

A comparative analysis of cloud computing services using multicriteria decision analysis methodologies

Jason Papathanasiou

Department of Marketing and Operations Management,
University of Macedonia,
49 Ag. Dimitriou Str., Edessa, 58200, Greece
E-mail: jasonp@uom.edu.gr

Vassilis Kostoglou

Department of Informatics,
Alexander Technological Educational Institute of Thessaloniki,
P.O. Box 141, Thessaloniki, 57400, Greece
E-mail: vkostogl@it.teithe.gr

Dimitris Petkos

Department of Informatics,
Alexander Technological Educational Institute of Thessaloniki,
P.O. Box 141, Thessaloniki, 57400, Greece
E-mail: dpetkos@it.teithe.gr

ABSTRACT

Cloud computing is changing rapidly the way users perceive the use of computer functions and resources as well as the development of more complex business models. A lot of new issues emerged by this ongoing trend, especially by privacy advocates as regards to the way cloud services providers control totally the communication and data exchanged between them and the users. The security status of the stored data offers another reason for concern, because as this new model is gaining popularity rapidly, so does the threat level increases. Cloud computing is however generally considered a reliable way to add features to the existing technical capabilities and increase business capacity on the fly without on the same time making costly new investments in more modern IT infrastructures. It also encompasses subscription-based or pay-per-use services, but at the same time offers an extensive variety of free services as well. This paper focuses on the users' perspectives towards the 11 most popular free services providers, chosen after a thorough literature review. A questionnaire survey was conducted mainly among the IT academic staffs of the Alexander Technological Educational Institute of Thessaloniki, Greece, who are specialized users, in order to determine the cloud computing provider selection criteria as well as the analytical relationships among these criteria. Goal programming techniques assessed the weights of the selected criteria in order to implement the AHP and PROMETHEE multi-criteria methodologies. The results provided an opportunity to gain insights on users' demands and expectations and evaluate the level of trust towards these new services. The usefulness and applicability of cloud computing in the modern educational procedure are also evaluated. Moreover, interesting relevant issues for further research are discussed and suggested.

Keywords

Multicriteria decision making; cloud computing; AHP; PROMETHEE; goal programming.

Biographical notes: Jason Papathanasiou is full-time lecturer at the department of Marketing and Operations Management, University of Macedonia, Greece. He holds a Ph.D. in Operational Research and Informatics and a degree in Physics, both from the Aristotle University of Thessaloniki. He has worked for a number of years at the Alexander Technological Institute of Thessaloniki and at the University of Western Macedonia. He has organized and participated in a number of international scientific conferences and workshops and has published papers in international scientific peer referred journals like the Environmental Monitoring and Assessment, Regional Studies, Proceedings of the National Academy of Sciences of the United States of America and European Journal of Operational Research; in all he has more than 60 papers published in conferences, books and journals. He has participated in many national and international research projects in FP6, FP7, Interreg and COST and he is a member of the Committee of Senior Officials of COST.

Vassilis Kostoglou is professor and director of the research laboratory “Information Systems and Management” at the Department of Information Technology of Alexander TEI of Thessaloniki, Greece. He received his PhD for his thesis titled “The employment of information and communications technologies’ specialties in the enterprises”. He also holds a BSc degree in Engineering (Greece) and an MSc in Operational Research (UK). He is/has been the leader of five research projects and took part in several research and educational projects. He is the author or co-author of 5 books and published 24 articles in journals and 38 articles in refereed conference proceedings. He is invited visiting professor at Warsaw University of Life Sciences, Poland. His research interests include employment analysis, management information systems, multicriteria decision making systems, and project management techniques.

Dimitris Petkos is graduating student at the Department of Information Technology of Alexander TEI of Thessaloniki, Greece, having accomplished all the required obligations for his degree. He acquired substantial experience on multicriteria decision making techniques during the preparation of his degree thesis titled “A comparative study of multicriteria decision making methodologies”.

Introduction

Cloud computing services are becoming increasingly popular; the range and variety of services has increased rapidly over the last years (Wikipedia 2012). The cloud computing paradigm aims to provide a robust and dynamic computing environment for end users and is promising to allow users' access and processing of their files from virtually anywhere, provided that an internet connection is available. Zhang (Zhang et. al. 2010) provide a comprehensive state of the art survey and Yang and Tate (Yang and Tate 2009) have published a literature review on the topic with the latest research. According to Buyya, computing will be "will one day be the 5th utility (after water, electricity, gas, and telephony) ... to deliver this vision, a number of computing paradigms have been proposed, of which the latest one is known as cloud computing" (Buyya et al 2009). There are, however, due to the very nature of these kinds of services many security concerns, not always unjustified; Subashini and Kavitha (2011) report that enterprise customers are still reluctant to adopt this business model as security is naturally at the very top of their agenda.

This paper is concerned with the evaluation of the cloud computing services supplied by a number of providers from the perspective of a Greek IT academic end user. Bearing this in mind, the main aim of the present study is to rank a list of available cloud computing services providers according to the perspective of the end users, a list of 21 experts in our case. The attempted ranking was according to the suitability of the provided services to the users' needs and expectations. Furthermore, among this paper's aims are:

- To check whether Greek academics in the IT sector are using cloud computing and to what extent.
- To assess whether they include such services to their courses and to their communication with their students and to assess also their perception of their students' attitude towards these services.

