Integrated Model to Assess Cloud Deployment Effectiveness When Developing an IT-strategy

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Abstract. Developing an IT-strategy of cloud deployment is a complex issue since even the stage of its formation necessitates revealing what applications will be the best possible to meet the requirements of a company business-strategy, evaluate reliability and safety of cloud providers and analyze staff satisfaction. A system of criteria, as well an integrated model to assess cloud deployment effectiveness is offered. The model makes it possible to identify what applications being at the disposal of a company, as well as new tools to be deployed are reliable and safe enough for implementation in the cloud environment. The data on practical use of the procedure to assess cloud deployment effectiveness by a provider of telecommunication services is presented. The model was used to calculate values of integral indexes of services to be assessed, then, ones, meeting the criteria and answering the business-strategy of a company, were selected.

1. Introduction

Looking for an approach to IT-infrastructure which is able to provide various scaling a growing number of companies want to use cloud-based technologies having huge potential for gain in performance without prejudice to efficiency [1-4]. Nevertheless, to gain this advantage and have the maximal return on investment companies have to consider diverse difficulties and peculiarities of deploying a cloud-based IT, specific for particular circumstances [5, 6]. Deployment of cloud technologies necessitates a strategic plan to set a correct IT goal and further its achievement, control and adjust the process, ensuring the best results, synchronize IT and business performance, make IT functioning efficient and transparent for business to succeed [7].

The process of managerial decision-making concentrated on deployment of cloud-based technologies is to be organized in line with assessment of their economic efficiency and utilization risks. The specifics of strategic decision-making consist in incompleteness and inaccuracy of reference information, typical for conditions that kind of decisions is made in. As the consequence, an expert has to describe circumstances relying both on quantity and quality characteristics. An expert's knowledge is a determining factor when selecting a cloud service. Moreover, he/she has to develop a single methodology combining quality and quantity assessments of possible alternatives [7].

This problem can be resolved provided that a multi-criteria approach and fuzzy sets theory are applied for decision-making, enabling simulation of a smooth change in object properties, as well as revealing unknown functional dependencies expressed as attribute-based relations.

2. Procedure of calculating criteria and integral index "Effectiveness of a cloud-based service"

The problem of insufficient comprehensive methodological base and tools to support decision making, which rely on the processes of efficiency assessment and risks in conditions of uncertain decision making environment is currently the urgent one in the sphere of cloud-based technologies integration. This issue is relevant for businesses of all branches and levels [6]. To solve a problem of this kind a system approach is to be applied, as well as method of system analysis. This approach can be reduced to giving a more precise definition of the problem and structuring it in a number of tasks soluble by economic and mathematical methods, revealing criteria for their decision, and making purposes more detailed.

The following procedure based on evaluation of 6 group criteria is offered to assess effectiveness of cloud-based IT-services:

1. Efficiency for business (*Eb*)
2. Financial benefit (*Fb*).
3 Technological priority (*Tp*)
4. Work reliability and information safety (*Is*) [8]
5. Risk degree of cloud service utilization (*Dr*)
6. Psychological factor influence (*Pf*)

The integral index is calculated by hybrid additive and multiplicative formula (1):

$$K_{ecs} = Is \cdot (a_1 \cdot Eb + a_2 \cdot Fb + a_3 \cdot Tp + a_4 \cdot Dr + a_5 \cdot Pf), \tag{1}$$

where K_{ecs} – integral index "Effectiveness of a cloud-based service";
Eb – value of criterion "Efficiency for business";
Fb – value of criterion "Financial benefit";
Tp – value of criterion "Technological priority";
Is – value of criterion "Work reliability and information safety";
Dr – value of criterion "Degree of risk";
Pf – value of criterion "Psychological factor".
a_1, a_2, a_3, a_4, a_5 – weight coefficients.

