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Choice of Efficient Information System with Service-Oriented Architecture using Multiple Criteria Threshold Algorithms (With Practical Example)

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***Abstract*—**Author presents the results of a study conducted to identify criteria of efficient information system (IS) with service-oriented architecture (SOA) realization and proposes a ranking method to evaluate SOA information systems using a set of architecture quality criteria before the systems are implemented. The method is used to compare 7 SOA projects and ranking result for SOA efficiency of the projects is provided. The choice of SOA realization project depends on following criteria categories: IS internal work and organization, SOA policies, guidelines and change management, processes and business services readiness, risk management and mitigation. The last criteria category was analyzed on the basis of projects statistics.

***Keywords*—**multiple criteria threshold algorithm, service-oriented architecture, SOA operational risks, efficiency criteria for IS architecture, projects ranking.

I. Introduction

THE problem to choose the best project of service-oriented architecture implementation within one line of business or cross lines of business is well-known to enterprises regardless the industry. From the moment SOA was invented the most developed enterprises (first-adopters) are trying to find the way successfully adopt this approach in IT-landscape and got the promised benefits. Companies get lots of proposals from software-providers who developed diverse platforms on the basis of SOA. Each project design proposed for SOA realization has advantages and disadvantages. Normally the requirements for information systems with service-oriented architecture are service re-usability, application flexibility, short response time, and probability of service request rejection and minimized operational risks of innovative architecture (personnel risks, information systems risks, and technical risks). How to choose efficient project for service-oriented architecture realization?

Practically tasks of efficient project choice are solved via analysis of core project characteristics using linear order algorithm. Often the decision on the IT-project is made based on the economic efficiency parameters. However, in case of IS with service-oriented architecture the benefits are rather qualitative than quantitative and they have indirect effect on key efficiency parameters. And linear order of key project parameters is not objective enough, because high value of one parameter compensates low values of others.

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In the article author defines key architecture characteristics of SOA and propose method to chose efficient project of IS with service-oriented architecture using multiple criteria threshold algorithm with a set of architecture quality criteria. Proposed method was applied to analyze seven projects of SOA implementation in companies from different industries. As a result through defined criteria and method one best project was chosen.

II. Preliminaries

Alternatives of information systems design with service-oriented architecture could be evaluated via n-dimensional vector of criteria. Let's define the alternative as an IT-project of SOA implementation which is evaluated by means of several key characteristics or criteria.

The purpose of this paper is to describe a method to rank the alternative projects and chose the most efficient project to implement information system with service-oriented architecture. The choice is made with help of multiple criteria threshold algorithm for four grades ranking of criteria adopted for SOA. According to this algorithm the conversion of criteria values per alternative is done with help of aggregation rule. The method helps to rank projects and give more precise and non-compensatory assessment of SOA efficiency. It is important to emphasis that efficiency in this case means not economic efficiency or project profitability but effect on the IT-landscape and correctness of service-oriented architecture implementation.

To verify the method several enterprises have been chosen from oil&gas and banking industry. This decision was made based on the assumption that projects of IS with service-oriented architecture can be compared with each other taking into account SOA definition and architecture design. The questionnaires were prepared to evaluate together with SAP architects and experts the projects of IS with service-oriented architecture which are proposed as alternatives for analysis. Detailed description of the alternative projects is provided in APPENDIX 1. Each project analysis also has risk estimation part for service-oriented architecture.

III. Risk analysis

Estimation of risks for IS with service-oriented architecture was made via error statistics gathered for all analyzed projects. Quality of information system architecture is connected with

continues error quantity in diverse system components. Correspondingly the risks of IS with service-oriented architecture can be decomposed on the system components risks. The approach author proposes classifies risks from IS with service-oriented architecture in a following way:

1) Input-output errors (I/O or user interface risks,
2) Functional risks,
3) Middleware risks,
4) Data risks,
5) System risks.

Totally 4435 errors were analyzed per seven projects during the period of 2006-2010 (Table 1). All errors have one of four priorities ("very high" – "high" – "medium" – "low") which correspond to the level of damage and importance of fast fixing.

