FACTA UNIVERSITATIS
Series: **Mechanical Engineering** Vol. 21, Nº 3, Special Issue, 2023, pp. 433 - 451
https://doi.org/10.22190/FUME230521023R

Original scientific paper

MULTI-CRITERIA SELECTION OF STANDARDS FOR SYSTEM ANALYST ACTIVITIES IN ORGANIZATIONS

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Abstract. *The paper defines the methodology for the selection of standards and tools that system analysts use for the purposes of analyzing the computer infrastructure of organizations. The goal of system analyst analysis is primarily to increase: the speed of processing information, the efficiency of data processing and data exchange. A large number of standards and tools complicates an adequate choice, and on the other hand system analysts are not the only ones who influence the choice. In the analysis of the choice of standards and tools, in the second chapter an algorithm for determining the weight coefficients for the criteria selected by the company and the ranking of the standards for selection is presented through an example. In order to choose the best standard, the choice was made between four standards described in the third chapter. The chapter defines the criteria that cover IT activities for the selection of standards according to selected criteria and defined weight coefficients in the observed company. Finally, on the assumption that the company together with the analyst chose "k" criteria, where the methodology (LBWA) for the selection of weight coefficients for the criteria was proposed, a new model for calculating the ranking of standards was presented, i.e. the choice of the best. The conclusion of the paper is that the presented procedure for choosing standards is not complicated, that it is very successful, and that in this way the proposals were more easily accepted and implemented in the fastest way.*

Key words: *Standard, Recording processes, Analyzing processes, LBWA method, Multi-criteria analysis, BPMN, IDEF0, IDEF3, DFD*

Received: May 21, 2023 / Accepted August 05, 2023
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1. INTRODUCTION

System analysts are IT professionals who work on analyzing the needs of an organization's computer infrastructure. Their primary goal is to increase information processing speed and efficiency of data processing, and to utilize existing computer resources (hardware, software, and personnel) in the most effective way to achieve better economic results in the organization's operations. Their goal is also to assess the organization's position in the market in the same field, and whether organizational changes and actions are needed to improve business processes and procedures in the organization in the near future, in order for the organization to be among the leaders in the field and to meet the assigned tasks.

Similarly, system analysts work on long-term research, identifying and studying problems. They propose solutions chosen from multiple possibilities in coordination with all participants in the organization's activities who may be interested in these solutions or who may be affected by them, with the aim that everyone works and collaborates to make the proposals more easily accepted and later implemented in the fastest way possible.

System analysts can be experts who work within an organization. In this case, they hold a high position in the organization hierarchy (usually with few superiors). Alternatively, they can be employed by another organization and perform these tasks upon the request of a given organization. In the first case, it can be said that system analysts continuously work on organizational changes aimed at achieving better business results for the organization, while in the other case, they are engaged by the organization's management to study its position in the relevant field and to work on organizational changes as needed.

This paper does not discuss organizational changes or types of business organization. We note that this job is almost always difficult, requiring immense energy and knowledge in the areas of information technology, organization, and the technology that people in the organization are involved in, as well as psychology, as it is necessary to ensure that individuals within the organization accept potential changes as a change that will also benefit them, as well as the organization itself. Likewise, sociological aspects of these tasks must be considered, as they are often related to relationships among interest groups within the organization, as well as relationships within the broader community, as organizations are almost always an important factor for the life of the local community, or if we look more broadly, state communities.

Therefore, organizational changes that system analysts design are mostly changes related to technology and the use of information technology, and they are independent of the type of organizational structure of the organization, i.e. they must fit into every type of organization.

Simply put, the principle is used that what is technologically better should be applied (similar to James Miller's idea of "Living Systems", good new theories do not eliminate previous good theories but incorporate them into the new theory - this theory by J.G. Miller is highly applicable for explaining the work of an organization as a whole and of each of its individual parts).

When starting a job, system analysts first need to record the organization's operations (focusing on what is relevant to their work), and for that, they need to use certain tools and standards. Today, numerous tools and standards are available for this purpose. However, all these tools and standards have certain advantages and disadvantages because they were created mostly for specific purposes, so the right choice is often crucial for successful work. In practice, the choice is primarily made through recommendations from colleagues who have used certain standards and tools in specific situations, and system analysts themselves typically choose the tools and standards they are accustomed to in their practice or those they have previously used.

If the situation arises where something else must be used, usually it is done on the recommendation of colleagues.

In existing literature [1], we find that the number of these standards and tools is continuously increasing, but there are no defined rules on how to make a choice between these standards and tools based on certain criteria and precisely defined indicators related to those criteria.

This can be explained by the fact that system analysts are not the only ones making this choice. Managers of organizations have a crucial role in the selection process, as they will be the ones who will primarily use these standards and tools for their daily work. Analysts certainly have great influence with their experience and knowledge, but they are not the deciding factor.

However, we must note that analysts as experts have a significant impact on the selection of standards and tools, as they define the criteria that these standards and tools individually fulfill and evaluate how well the proposed criteria meet specific standards.

In this paper, experts have defined possible criteria (there are 28 of them), and ratings from 0 to 1 have been given for each criterion. The assumption is always - regardless of the nature of the criterion - that it is a maximizing criterion, that is, 1 is the best rating and 0 is the worst rating. However, in the observed case, it is acceptable to choose a criterion with a rating of 0, and it is not discarded for that reason. Therefore, minimizing criteria have been translated into maximizing criteria.