The above criteria have ranks (weight coefficients) to ensure compliancy. Calculating the coefficients an expert has to take into account the range of criteria scale and average statistical numerical scores of a criterion. Research revealed the distinction between weights determined by an expert and those ones resulted from his/her activities. The weights of the most essential criteria are usually underestimated while those of less important criteria are overrated. Therefore, to avoid subjectivity pairwise comparison method is used when allocating weights [9, 10]. Weight coefficients are values of vector r_i calculated according to formula $r_i = 1 \Big/ \sum_{i=1}^{n} k_i$, where k is a sum total of pairwise comparison matrix column *i*. Vector $r_i = (a_1; a_2; a_3; a_n)$.

Criterion "Efficiency for business"

Indexes of this criterion are used mostly for quality assessment of data and their presentation in numerical scores. Then it is calculated by additive formula 2.

$$Eb = a_{11} \cdot Iv + a_{12}WEu + a_{13}Oru + a_{14}Cb, \tag{2}$$

where Iv – score of index "Increase in velocity";
WEu – score of index "Work efficiency of user";
Oru – score of index "Optimization of resource utilization";
Cb – score of index "Criticality for business";
$a_{11}, a_{12}, a_{13}, a_{14}$ – weight coefficients.

Cloud computing profitability is to be calculated by formula 3 to determine appropriate resources utilization.

The following formula is used to calculate index "Optimization of resource utilization" (*Oru*):

$$Uh \times (I - Ch_c) \geq Uh_{DPC} \times \left(I - \frac{Ch_{DPC}}{Al} \right)_, \tag{3}$$

where Uh_c – spent hours of cloud work;

I – profit;

Ch_c – cost of 1 hour of work in a cloud;

Uh_{DPC} – spent hours of Data Processinf Centre;

Ch_{DPC} – cost of 1 hour of Data Processing Centre work;

Al – average load.

Criterion "Financial benefits" was calculated according to multiple formula (4).

$$Fb = \frac{Ecs}{As}, \tag{4}$$

where Ecs – score of index "Expenditures on cloud services";

As – score of index "Assets saving".

Criterion "Technological priority" is also calculated by additive formula (5).

$$Tp = a_{21} \cdot I + a_{22} \cdot Pamc + a_{23} \cdot Ts + a_{24} \cdot Sa, \tag{5}$$

where I – score of index "Integration";

Pamc – score of index "Possibility of application migration into a cloud";

Ts – score of index "Technological stack";

Sa – score of index "Application style";

$a_{21}, a_{22}, a_{23}, a_{24}$ – coefficients of impact degree.

Criterion "Work reliability and information safety" is calculated by multiplicative formula (6).

$$Is = \sqrt[5]{Sd \cdot St \cdot Au \cdot Iu \cdot So}, \tag{6}$$

where *Sd* – relative safety index of data to be stored;

St – index of data safety under data transmission;

Au – index of authentication;

Iu – relative index of users isolation;

So – index of smooth operation;

Criterion "Degree of risk" is calculated by hydride formula (7)

$$Dr = a_{31} \cdot Nli + a_{32} \cdot Ir + a_{33} \cdot Ii + a_{34} \cdot Rd + a_{35} \cdot P, \tag{7}$$

where *Nli* – score of index of addressing to normative and legal issues;

Ir – index score of response to incidents;

Ii – score of incompatibility index;

Rd – index score of privacy and data recovery;

P – score of overpayment index outlined as pay-as-you-go;

$a_{31}, a_{32}, a_{33}, a_{34}, a_{35}$ – weight coefficients.

Criterion "Psychological factor" is calculated by formula (8)

$$Pf = (Ss + Cs + Wi + MIa + Im)/50, \tag{8}$$

where Ss – index of staff satisfaction;

Cs – index of customers satisfaction;

Wi – index of willingness to innovations;

MIa – index of mental and intellectual abilities;

Im – index of motivation.