The project risks are going to be used as a separate category of criteria which affects the decision making on the alternative. For final ranking on this category risks statistics will be aggregated using maximin method.

IV. Criteria Definition

TABLE I
STATISTICS ON RISKS REALIZATION

№	Priority	Risks types				
		I/O risks	Functional risks	Middleware risks	Data risks	System risks
1	Very high	1	19	1	4	9
	High	44	463	25	170	128
	Medium	140	1251	82	509	283
	Low	1	12	1	6	7
2	Very high	0	7	0	1	7
	High	24	109	24	21	73
	Medium	45	151	29	18	192
	Low	3	8	20	1	14
3	Very high	0	0	0	0	1
	High	0	0	0	0	0
	Medium	5	11	1	4	3
	Low	1	1	0	0	1
4	Very high	0	0	0	1	0
	High	0	17	1	5	5
	Medium	10	59	1	10	18
	Low	0	0	0	0	3
5	Very high	0	2	1	0	1
	High	9	26	2	5	13
	Medium	10	49	3	23	10
	Low	0	1	0	2	0
6	Very high	0	1	0	1	0
	High	2	48	0	17	5
	Medium	6	74	3	26	5
	Low	0	0	0	0	0
7	Very high	0	1	0	0	1
	High	0	4	1	2	5
	Medium	3	4	2	2	4
	Low	0	0	0	0	0
	Total	**304**	**2318**	**197**	**828**	**788**

Let's define solution architecture quality for SOA via a set of characteristics and criteria which help to prove compliance with service-oriented architecture principles. Service-oriented architecture [4] – is a solution architecture where functions are defined via independent services with callable interfaces. Application logic is implemented as usual in separate applications and sub-systems but to access application functions specific Web-service wrap is used. This allows calling the function from any other application or sub-system. Different definitions of term service-oriented architecture exist [3],[4]. To identify characteristics and criteria author analyzed information system with SOA from the perspective of system organization efficiency, work effect, service and data governance efficiency, existence of key platform components and governance rules as well as SOA operational risks. Such approach to estimate quality of architecture is mainly oriented on Information systems with SOA governance improvement and gives a mechanism to modify specific unproductive components of SOA management. Interestingly enough is that success of SOA implementation project depends not only on software components and architecture but also on timely risks identification of SOA approach to design information system.

The approach proposed in this paper is designed to evaluate quality of IS architecture in four key categories:

1) *Internal work and organization of IS with service-oriented architecture* stands for quality of application architecture, process management, usage of key SOA principles for data, service and application management.
2) *SOA policies, guidelines and change management* are measures used to adopt SOA in enterprise and to control the operations. This category checks the availability of SOA governance policies and verifies the change management activities to adopt SOA.
3) *Readiness of process and business services* stands for level of process standardization, readiness and availability of service identification methods and regulations to support SOA requirements coverage and further adoption of SOA in the enterprise.
4) *Operational risks* are defined as potential losses from errors of SOA implementation in the enterprise.

Each category contains a set of criteria to compare alternative projects of IS with service-oriented architecture:

A. Internal work of IS with service-oriented architecture

1) Level of service platform existence is measured by availability of required and sufficient platform components which meet the SOA definition. The following components are evaluated:
   - Readiness of platform for people integration,
   - Readiness of platform to connect information sources and receivers to technical services,
   - Readiness of platform to consume services and to connect processes to technical services,
   - Readiness of development platform to change, maintain technical services.

   Ranking are assigned per level of availability of listed criteria accordingly and can be defined as follows: availability of at least one platform components out of four (1), availability of two components (2), three component availability (3), all components are available (4).
2) High availability of services means that concepts in development already in place which describe how to make technical service highly available from the business

perspective and how to deal with a non-available service. According to definition services in SOA must provide high level of readiness, availability and visibility between service-provide and consumer. Service readiness depends on the extension to which service-provider has relationships with service-consumer. Service availability depends on level of connection between service participants and quality of communication channel. The criteria assessment differentiate the notification methods about service availability, the level of service readiness and accessibility:

- Grade 1 means low level of service-consumers notification, low readiness and accessibility,
- Grade 2 stands for publication of service requests, medium readiness and accessibility,
- Grade 3 is sending notification about services, high readiness and accessibility,
- Grade 4 means using the unified repository to manage service relationships with consumers, very high readiness and accessibility.