The selection of the providers was according to the following guidelines:

- They should offer basic free services to the individual end user.
- They should have a simple enough user interface in order to be easily utilized by the average user; this is important as we were interested not only whether experts use these services, but also students with little relevant experience.
- They should be used currently or in sometime the past by the experts participating in the questionnaire survey.
- Our professional judgment was also used as all the authors of this paper are experienced web users.

The list of providers used in the ranking and some comments describing each is on Table 1.

Table 1. Cloud services providers list

Provider name	Free space	Website	Comments
Dropbox	2 GB	www.Dropbox.com	Dropbox was created in 2007 and in this period of 5 years it has become a widely recognized provider of cloud storage with over 50 million users. http://www.Dropbox.com/static/docs/DropboxFactSheet.pdf
SugarSync	5 GB	www.sugarsync.com	SugarSync was created in 2008 and until now has several million users worldwide while working with companies such as Lenovo, SanDisk, France Telecom-Orange, Korea Telecom and others which certifies that it is a popular cloud storage provider. http://www.sugarsync.com/company/ http://en.wikipedia.org/wiki/SugarSync

GoogleDrive	5 GB	drive.google.com	The GoogleDrive by Google is fairly new as a provider of cloud storage, created in April 24 2012. Despite being only 4 months on the market, considering the big popularity of Google and its services like Google Docs, this service has a very good potential. http://en.wikipedia.org/wiki/Google_drive
Microsoft SkyDrive	7 GB	skydrive.live.com	Microsoft's SkyDrive was created on August 1, 2007 as Windows Live Folders and adopted the current name 8 days later on 9 August 2007. It became available to the general public on May 22 2008 and till now it counts more than 100 million users. A specific advantage is that it is translated in many languages other than English compared to other providers. http://en.wikipedia.org/wiki/Skydrive
Apple iCloud	5 GB	www.apple.com/icloud	Apple's iCloud was launched for developers on June 6, 2011 and for the general public on October 12 2011. Until the end of the July 2012 there were recorded over 150 million users. Its services are provided only for Apple devices users. http://en.wikipedia.org/wiki/Icloud
Box	5 GB	www.box.com	Box.net was founded in 2005 and from then on counts more than 10 million users while it is used by approximately 120,000 businesses. http://techcrunch.com/tag/box-net/
Amazon	5 GB	www.amazon.com	Amazon Cloud Drive is another application of Amazon, which was created on the 29th of March 2011. Cloud Drive gives more benefits to users of Amazon services than to ordinary users. http://en.wikipedia.org/wiki/Amazon_Cloud_Drive
MegaCloud	8 GB	www.megacloud.com	MegaCloud was created in 2011 and is quite popular as it offers a lot of free storage capacity and it is listed on many top 10 lists of cloud services providers. http://www.cloudreviews.com/megacloud-review.html
JustCloud	Unlimited	www.justcloud.com	JustCloud was launched on May 25 2010. It does not have file storage limitations making it very attractive to users. http://www.justcloud.com/terms
Ubuntu one	5 GB	one.ubuntu.com	The Ubuntu One was launched in May 2009 and until July 2011 counted over 1 million users; the advantage of being open source making it popular. http://en.wikipedia.org/wiki/Ubuntu_One
Mozy	2 GB	www.mozy.com	Mozy was founded in 2005 and currently has over 3 million registered users and approximately 80,000 registered businesses. http://www.mozy.com/news http://en.wikipedia.org/wiki/Mozy

Research methodology

In order to perform this research study, a questionnaire survey was conducted across 21 IT experts; they were academics mainly from the Department of Informatics, Alexander Technological Educational Institute of Thessaloniki and a few from the Aristotle University of Thessaloniki and the University of Macedonia. All of them have been working with cloud computer services at various utilization levels, while some have been using it to conduct their lectures and communication with the students on day-to-day bases. The questionnaire was aimed mainly to assess the criteria used to select a service; as such a list of 12 possible criteria was available and the responder had to evaluate the importance of each on a 5-point Likert scale (Likert 1932). Based on the weighted average of the results, six criteria were selected for further analysis; the rest were not taken into account. The list of all the criteria – selected and dropped ones – is presented in Table 2. In addition, the questionnaire survey aimed at

evaluating the participants' level of satisfaction towards specific cloud computing providers' services, their level of trust towards them, as well as to assess the value of these services with regard to their teaching activities and the attitude of their students towards them.

Afterwards, based on the questionnaire responses, the goal programming technique was used in order to define the weights of the individual selected criteria. The use of this technique was preferred than Simos method as it is based less on personal judgement and gives more accurate results. The next step was to organize and perform a workshop of experts in order to implement the AHP and PROMETHEE multicriteria methods; this is the main reason for selecting 6 criteria only out of 12, the need to keep the workshop reasonable as regards to time limitations. Out of the 21 initial participants that originally responded to the questionnaire, nine of them participated in the workshop; their number was considered as adequate as this panel consisted of fully experienced experts on the topic. The workshop took place at the premises of the Department of Informatics, Alexander Technological Educational Institute of Thessaloniki and lasted the better part of a forenoon. Figure 1 depicts the research methodology described above. The timeframe of the research activities and the workshop was from the beginning of November 2012 to the end of December 2012.

