaaS) enterprise resource planning (ERP) systems in small and medium sized enterprises (SMEs). Inf. Syst. Front. **17**, 475–492 (2015)
16. Whaiduzzaman, M., Gani, A., Anuar, N.B., Shiraz, M., Haque, M.N., Haque, I.T.: Cloud service selection using multicriteria decision analysis. Sci. World J. **2014** (2014)
17. Garg, S.K., Versteeg, S., Buyya, R.: SMICloud: a framework for comparing and ranking cloud services. In: 2011 Proceedings of the 4th IEEE International Conference on Utility and Cloud Computing, UCC 2011, pp. 210–218 (2011)
18. Lee, S., Seo, K.-K.: A hybrid multi-criteria decision-making model for a cloud service selection problem using BSC, fuzzy Delphi method and fuzzy AHP. Wirel. Pers. Commun. **86**, 57–75 (2016)
19. Dyer, J.: Multiple criteria decision analysis: state of the art surveys. Int. Ser. Oper. Res. Manag. Sci. **78**, 265–292 (2005)
20. Kitchenham, B.: Procedures for performing systematic reviews. vol. 33, p. 28. Keele University, Keele (2004)
21. Qu, L., Wang, Y., Orgun, M.: A: cloud service selection based on the aggregation of user feedback and quantitative performance assessment. In: 2013 IEEE International Conference on Services Computing, pp. 152–159 (2013)
22. Karim, R., Ding, C., Miri, A.: An end-to-end QoS mapping approach for cloud service selection. In: Proceedings of the 2013 IEEE Ninth World Congress on Services, pp. 341–348 (2013)
23. Wilson, B.M.R., Khazaei, B., Hirsch, L.: Towards a cloud migration decision support system for small and medium enterprises in Tamil Nadu. In: CINTI 2016 - Proceedings of the IEEE 17th International Symposium on Computational Intelligence and Informatics, pp. 341–346 (2017)
24. Godse, M., Mulik, S.: An approach for selecting Software-as-a-Service (SaaS) product. In: CLOUD 2009 - IEEE International Conference on Cloud Computing, pp. 155–158 (2009)
25. Rehman, Z.U., Hussain, O.K., Hussain, F.K.: Iaas cloud selection using MCDM methods. In: Proceedings of the 2012 IEEE Ninth International Conference on e-Business Engineering, ICEBE 2012, pp. 246–251 (2012)

26. Eisa, M., Younas, M., Basu, K., Zhu, H.: Trends and directions in cloud service selection. In: Proceedings - 2016 IEEE Symposium on Service-Oriented System Engineering, SOSE 2016, pp. 423–432 (2016)
27. Şener, U., Gökalp, E., Eren, P.Erhan: Cloud-based enterprise information systems: determinants of adoption in the context of organizations. In: Dregvaite, G., Damasevicius, R. (eds.) ICIST 2016. CCIS, vol. 639, pp. 53–66. Springer, Cham (2016). doi:10.1007/978-3-319-46254-7_5
28. Saaty, T.L.: The analytical hierarchy process, planning, priority. In: Resource Allocation. RWS Publications, USA (1980)