3) The level of flexibility and scalability of SOA-platform is oriented on the following aspects: configuration from the performance point of view, support of different service availability levels, capabilities to meet the needs of changing business requirements especially from higher requirements of service level agreement (SLA) and load increase. There are the following ranking approach proposed: (1) low platform flexibility and scalability, (2) – medium platform flexibility and scalability, (3) – high platform flexibility and scalability, (4) – very high platform flexibility and scalability.
4) Readiness of existing applications to consume and provide services can be defined according to the level of customization and development needed to adopt current applications to define and implement services. Ranking approach is the following: (1) – high customization and development effort required for all systems, (2) – medium effort for all or for several systems, (3) – IT landscape contains the systems providing services, (4) – all systems are ready to provide and consume services.

B. SOA Guidelines, policies and change management

1) Level of services reuse in IT landscape which partly depends on the methods and procedure to adopt existing processes to new way of systems design. The ranking approach is as follows: (4) the level of service reuse is more than 40%, (3) the level of service reuse is around 20%-40%, (2) the level of service reuse is around 10%-20%, (1) the level of service reuse is around 0%-10%.
2) Service design capabilities are measuring the knowledge and expertise level required for service management, service requests processing and service applications change. In other words, the criteria check whether experts know the methods to orchestrate and redesign services. Ranking approach is as follows: (4) – very high expertise level and enough experts available, (3) – high expertise level, (2) – medium expertise level, (1) – low expertise level.
3) Capabilities to support high service availability depend on the experts availability and platform support. Ranking approach is following: (4) – very high capacity and support level, (3) – high capacity and support level, (2) – medium capacity and support level, (1) – low capacity and support level.
4) Change management for service provider is a criterion to define readiness level of service provider, capabilities to offer business process and technical services to different (internal) customers at different service levels. Ranking approach is following: (4) – very high level of service provider flexibility and reliability, (3) – high level of reliability, (2) – medium level of reliability, (1) – low level of reliability.
5) Service level (SLA) – criterion is used to define level of service level agreement preparation. SLA should be simple, concrete and should define quality, performance and response time. Ranking approach is following: (4) – availability of SLA with control system, penalties and incentives, (3) – availability of SLA with partial control, (2) – partly defined SLA, (1) – absence of SLA.

C. Readiness of process and business services

1) Service governance processes criterion controls the existence of governance processes to identify benefits in standardization, reusable granularity, cutting and designing the processes accordingly. It is important to take care of holistic life-cycle management for processes and services. Ranking approach is following: (4) governance on the project portfolio level, (3) – governance board level, (2) – separate service governance on the line of business, (1) – partly governed.
2) Master data compliance level defines the level of common and harmonized view for all master data objects across all systems. To simplify the service-oriented architecture adoption the master data should have common, unified view on business partners, materials, employees, organizational units and other data objects. Ranking approach is following: (4) – very high level of data compliance, (3) – high level of data compliance, (2) – medium level of data compliance, (1) – low level of data compliance.
3) Level of transactional data compliance. As transactional data is more the result of a business activity process the more it has the same look and feel, the higher the application of harmonization and the less logic and intelligence you need for the next business step, to map and prepare the parameters. Ranking approach is following: (4) – very high level of data compliance, (3) – high level of data compliance, (2) – medium level of data compliance, (1) – low level of data compliance.
4) Version control[1] of process steps stands for the way of process change control and version management. It describes how to feed a business process (parameters) and

[1] Let's define version control as new variants of existing process steps which were changed because of new system implementation and new rules adoption.

what expect from a business process (results). Versioning approach depends on how stable are versions of process steps. Ranking approach is following: (4) – absence of process change and high service granularity, (3) – rare process change and low service granularity, (2) – often process change and low service granularity, (1) –absence of version control.

D.Minimized operational risks,

1) The criterion aimed to check potential operational risks from errors of information system work with SOA [6]. Risk analysis is provided on the basis of classification approach and statistics, described in chapter 2.