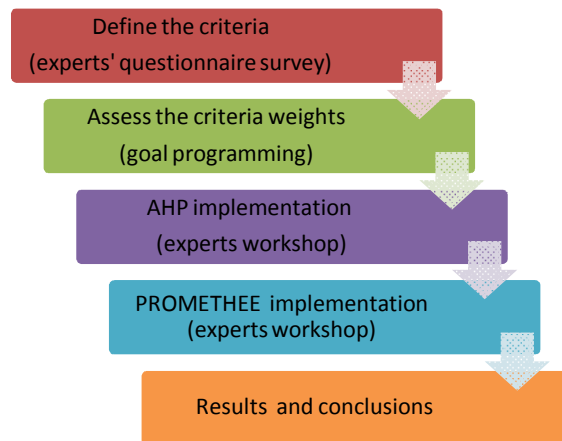


Figure 1. Research methodology

Figure 2 illustrates the cloud computing services providers that are used by the expert group taking part in the questionnaire survey. It is worth noting that Dropbox seems to lead, as is one of the oldest providers and has managed to acquire a high level of satisfaction (Figure 3) by its users and an equally high level of confidence and trust (Figure 4). Amazon and Apple services are oriented mainly to a specific type of user, the consumer of their products, and as such are not totally applicable to the rest of the users. Nevertheless, due to the highly valued brand name of both companies and the vast number of followers they were included in our research. On the other hand, Megacloud, JustCloud and Mozy seem to lag behind the competition. The first two have entered the market recently and lack a famous brand name; especially in the case of JustCloud it offers unlimited file storage space, something that could appeal a lot to the users. However it seems that it has not reached a level of maturity enough to be able to compete Dropbox and GoogleDrive and the same can be said for Mozy regardless of the fact that this particular service has been around for some time.

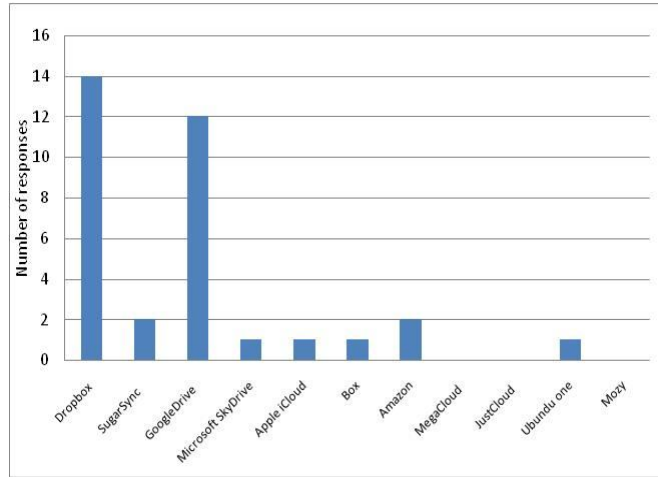


Figure 2. Cloud computing services providers used by the group of experts

Regarding the level of satisfaction from cloud computing services, experts are very or extremely satisfied from Dropbox, and very satisfied form GoogleDrive. The relatively low use of the other providers does not allow drawing safely relevant conclusions (Figure 3).

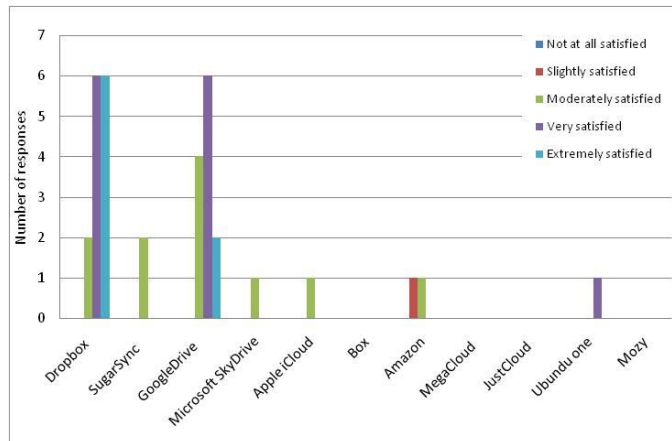


Figure 3. Experts' level of satisfaction to the cloud computing providers' services

The results concerning the level of confidence to cloud computing services are similar: users show high confidence to Dropbox and GoogleDrive. The few experts using Amazon, Apple iCloud and Ubuntu declare also a very good confidence level (Figure 4).