The general algorithm of calculating the integral index comprises the following phases:

1. Data mining. Qualitative and quantitative indexes are selected with respect to responses of cloud IT-providers, contracts, agreements, and price-lists. It was performed over the first phase of the systematic approach to strategy development.

2. All indexes were assessed in numerical scores by an expert using 0 to 1 scale (Table 1) and in compliance with required indexes and standards. To realize the requirements "Standards and guidelines on application of cloud computing" developed by the Joint Technical Committee in 2014 are to be referred to, such indicators as those of a leader-competitor and counterpart-competitor on the market can also be used.

3. Calculation of weight coefficients for criteria.

4. Calculation of criteria by formulae 2, 4-8.

5. Calculation of an integral effectiveness index of a cloud-based service (K_{ecs}) by formula 1.

Iteration of indexes is eliminated in the method, enabling objective estimation of effectiveness of cloud-based IT-service application.

An application answers the criteria and meets the business-strategy of a company provided that its integral index $Kecs$ is more 0.5. Therefore, we can analyze the possibility to transfer them into a cloud.

Table 1. Preference scale of indexes (criteria)

Value of index	Verbal expression of an index (criterion) of cloud-based service effectiveness
1	Effectiveness index is very high (exceeds the standard one twice and more)
1.00…0.75	Effectiveness index is quite high (exceeds the standard one by 75-100 %)
0.75…0.5	Effectiveness index seems to be high (exceeds the standard one by 50-75 %)
0.5	Average effectiveness index (at level of the standard one)
0.5…0.25	Effectiveness index seems to be low (0-25 % lag behind the standard one)
0.25…0	Effectiveness index is quite low (25-50 % lag behind the standard one)
0	Effectiveness index is very low (100% lag behind the standard one)

3. Results and Discussion

The integrated model to assess effectiveness of cloud computing deployment was applied by Public company "Rootelecom".

Let us address the issue of determining the advantages for following services Business administration (Ba), Personnel management (Mpe), Accounting (Acc), Cloud server (CS), Corporate mail (Cm), Microsoft Office (MO), File backup (Fb), Automatic switching center cloud IP-automatic switching center (ASC), Private cloud (PC). We calculate all criteria and integral index $Kecs$ for them. We also follow data given by the provider, those ones on internal infrastructure and standards [11].

As a cloud provides we considered "Cloud4Y". It provides the above services as SaaS.

Weight coefficients of cloud IT-service effectiveness criteria

First we calculate weight coefficients and use them in formulae of effectiveness criteria for applications to be assessed. Formulae for effectiveness criteria are given below.

Efficiency for business: (Eb)=0.51·Iv+0.28·WEu+0.12· Oru+0.08·Cb;

Technological priority: (Tp)= 0.68·I+0.15·Pamc+0.09·Ts+0.06·Sa;

Degree of risk: (Dr)= 0.22·Nli+0.16·Ir+0.08·I+0.43·Rd+0.03·P.

The integrated model is as follows:

K_{ecs}=Is·(0.26·Eb+0.13·Fb+0.06·Tp+0.5·Dr+0.03·Pf).

Expert assessment of effectiveness indexes

Scores of effectiveness criteria indexes for application «1C: Business administration" are presented in Table 2.

Table 2. Scores of effectiveness criteria and risks for application "Business administration"

Eb		Tp		Is		Dr		Pf	
Index	Value	Index	Value	Index	Value	Index	Value	Index	Value
Iv	0.75	*I*	0.5	*Sd*	0.85	*Nli*	1	Ss	9.5
WEu	0.8	*Pamc*	0.65	*St*	0.85	*Ir*	0.9	Cs	8
Oru	0.5	*Ts*	0.75	*Au*	0.75	*Ii*	0.85	Wi	6
Cb	0.4	*Sa*	0.9	*Iu*	0.9	*Rd*	0.7	MIa	8.5
				So	0.7	*P*	0.7	Ia	10

Calculation of criteria and integral effectiveness index of cloud-based technologies

Effectiveness criteria were calculated for each service. Let us address to application "1C: Business administration" as an example.