For each project (or alternative) solution architecture and implementation readiness estimations were made. Totally 7 projects were analyzed. Every project got grades per criteria listed earlier in this chapter. All criteria provide qualitative estimation using following ranking approach:

1) Low risk– 1
2) Medium risk– 2
3) High risk – 3
4) Very high risk– 4.

V. Aggregation methods

After defining the method of data processing one of the main tasks is to get the most constructive and justified assessment of architecture quality for analyzed project with service-oriented architecture. To reach the goal two methods were used: multiple criteria threshold algorithm for four grades and maximin method.

A. Multiple criteria threshold method

Identified criteria of information system architecture evaluation couldn't give a clear understanding of the most efficient project without aggregation approach. Normally for such tasks the linear order method is used. However the use of this method for some types of tasks is not efficient enough because of "compensatory" disposition of estimated criteria. In other words criteria after application of linear aggregation could compensate low values for one criterion by high values of others. Unlike the linear order, multiple criteria method [1], [2] is based on final ranking of criteria categories with 4 grades. Values are aggregated per category first and then the procedure is repeated second time for resulting values to get final ranking. Aggregation is made according to the threshold rule. Binary relationships are generated by this threshold rule and are defining the preferences for variety of projects.

The set of projects with service-oriented architecture is evaluated using identified criteria. Every project gets grade for every criteria using 4-grade scale.

Aggregation is made using following threshold rule

W_{tr} = {(x,y)|[$v_1(x) < v_1(y)$] or [$v_1(x) = v_1(y)$ and $v_2(x) < v_2(y)$] or [$v_1(x) = v_1(y)$ and $v_2(x) = v_2(y)$ and $v_3(x) < v_3(y)$]}, where $v_1(x)$ – the multiplicity of grade one («1») in vector x, $v_2(x)$ – correspondingly multiplicity of grade two («2»), and $v_3(x)$ – multiplicity of grade three («3»). So the relation W_{tr} represents a set of binary pairs of vectors for which either first vector has less multiplicity of grade one rather than second or they have equal multiplicity of grade one and less multiplicity of grade two for first vector, or they have equal multiplicity of grades one and two, and less multiplicity of grade three for first vector. As a result the vectors are ranked.

In case of four grades and three criteria to compare the whole set of vectors can be grouped following way:

1. {1,1,1} –all criteria has grades «low»,
2. {2,1,1}, {1,2,1},{1,1,2} – all criteria except one with grade «2», have grades «low»,
3. {3,1,1}, {1,3,1},{1,1,3} – all criteria except one with grade «3», have grades «low»,
4. {4,1,1}, {1,4,1},{1,1,4} – all criteria except one with grade «4», have grades «low»,
5. {2,2,1},{2,1,2}, {1,2,2} – all criteria except one with grade «1», have grades «medium»,
6. {1,2,3},{2,3,1}, {1,3,2}, {2,1,3}, {3,1,2},{3,2,1} – vector consists of the grades «low», «medium» and «high»,
7. {1,2,4},{2,4,1}, {1,4,2}, {2,1,4}, {4,1,2},{4,2,1} – vector consists of the grades «low», «medium» and «very high»,
8. {1,3,3},{3,3,1}, {3,1,3} – all criteria except one with grade «1», have grades «high»,
9. {1,3,4},{3,4,1}, {1,4,3}, {3,1,4}, {4,1,3},{4,3,1} – vector consists of the grades «low», «high» and «very high»,
10. {1,4,4},{4,4,1}, {4,1,4} – all criteria except one with grade «1», have grades «very high»,
11. {2,2,2} – all criteria have grade «medium»,
12. {2,2,3},{2,3,2}, {3,2,2} – all criteria except one with grade «3», have grades «medium»,
13. {2,2,4},{2,4,2}, {4,2,2} – all criteria except one with grade «4», have grades «medium»,
14. {2,3,3},{3,3,2}, {3,2,3} – all criteria except one with grade «2», have grades «high»,
15. {2,3,4},{3,4,2}, {2,4,3}, {3,2,4}, {4,2,3},{4,3,2} – vector consists of the grades «medium», «high» and «very high»,
16. {2,4,4},{4,4,2}, {4,2,4} – all criteria except one with grade «2», have grades «very high»,
17. {3,3,3} – all criteria have grade «high»,
18. {3,3,4},{3,4,3}, {4,3,3} – all criteria except one with grade «4», have grades «high»,
19. {3,4,4},{4,4,3}, {4,3,4} – all criteria except one with grade «3», have grades «very high»,
20. {4,4,4} – all criteria have grade «very high».