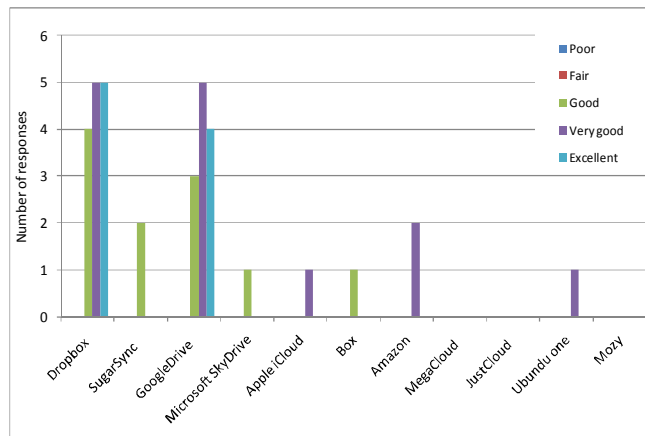


Figure 4. Experts' level of confidence to the cloud computing providers' services

In Figure 5 it is visually evident that most of our experts do not use cloud computing in their courses as only seven out of 19 valid responses (almost 37%) are positive. Despite that, most of the experts consider with a positive view the adoption of cloud computing services in the near future. Also, the vast majority of experts state that they are content with the level of service they enjoy for free and are not interested in upgrading to a more enhanced but costly level.

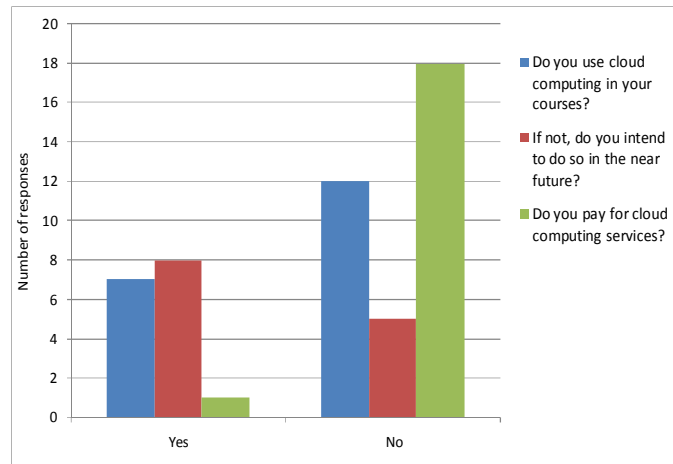


Figure 5. Experts' level of use of cloud computing services in teaching

Finally, the team of experts assesses the students' response to cloud computing with a positive view (Figure 6), but one must keep in mind that these are IT or relevant students and as such they are more familiar to IT technologies than the average student.

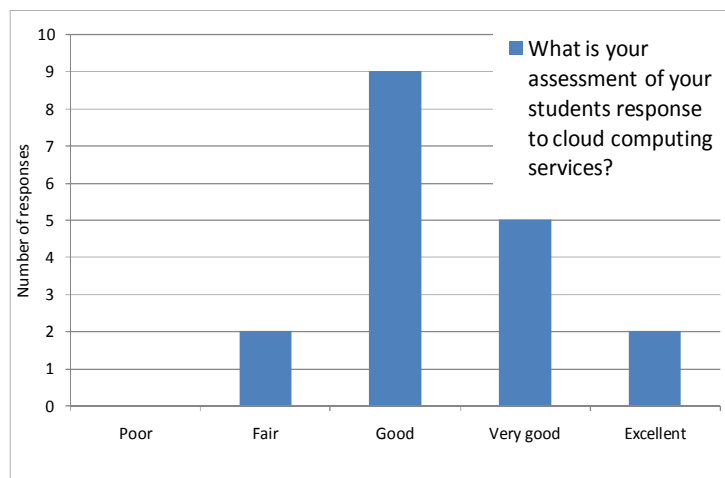


Figure 6. Assessment of the student response to cloud services by the team of experts

Criteria selection for ranking cloud computer services - assessment of criteria weights

The questionnaire included a number of criteria for choosing a cloud computing services provider; additionally personal informal interviews were also conducted with the experts in order to have a better view of their preferences and to formulate a set of relationships among the criteria. Table 2 presents the list of the initial group of 12 criteria based on relevant literature review, out of which the six scoring the highest weighted average value were selected and are listed in descending order.

Security proved to be the major concern of the experts and file sharing capabilities were considered as important, if the service is to be used for educational purposes. File sizes have also increased rapidly during the last years, since multimedia files are occupying huge spaces and this is a source for concern, while this is combined with the available free storage. A

casual user in Greece is mostly using Microsoft Windows as an operational system; this is not the case in IT academics that also use various distributions of Linux and this criterion was important as well. Finally, the ‘ease of use’ criterion has also proved to be important, mainly as the experts were concern whether the students will be able to enjoy the services without much hassle. Technical support seems to be running at a high level of effectiveness as it ranked seventh on the criteria list proving the high level of maturity that these services have reached. On the other hand, mobile internet seems not to be used frequently yet, and market share by the provider ranks as being not important.