We calculate a score for each criterion by using values of indexes in a corresponding model.

$Eb = 0.51 \cdot 0.75 + 0.28 \cdot 0.8 + 0.12 \cdot 0.5 + 0.08 \cdot 0.4 = 0.3825 + 0.224 + 0.06 + 0.036 = 0.7$

$Fb = \dfrac{9543}{34487} = 0.28$ Criterion Fb is given score – 0.7.

$Tp = 0.68 \cdot 0.5 + 0.15 \cdot 0.65 + 0.09 \cdot 0.75 + 0.06 \cdot 0.9 = 0.34 + 0.104 + 0.0675 + 0.063 = 0.56$

$Is = \sqrt[5]{0.85 \cdot 0.85 \cdot 0.75 \cdot 0.9 \cdot 0.7} = 0.81$

$Dr = 0.22 \cdot 1 + 0.16 \cdot 0.9 + 0.08 \cdot 0.85 + 0.43 \cdot 0.7 + 0.03 \cdot 0.7 = 0.22 + 0.216 + 0.1275 + 0.238 +$

$+ 0.035 = 0.76$

$Pf = (9.5 + 8 + 6 + 8.5 + 10)/50 = 0.84$

Let us calculate integral index *Kecs* for application "1C: Business administration", using values of criteria in the model:

$Kecs = 0.81 \cdot (0.26 \cdot 0.7 + 0.13 \cdot 0.7 + 0.06 \cdot 0.56 + 0.5 \cdot 0.76 + 0.03 \cdot 0.84) =$

$= 0.81 \cdot (0.18 + 0.09 + 0.03 + 0.38 + 0.02) = 0.59$

Criteria and integral index are calculated the same way for other services. Calculations were performed in software. Ranked calculations for 9 services to be assessed are given in Table 3.

Table 3. Calculations for 9 services to be assessed of Public Company "Rootelecom"

Services to be assessed	Effectiveness criteria						K_{ecs}
	Eb	Fb	Tp	Is	Dr	Pf	
Private cloud 2.0	0.82	0.9	0.5	0.85	0.77	0.92	0.66
«1C: Business administration»	0.7	0.7	0.56	0.81	0.76	0.84	0.59
Cloud IP-Automatic Switching Center	0.84	0.45	0.79	0.75	0.83	1	0.58
«1C: Accounting»	0.65	0.4	0.78	0.85	0.66	0.56	0.53
File backup	0.34	0.15	0.77	0.83	0.68	0.5	0.42
«1C: personnel management»	0.44	0.15	0.76	0.81	0.55	0.46	0.38
Corporate mail	0.28	0.05	0.68	0.78	0.7	0.5	0.38
Virtual cloud server	0.29	0.25	0.63	0.69	0.68	0.5	0.35
Microsoft Office	0.11	0.15	0.68	0.65	0.58	0.42	0.25

Integral index *Kecs* for services Private Cloud 2.0, Business Administration, IP-Telephony and 1C: Accounting is more 0.5. Therefore, these services answer the criteria and meet business-strategy of a company. We can take them into account when analyzing the possibility of transfer/deployment in a cloud. Other applications are not subjected to further analysis.

Conclusion

The system of criteria, as well as integrated model to assess effectiveness of cloud services deployment are presented in the paper. The integrated model of effectiveness assessment based on the system of criteria enables making a decision what applications will be the best possible to meet the

requirements of a company business-strategy, evaluate reliability and safety of cloud providers and analyze staff satisfaction even at the phase of strategy formation.

The system of criteria and integrated model were used for calculation of deployment effectiveness of 9 cloud services by Public Company "Rootelecom", providing telecommunication services. 4 services answering business aims and meeting safety requirements were selected on the base of integral index: Private Cloud 2.0, "1C: Business Administration", Cloud IP-Automatic Switching Center, "1C: Accounting".

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