K – is a number of equivalence classes.

$$K = \frac{(n+3)(n+2)(n+1)}{6}, \quad (1)$$

where n – is number of criteria within the category. As a result the enumerating scale is generated which can be reflected on the segment [0,1]. As an aggregated value of IS category the following values can be used

$$v = \frac{i-1}{K} \in [0,1], \quad (2)$$

where i – index of equivalence class.

B. Maximin method

In case of risks ranking author proposes to use maximin method to analyze data [5]. Ranking is generated according to the following rule:

Construct a matrix S+ such that,

$$\forall x, y \in A, S^{+} = \{n(x,y)\}, \quad (3)$$

where $n(x,x) = +\infty$, A – project set

and $n(x,y) = \{l | P_l(x) > P_l(y)\}$.

In other words, in matrix S+ in the intersection of row X and column Y the number is put n(x,y) equal to the number of criteria in which alternative X has higher values than alternative Y taking into account the measurement error. In this paper alternatives X and Y correspond to compared projects, and *n(x,y)* – number of criteria to compare risk types.

Choose row minima from every row (for every alternative). Then choose the highest value from the identified minimum values. Final «maximin» value (i.e. risk category) gets the highest rank. Then this procedure is repeated for all the other risks. So the maximin rule can be presented as follows

$x \in C_1(A)$ iff

$$n(x,y) = \max_{a \in A}\left\{\min_{b \in A}\{n(a,b)\}\right\}$$

for some $x, y \in A$.

In case of maximin criteria guaranteed bottom value for all $n(x,y)$ is gotten, which is seen as advantage comparing to linear order method.

VI. From Numerical values to Ranks

The aggregation method is applied for every numerical value within four criteria categories: for first three categories – multiple criteria threshold algorithm is used [1], for the last one with risks – maximin method is applied. For aggregation purposes the resulting numerical values are converted into ranks. The conversion is made for every initial ranking result of four criteria categories. To covert numerical values into rank let's divide the interval [0,1] into 4 equal parts. It allows grouping the ranking results into 4 ranks:

1) The first and the lowest rank belongs to the interval [0; 0,25],
2) Medium rank is in the interval [0,25; 0,5],
3) High rank is in the interval [0,5; 0,75],
4) Very high rank belongs to the interval [0,75; 1].

For example the category of criteria «Internal work of IS with service-oriented architecture» has 4 criteria and 7 numerical values per each. After application of multiple criteria threshold algorithm the values in the category are displayed in the Table 2.

To provide final ranking on the projects level (not on the level of project categories) the aggregation procedure should be done second time using as starting value the result of criteria categories analysis. In this case the result corresponds only to one criteria categories «Internal work of IS with service-oriented architecture». What is needed to repeat the analysis that is to convert the numerical values into ranks. The result of conversion is demonstrated in Table III. Proposed conversion method from numerical values into ranks is applied to every category within the first step of aggregation and to every value in the step of final projects ranking.

TABLE II
AGGREGATION OF VALUES IN 1ST CRITERIA CATEGORY

Criteria	Project						
	1	2	3	4	5	6	7
Organization of IS with SOA	0,06	0,62	0,97	0,97	0,97	0,97	0,97