Table 2. List of criteria

Criterion	Selected/Dropped	Weighted average value	Weight
Security protocols enabled	✓	4.90	W ₁
File shearing capabilities	✓	4.45	W ₂
Maximum file size upload	✓	4.20	W ₃
Free storage space	✓	4.15	W ₄
Supported Operational Systems	✓	4.00	W ₅
Ease of use	✓	3.85	W ₆
Technical support	✗	3.75	✗
Version control	✗	3.75	✗
Service provider reputation	✗	3.40	✗
Additional free storage space under conditions	✗	3.05	✗
Mobile internet support (iOS, Blackberry, Android, etc)	✗	2.90	✗
Market share	✗	2.45	✗

The relationships among the six selected criteria have been based on the calculated weighted average values and the informal interviews with the experts; they are the following:

- The criterion 'Security protocols enabled ' is considered by far the most important
- The criteria weights for "Maximum file size upload" and "Free storage space" are approximately equivalent
- The criterion ‘Ease of use’ is by far the least important from the rest (weights less than 0.1 but more than 0.05)
- None of the criteria (except the ‘Security protocols enabled’) can weigh more than 0.25, and ‘Security protocols enabled’ cannot weight more than 0.3
- The sum of all weights is equal to 1

A goal programming model based on the above relationships was developed (Siskos 2008); it is the view of the authors that this technique provides more reliable and detailed weights estimation than other simpler ones like the Simos method (Simos 1990a, 1990b). This model can be defined as follows:

$$\text{Min } Z = s_1 + s_2 + s_3 + s_4 + s_5 + s_6 + s_7 + s_8 + s_9 + s_{10} + s_{11} + s_{12} + s_{13} + s_{14} + s_{15}$$

subject to the following goals

$$w_1 - w_2 + s_1 \geq 0.01$$

$$w_2 - w_3 + s_2 \geq 0.01$$

$$w_3 - w_4 + s_3 \geq 0.01$$

$$w_4 - w_5 + s_4 \geq 0.01$$

$$\begin{aligned}
w_5 - w_6 + s_5 &\geq 0.01 \\
w_1 + s_6 &\geq 0.25 \\
w_1 - s_7 &\leq 0.3 \\
w_2 - s_8 &\leq 0.25 \\
w_3 - s_9 &\leq 0.25 \\
w_4 - s_{10} &\leq 0.25 \\
w_5 - s_{11} &\leq 0.25 \\
w_6 - s_{12} &\leq 0.1 \\
w_6 + s_{13} &\geq 0.05 \\
w_3 - w_4 + s_{14} - s_{15} &= 0 \\
w_1 + w_2 + w_3 + w_4 + w_5 + w_6 &= 1
\end{aligned}$$

and the non-negativity constraints:

$w_i \geq 0$, for $i = 1, 2 \dots 6$ (w_i is the weight allocated to each of the 6 criteria) and
 $s_i \geq 0$, for $i = 1, 2 \dots 15$ (s_i is the deviation variable from the goals)

The above goal programming model has been solved using the optimization software LINGO v.11 (www.lindo.com) and yielded the following results: $w_1 = 0.25$, $w_2 = 0.185$, $w_3 = 0.175$, $w_4 = 0.175$, $w_5 = 0.165$ and $w_6 = 0.05$, minimizing thus the total deviation (value of objective function Z) approximately to zero.

AHP (Analytic Hierarchy Process) implementation

As mentioned above the Analytic Hierarchy Process was implemented by nine experts during a specially organized workshop. They were given the day before the list of providers and asked to familiarise themselves with the offered services of each one of the providers regardless of whether they are currently using a specific provider or not. All of them were familiar with the procedure of the AHP method and ready to perform the dual comparisons indicated by the method on the day of the workshop. The Analytic Hierarchy Process (AHP) method was developed by Saaty (1980, 1994, 2008) and in a given situation that requires decision is creating a hierarchy structure to represent the relationships of importance elements. It is a widely used and documented Multicriteria Decision Making method despite the fact that it has received criticism (Bana e Costa and Vansnick, 2008, Belton V and Stewart TJ, 2002), which in some cases seems justified. In the authors' point of view, the methodology has its limitations, especially in a decision problem with many alternatives, but it is performing well in a workshop environment with a small group of experts as participants and has been successfully used in the past on a similar topic (Ercan 2010). The software package that was used is Expert Choice v.11 (www.expertchoice.com), which is solely dedicated to the AHP method and provides analytical and thorough results.

Tables 3 through 8 present the comparisons of the relative preference with respect to each of the 6 criteria. Figure 7 depicts the results for each criterion and each alternative and the final ranking is on Figure 8. Inconsistency in all Tables is well below 0.10, offering an acceptable level of reliability (Forman and Selly, 2002), meaning that both the intensity condition and the transitivity condition are well satisfied. It is very important to be aware of the degree of deviation from consistency in all judgments as achieving perfect consistency is not possible in most cases (Keeney, 2002; Saaty, 1980).

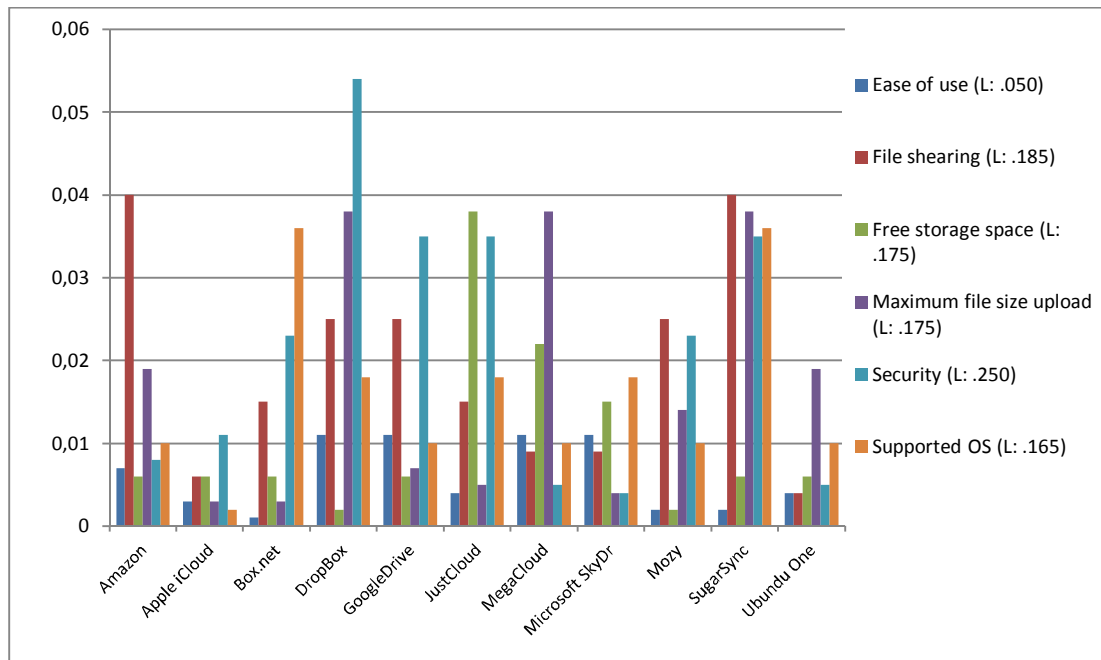


Figure 7. Results for each criterion and each alternative (L denotes the weight of each criterion)

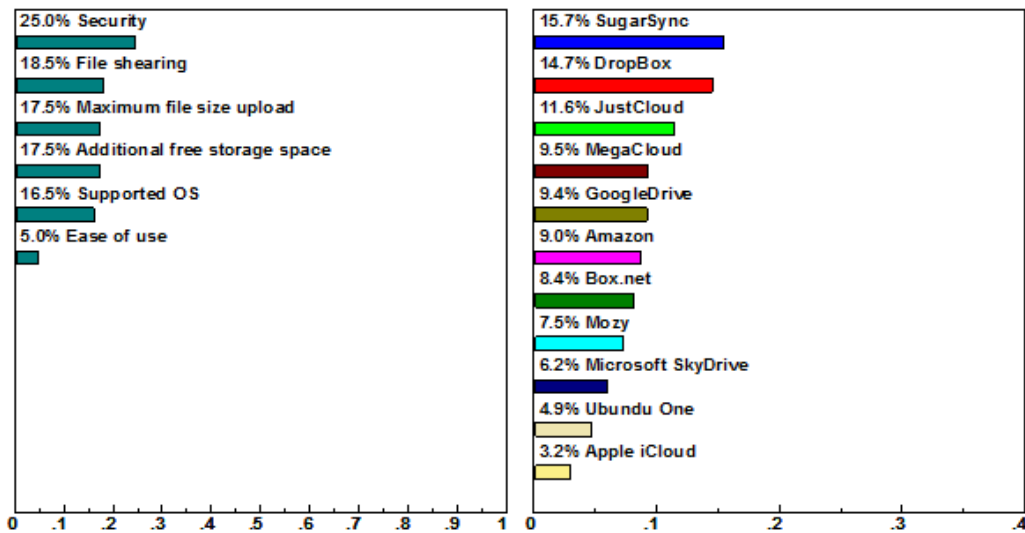


Figure 8. AHP results and final ranking

The right hand panel of Figure 8 presents the final ranking of the cloud computing services providers. SugarSync leads the way, followed closely by DropBox and a little further by JustCloud. Apple iCloud has been ranked last, nevertheless one must always keep in mind that this specific service is dedicated mainly to the consumers of Apple's products.

PROMETHEE (Preference Ranking Organisation MeTHod for Enrichment Evaluations) implementation

The Preference Ranking Organisation MeTHod for Enrichment Evaluations is a group of multicriteria methods belonging to the outranking family of methods and was initially developed by Brans (1982) and extended later by Brans et al (1984, 1986), Brans and Vincke (1985), and Brans and Mareschal (1994). PROMETHEE I is a partial ranking while PROMETHEE II is a complete ranking; the later has been used in this paper and all actions (providers) were ranked from best to worst. PROMETHEE is relying on pairwise comparisons as the decision maker is expected to compare each of the actions with all the

rest; for that the relative importance of each of the criteria is needed and the preference function used by the decision maker out of six available by the method. The software used was the Visual PROMETHEE, freely available on the internet for academic purposes. Three consecutive Tables present the essential information related to the implementation of PROMETHEE, as following: Table 9 presents the parameters set by the decision maker in order to make the decision, Table 10 includes the evaluation table statistics, and Table 11 presents the actual evaluation on a 9-point Likert scale as set by the experts in the workshop. The final results of PROMETHEE are presented on Table 12, compared also with the analogous results of AHP. The provider SugarSync is again ranked first; the Phi, Phi+ and Phi- in this Table are the preference flows according to the methodology (net, positive and negative flow respectively).