TABLE III
RANKING RESULTS IN 1ST CRITERIA GROUP

Criteria	Project						
	1	2	3	4	5	6	7
Organization of IS with SOA	1	3	4	4	4	4	4

TABLE IV
PROJECT DESCRIPTION – IN A NUTSHELL

Project №	Description
1	Design of enterprise applications with service-oriented architecture. Development of 4 composite applications with 9 enterprise services within one business process.
2	Implementation of application «transport-manager», supporting composite process of presenting a request on transport using service approach of integration platform.
3	Development of application providing «single sales channel», integration of client interaction channels, management of unified client database, and the ability of flexible adoption of this functions according to new business requirements, new products or sales channels.
4	Creation of information system for all tasks connected with handling and usage of data in the enterprise. Solution provides an opportunity to integrate with different information systems (ERP, accounting, and manufacturing) on the data level, with the capability to restrict access rights to the information.
5	An integration project of local information systems is done for efficient work of enterprise information systems, interaction of all catalogs and databases of the enterprise. The project is using single technological platform and service-oriented architecture design. The project developed user-friendly mechanism of access to information regardless of local systems and platforms.
6	The project is oriented on integration of ERP system and oil&gas system (OIS) supporting the transparency of business-processes with ability to use data from different systems-providers. Practically the automated process provides actual data about event execution using standard documents of ERP system and statement of work from the maintenance system which is OIS component.
7	Key project objective is to integrate accounting system, ERP and other systems (like «Sphera», 1C, Lotus, TIBCO BW). This helps to streamline accounting functions, resource management and cross business processes using data from different system-sources.

TABLE V
RESULTS OF ARCHITECTURE ANALYSIS

№	Criteria	Projects						
		1	2	3	4	5	6	7
I	Organization of IS with SOA							
1.	Level of service platform availability	3	2	4	4	4	4	4
2.	Service reliability level	1	3	3	3	3	3	3
3.	Level of SOA platform flexibility and scalability	1	2	4	4	4	4	4
4.	Current systems readiness	1	2	4	4	4	4	4
II	Change management and regulations							
1.	Level of reusability in enterprise architecture	1	2	4	2	2	2	2
2.	Capabilities in Service design	1	3	3	3	3	2	3
3.	Capabilities in service support	1	3	3	3	3	3	3

4.	Service provider change management	1	4	4	4	4	4	4
5.	Level of SLA	1	3	3	3	3	3	3
III	Processes and business services readiness							
1.	Level of service management	2	2	2	2	2	2	2
2.	Level of master data compliance	3	4	2	4	4	2	2
3.	Level of transaction data compliance	3	2	4	3	3	4	4
4.	Process version control	1	2	2	3	3	2	2
IV	Operational risk optimization							
1.	I/O risks	1	1	1	1	1	1	1
2.	Functional risks	4	4	1	1	4	1	1
3.	Middleware risks	1	1	1	1	1	1	1
4.	Data risks	2	1	1	1	1	1	1
5.	System risks	3	4	1	1	1	1	1

VII. Practical example

To verify proposed method of choosing the information system with service-oriented architecture 7 projects were selected. For each project the assessment of architecture was done including internal work of information system and risks of service-oriented architecture using identified evaluation criteria. There is a short description of analyzed projects (see Table 4). More details you can find in the Appendix 1. Data gathering for all categories of criteria except risks was done in a form of questionnaire. SAP experts together with customer representatives provided the evaluations of architectures. The questionnaire consisted of the proposed criteria. Questions were grouped per three main categories. As a result analyzed projects got the evaluation for every criteria within three categories aimed to define the quality of service-oriented architecture.Answers are given in a form of four grade values («very high» - 4, «high» - 3, «medium» - 2, «low» - 1). Integral value on the category level is calculated using multiple criteria threshold algorithm [1] in case of first three categories and using maximin method in case of risks. Gathered projects assessments are shown Table 5. Risks assessments were gathered not via questionnaire but on the basis of statistics for the systems used as services in every analyzed project. The maximin method was used to get accumulative value for every risk type. To demonstrate the method let's look on the risks of first project (see Table 6).

TABLE VI
Project 1 Risks

Risks type	Very high	High	Medium	Low	Ranking
I/O risks	**1**	44	140	**1**	4
Functional risk	19	463	1251	**12**	1
Middleware risks	**1**	25	82	**1**	4
Data risks	**4**	170	509	6	3
System risks	9	128	283	**7**	2

Minimum values for risk type are emphasized with color.