Table 9. PROMETHEE preference parameters

	Security protocols enabled	File shearing capabilities	Maximum file size upload	Free storage space	Supported Operational Systems	Ease of use
Min/Max	max	Max	Max	max	max	max
Weight	0.25	0.185	0.175	0.175	0.165	0.05
Preference Function	Level	Level	V-shape	V-shape	Level	Level
Thresholds	Absolute	Absolute	Absolute	Absolute	Absolute	Absolute
Q: Indifference	1.00	1.00	n/a	n/a	1.00	1.00
P: Preference	2.00	2.00	2.00	2.00	2.00	2.00

Table 10. PROMETHEE evaluation table statistics

	Security protocols enabled	File shearing capabilities	Maximum file size upload (Unit: GB)	Free storage space (Unit: GB)	Supported Operational Systems	Ease of use
Minimum	2.00	3.00	0.02	2.00	1.00	2.00
Maximum	9.00	9.00	8.00	999.00	9.00	9.00
Average	4.82	6.45	2.92	95.27	4.45	5.91
Standard Dev.	2.33	1.97	2.38	285.79	2.43	2.64

Table 11. PROMETHEE evaluations

Provider	Security protocols enabled	File shearing capabilities	Maximum file size upload (Unit: GB)	Free storage space (Unit: GB)	Supported Operational Systems	Ease of use
Dropbox	9.00	9.00	2.00	2.00	9.00	9.00
SugarSync	7.00	9.00	5.00	5.00	9.00	9.00
GoogleDrive	7.00	8.00	5.00	5.00	5.00	9.00
Microsoft SkyDrive	7.00	8.00	2.00	7.00	5.00	9.00
Apple iCloud	5.00	8.00	0.02	5.00	5.00	7.00
Box.net	5.00	6.00	0.10	5.00	3.00	5.00
Amazon	4.00	6.00	2.00	5.00	3.00	5.00
MegaCloud	3.00	5.00	8.00	8.00	3.00	4.00
JustCloud	2.00	5.00	1.00	999.00	3.00	3.00
Ubuntu One	2.00	4.00	5.00	5.00	3.00	3.00
Mozy	2.00	3.00	2.00	2.00	1.00	2.00

Table 12. PROMETHEE results – comparison with AHP results

No	PROMETHEE				AHP
	Provider	Phi	Phi+	Phi-	
1	SugarSync	0.5320	0.6270	0.0950	SugarSync
2	GoogleDrive	0.4495	0.6125	0.1630	Dropbox
3	Microsoft SkyDrive	0.4495	0.5775	0.1280	JustCloud
4	Dropbox	0.3695	0.5970	0.2275	MegaCloud
5	Apple iCloud	0.0109	0.3750	0.3640	GoogleDrive

6	MegaCloud	0.0050	0.3725	0.3675	Amazon
7	Amazon	-0.1915	0.2310	0.4225	Box.net
8	JustCloud	-0.2821	0.2429	0.5250	Mozy
9	Box.net	-0.3034	0.2049	0.5082	Microsoft SkyDrive
10	Ubundu One	-0.3180	0.1740	0.4920	Ubuntu One
11	Mozy	-0.7215	0.0525	0.7740	Apple iCloud

Conclusions

The whole rationale behind this paper was due to the attempt of the first two authors to decide upon the selection and use of appropriate cloud computing services providers and build a steady relationship with their students with the help of these services. In order to avoid making an unfit decision that would most probably damage the smooth execution of their courses, they decided to examine deeply this issue using also the relevant opinions of an experts' group consisted of relevant academics. Aiming to get more reliable and comparable results two multicriteria methodologies were used, namely PROMETHEE and AHP. They were used separately from each other and not combined as in the case of Macharis (Macharis et al 2004) and Dagdeviren (Dagdeviren 2008).

Without doubt GoogleDrive and Dropbox are the providers used mostly by the participated experts. However, the results of both methodologies yielded SugarSync as best provider, despite the fact that it is not used as widely as the forth mentioned providers by these same experts. It is worth repeating that all experts were asked to familiarise themselves with all of the providers prior to the workshop so they can be ready to perform the comparisons, especially in the case of AHP. Microsoft SkyDrive and Apple iCloud are in the top five of PROMETHEE results, while they rank 9th and 11th (respectively in the AHP case. JustCloud and MegaCloud complete the top five in the AHP case, while they rank 8th and 6th respectively in PROMETHEE ranking. Dropbox and GoogleDrive were in both cases in the top five and these two in any case are the ones mostly used by academic staff and students alike. Thus the suggested final choice should rest among SugerSync, Dropbox and GoogleDrive.

Last but not least it has been obvious from both literature review and practice that cloud computing services "came to stay"; a statement also expressed by all the experts who participated in our research survey. As a confirmation of the above, new cloud computing providers arise continuously and compete with the established for a market share of the very rapidly expanding relevant market. Thus, the repetition of a similar research study (we suggest a time interval of two years between two successive surveys) is strongly recommended. The examination of more cloud computing services providers and the use of more MCDM methods comparing thoroughly their results would be both scientifically interesting and practically fruitful regarding a documented suggestion for a reliable and appropriate for each case provider.

Acknowledgment

This research has been implemented through the Operational Program "Education and Lifelong Learning" which is co-financed by the European Union (European Social Fund) and Greek national funds. Project title: "Digital map of higher technological education professions".

The authors of this paper would like to thank the IT experts, members of higher education academic staff, for their participation in the questionnaire survey and/or the organized workshop. Their contribution towards the reliable selection and comparison of criteria was invaluable.

References

- Bana e Costa, C. A. and Vansnick, J. C. (2008) 'A critical analysis of the eigenvalue method used to derive priorities in AHP', *European Journal of Operational Research*, Vol. 187 No. 3, pp. 1422 - 1428.
- Belton, V. and Stewart, T. J. (2002) *Multi criteria decision analysis - An integrated approach*. Kluwer Academic Publishers, Boston.
- Brans, J.P. (1982) L'ingénierie de la décision; Elaboration d'instruments d'aide à la décision. La méthode PROMETHEE. In R. Nadeau and M. Landry, editors, *L'aide à la décision: Nature, Instruments et Perspectives d'Avenir*, pp. 183-213, Québec, Canada. Presses de l'Université Laval.
- Brans, J.P., Vincke, Ph. (1985) A preference ranking organization method: The PROMETHEE method. *Management Science*, Vol. 31, pp. 647-656.
- Brans, J.P. and Mareschal, B. (1994) The PROMCALC and GAIA decision support system for MCDA. *Decision Support Systems*, Vol. 12, pp. 297-310.
- Brans, J.P., Mareschal, B., and Vincke, Ph. (1984) PROMETHEE: A new family of outranking methods in multicriteria analysis. In J.P. Brans, editor, *Operational Research '84*, pp. 477-490. North-Holland, Amsterdam.
- Brans, J.P., Mareschal, B., and Vincke, Ph. (1986) How to select and how to rank projects: The PROMETHEE method. *European Journal of Operational Research*, Vol. 24(2), pp. 228-238.
- Buyya, R., Yeo, C. S., Venugopal, S., Broberg, J. and Brandic, I. (2009) 'Cloud computing and emerging IT platforms: Vision, hype and reality for delivering computing as the 5th utility', *Future Generation Computer Systems*, Vol. 25 No. 6, pp. 599 - 616.
- Dagdeviren, M. (2008) 'Decision making in equipment selection: an integrated approach with AHP and PROMETHEE', *Journal of Intelligent Manufacturing*, Vol. 19, pp. 397 - 406.
- Ercan, T. (2010) 'Effective use of cloud computing in educational institutions', *Procedia - Social and Behavioral Sciences*, Vol. 2 No. 2, pp. 938 - 942.
- Forman, E. and Selly, M. A. (2002) *Decisions by objectives*, World Scientific Publishing Company.
- Keeney, R. L. (2002) 'Common mistakes in making value trade-offs'. *Operational Research*, Vol. 50 No. 6, pp. 935 - 945.
- Likert, R. (1932). 'A Technique for the Measurement of Attitudes'. *Archives of Psychology* Vol.140, pp. 1-55.
- Macharis, C., Springael, J., De Brucker, K. and Verbeke, A. (2004) 'PROMETHEE and AHP: The design of operational synergies in multicriteria analysis: Strengthening PROMETHEE with ideas of AHP', *European Journal of Operational Research*, Vol. 153, No. 2, pp. 307-317.
- Saaty, T. L. (1980) *The analytic hierarchy process*, McGraw-Hill International, New York.
- Saaty, T. L. (1994) 'How to make a decision: the analytic hierarchy process', *Interfaces*, Vol. 24 No. 6, pp. 19-43.
- Saaty, T. L. (2008) 'Decision making with the analytic hierarchy process', *International Journal of Services Sciences*, Vol. 1 No. 1, pp. 83-98.
- Simos, J. (1990a) L'évaluation environnementale: Un processus cognitif négocié. *Thèse de doctorat*, DGF-EPFL, Lausanne.
- Simos, J. (1990b) *Evaluer l'impact sur l'environnement: Une approche originale par l'analyse multicritère et la négociation*. Presses Polytechniques et Universitaires Romandes, Lausanne.
- Siskos, Y. (2008) *Decision models*, New Technologies publications, Athens (in Greek).
- Subashini, S. and Kavitha, V. (2011) 'A survey on security issues in service delivery models of cloud computing', *Journal of Network and Computer Applications*, Vol. 34 No. 1, pp. 1-11.

- Vaidya, O. S. and Kumar, S. (2006) 'Analytic hierarchy process: An overview of applications', *European Journal of Operational Research*, Vol. 169 No. 1, pp. 1-29.
- Yang, H. and Tate, M. 'Where are we at with Cloud Computing?: A Descriptive Literature Review' in *ACIS 2009 proceedings*, Paper 26, <http://aisel.aisnet.org/acis2009/26>
- Zhang, Q., Cheng, L. and Boutaba, R. (2010) 'Cloud computing: state-of-the-art and research challenges', *Journal of Internet Services and Applications*, Vol. 1 No. 1, pp. 7-18.
- Wikipedia [online] http://en.wikipedia.org/wiki/Cloud_computing (Accessed 21 December 2012).