Then conversion method was applied to translate numerical values into grades. As a result the grade 1 was given to functional risks. During the ranking the highest numbers from the minimal values should be chosen. This gives an overview of the maximum errors quantity and demonstrates the highest risks correspondingly. In this case grade 1 is given to the highest risk because the higher the risks value is the worse the project is. Unlike the previous ranking example in other categories, in case of risks the opposite ranking approach is used: grade 1 is assigned to the highest risk, grade 4 – to the lowest risks. Bearing in mind that in other categories the lowest value is assigned to grade 1, in case of risks the higher value is assigned to grade 1. Ranking result is shown in Table 6. The values for other 6 projects for category «Minimized operational risks» are done using the same principle.

Next step is to apply miltiple criteria threshold algorithm to accumulated ranks from previous step, shown in the Table 5. As a result the aggregated value is generated for four categories for every project (see Table 7). Then the values from Table 7 are translated into ranks using apporach of conversion from numerical values to ranks (see Table 8).

TABLE VII
Results of aggregation per group

№	Criteria	Projects						
		1	2	3	4	5	6	7
I	Organization of IS with SOA	0,06	0,62	0,97	0,97	0,97	0,97	0,97
II	Change management and regulations	0	0,84	0,95	0,84	0,84	0,76	0,84
III	Processes and business services readiness	0,38	0,65	0,64	0,79	0,79	0,64	0,64
IV	Operational risk optimization	0,25	0,16	0	0	0,05	0	0

TABLE VIII
Results of multiple ranking per group

№	Criteria	Projects						
		1	2	3	4	5	6	7
I	Organization of IS with SOA	1	3	4	4	4	4	4
II	Change management and regulations	1	4	4	4	4	4	4
III	Processes and business services readiness	1	3	3	4	4	3	3
IV	Operational risk optimization	4	3	1	1	2	1	1

Final ranking per category allows conducting the second aggregation and ranking of values already on the project level (see Table 9). Final ranking is accomplished using 7 grades according to 7 analyzed projects.

TABLE IX
FINAL RANKING RESULTS

№	Criteria	Projects						
		1	2	3	4	5	6	7
I	Aggregation	0,08	0,91	0,53	0,56	0,82	0,53	0,53
II	Final ranking	1	7	4	4	6	4	4

Looking at the aggregation results (see Table 9) the second project is a most efficient way to implement IS with service-oriented architecture. This project is second to none taking into account architectural characteristics analysis, internal work of information system with service-oriented architecture and potential operational risks. Besides, chosen project complies with SOA principles more than other projects. Second place is taken by project 5. Forth place is occupied by projects 3, 4, 6 and 7, and the last or the worst is project 1.

VIII. Conclusion

In the article the method is proposed to support decision making process around service-oriented architecture design and implementation. In fact the choice of the information system with SOA depends on a set of criteria in following categories: (1) internal work and organization of information system with service-oriented architecture, (2) SOA guidelines, policies and changed management, (3) readiness of process and business services, as well as (4) minimized operational risks. Evaluation of the last category is defined according to the statistics of service-providers work. The task to choose the most beneficial project of IS with service-oriented architecture is solved using multiple criteria threshold algorithm. The quality criteria for service-oriented architecture are defined to apply evaluation algorithm. Each criterion is ranked using 4 grades which show either priority («very high», «high», «medium», «low»), or maturity level of business service («best», «good», «medium», «painful»), or automation level (30%-50%-70%-100%). At the beginning the analysis is done within each category to aggregate criteria assessments, than the procedure is repeated to get final aggregated and ranked values for each project. Advantages of proposed method are «non-compensatory» characteristics of compared alternatives. Ranking results give clear understanding of project priority and efficiency according to identified criteria.

Quality analysis for information system with service-oriented architecture in different companies gives an opportunity to compare it with projects (or alternatives) and to define the priorities for further development of considered information systems to meet business goals. Additionally this allows generalizing the best practice of implementation projects with service-oriented architecture design.

TABLE X
PROJECT DESCRIPTION

Project 1 Oil&Gas company	
Project description	Design of enterprise applications with service-oriented architecture. Development of 4 composite applications with 9 enterprise services within one business process.
Architecture description	Design of unified system of request approval for expensive goods acquiring (4 composite process are used and 9 web-services). The system includes usage of process elements from local systems existing in the IT landscape of enterprise with system mySAP Enterprise Resource Planning (ERP) and Supply Relationship Management (SRM). Using integration platform SAP NetWeaver data is disctributed to the mentioned systems. As a user interface corporate portal is used. Master data is handled in SAP NetWeaver Master Data Management (MDM).
Organizational support	Business process owners are defined and are the part of organizational unit supporting SOA (process owners, SOA architect, business-analyst, service developer, integration expert).
Project 2 Oil&Gas company	
Project description	Implementation of application «transport-manager», supporting composite process of presenting a request on transport using service approach of integration platform.
Architecture description	Development of composite application on the basis of the SAP NetWeaver platform to tier the engineering and controlling systems in IT-landscape (IS-AT, GIS, SAP systems), provide flexible and fast system design on request, to optimize current transport management process.
Organizational support	Introduction of new process roles into IT organizational structure
Project 3 bank company	
Project description	Development of application providing «single sales channel», integration of client interaction channels, management of unified client database, and the ability of flexible adoption of this functions according to new business requirements, new products or sales channels.
Architecture description	Ket tas of the system – integration of accounting systems, SAP R/3 and «non-SAP systems» («Sphera», 1C, Lotus), to provide the just in time work of specialist. Coposite applications support: - Single user interface oriented in joint work (Web-interface) - Unified handling of master data - Independence of process from the business-service specifics
Organizational support	No
Project 4 Oil & Gas company	
Project description	Creation of information system for all tasks connected with handling and usage of data in the enterprise. Solution provides an opportunity to integrate with different information systems (ERP, accounting, and manufacturing) on the data level, with the capability to restrict access rights to the information.
Architecture description	Creation of unified system for master data management on the basis of SAP NetWeaver MDM with phasing rollout of technical landscape and central data storing, including all key catalogs and classifications of enterprise applications (like ERP, accounting and engineering). Creation of basis integration infrastructure on the basis of SAP NetWeaver.
Organizational support	Introduction of new process roles into IT organizational structure
Project 5 Oil & Gas company	
Project description	An integration project of local information systems is done for efficient work of enterprise information systems, interaction of all catalogs and databases of the enterprise. The project is using single technological platform and service-oriented architecture design. The project developed user-friendly mechanism of access to information regardless of local systems and platforms.

TABLE X
PROJECT DESCRIPTION (CONTINUATION)

Project 5 Oil & Gas company	
Architecture description	Integration of implemented SAP systems with local information systems using SAP NetWeaver integration platform. The solution is designed to work with key standards like Microsoft.NET and J2EE to integrate modern applications.
Organizational support	Introduction of new process roles into IT organizational structure
Project 6 Oil&Gas company	
Project description	The project is oriented on integration of ERP system and oil&gas system (OIS) supporting the transparency of business-processes with ability to use data from different systems-providers. Practically the automated process provides actual data about event execution using standard documents of ERP system and statement of work from the maintenance system which is OIS component.
Architecture description	The project provides integration of OIS and R/3, which is oriented on the following functions: - Support of existing protocol and data transfer formats. - Support of new systems connection to existing infrtracture without failures. - Guaranteed provision of data from sender to receiver with monitoring and controlling data flow tools. - Efficiently use of existing communication channels and use reserved tools of data transfer.
Organizational support	No
Project 7 bank company	
Project description	Key project objective is to integrate accounting system, ERP and other systems (like «Sphera», 1C, Lotus, TIBCO BW). This helps to streamline accounting functions, resource management and cross business processes using data from different system-sources.
Architecture description	Projects is oriented on the SAP R/3 and «non-SAP systems» integration. It helps to provide following functions: - Support of existing protocol and data transfer formats.. - Support of new systems connection to existing infrastructure without failures - Helps to integrate projects on the organizational as well as information and technology levels. - Provide implementation of new business processes into existing process environment of the enterprise.
Organizational support	No

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