In the specific analysis, it was found that in each particular case, the choice of criteria is made in coordination between the management of the organization and system analysts who deal with organizational changes, or IT organizational changes in the organization. Therefore, each organization will have its own criteria for choosing standards and tools [2]. However, since the standards and tools for this work are not developed for a specific organization, it can be noted that they are developed for use in various organizations that will choose the standards and tools that have criteria they need. The paper deals with criteria that exist in various standards. These criteria are of a general nature and are differently fulfilled in different standards - the ratings of the fulfillment of a certain criterion in a standard are given by experts, i.e. experienced system analysts, for each standard and each criterion individually.

Clearly, the organizations themselves will rank their selected criteria according to importance for their work, and this will be the basis for choosing standards. This ranking will be done by determining the weight coefficients of the criteria by the organizations themselves.

The method of analysis and synthesis examples according to the experiences of experts has been used. In this paper, we limit ourselves to proposed criteria, and solutions. According to the experiences of experts, these criteria often have emerged in different cases of organizations and institutions that they have observed and worked in as system analysts. Concrete numerical data to process analysis was used as an example to open questions about the advantages and disadvantages of chosen criteria and method. The disadvantages of this method are the limit of chosen criteria and the limit of concrete numerical data of weight coefficients for example. However, at the end of the work, the case of adding new criteria for the system analysis of a particular organization was analyzed. Adding new criteria is done by simply introducing new criteria into the existing model as shown.

The major problem in MCA (Multi-criteria Analysis) models is determining the importance of criteria and ist weight coefficients. Generally, authors tend to divide models for determining the weight of criteria into subjective and objective ones [3].

The subjective approach to determining weight criteria is based on information obtained from decision makers or experts, as is the case with the SWARA (Step-wise Weight Assessment Ratio Analysis) method [4], BWM (Best Worst Method) [5] or FUCOM method (FUll COnsistency Method) [6], etc. In the case of an objective approach for determining the weighting factors, the opinions of the decision-makers are ignored, and decisions are made based on the information obtained in the decision-making matrix. Such a method is e.g. FANMA method [7]. Also, methods that are often used to determine the measure of preference of one criterion over another are methods based on pairwise comparisons [3], and they are the AHP method, BWM, and DEMATEL method [8]. Nevertheless, the method most often used for determining the mutual influence of criteria and for determining the diagram of relational relationships is the DEMATEL method (except for the widely used BMW method due to the comparison of fewer pairs) [9].

Each of these methods, in addition to their qualities, functionality, simplicity, and applicability, also has disadvantages. One of the methods that is often used, which relatively well overcomes the shortcomings of the mentioned methods, is based on the Level Based Weight Assessment model (LBWA), whose algorithm requires a small number of comparisons in pairs of criteria and whose mathematical algorithm is rational and logical [10]. Through research conducted on various examples [11, 12, 13], and by comparing the values of weighted coefficients obtained by applying the LBWA model with the values of weighted coefficients in other studies, almost identical weight values were obtained. Thus, validating the LBWA model. The LBWA model has a number of advantages that favor it for application, especially because it is a model that is flexible to additional corrections of the values of the weighted coefficients. In addition, this model is suitable for modeling problems in an uncertain environment, because even in that case it enables the processing of expert preferences [10].

Therefore, the subject of this paper is to determine the weight coefficients for the criteria that are selected by the organization and then rank the standards accordingly.

Before defining the criteria and rules for selecting standards and tools, the next chapter provides a description of the four most commonly used standards that will be the subject of selection in this paper. In the third chapter, criteria (28 in total) covering IT activities in almost all observed organizations are defined. In addition, expert assessments from this field are given on the fulfillment of these criteria in the proposed selection standards. Finally, in the chapter of Standard selection on the assumption that the company chose the methodology LBWA (Level Based Weight Assessment) for the selection of weight coefficients for the criteria was proposed, a new model for calculating the ranking of standards was presented, i.e. the choice of the best. The conclusion of the paper is that the presented procedure for choosing standards is not complicated, that it is very successful, and that in this way the proposals were more easily accepted and implemented in the fastest way.

2. Selection Standard

Alternatives (A_1, A_2, A_3 i A_4) are presented through the most widespread standards currently applied for recording and subsequent process analysis:

- DFD (Data Flow Diagram) (A_1)
- IDEF0 (Icam DEFinition for Function Modeling, where ICAM is an acronym for Integrated Computer Aided Manufacturing) (A_2)
- IDEF3 (Integrated DEFinition for Process Description Capture Method) (A_3), i
- BPMN (Business Process Model and Notation) (A_4).

Each of these standards has its own capabilities, specifics, advantages and disadvantages, and they have certain limitations in relation to the type of process being recorded.

2.1. Data Flow Diagram

Data flow diagram (DFD) or Data flow chart (DFC) is used in process modeling, and it focuses on the flow of data between processes while analyzing data storage for maximum availability and reduced search time.

This is a set of processes that are executed in parallel and represents a set of parallel processes and connections of data flow and storage between them.

It is graphically described through processes, data flow, data storage, and external entities. A process is a set of operations that transform input data into output data and define the process with input data flow based on a clearly specified processing logic, using data from the input flow or data storage, with the result of processing being output data flow and/or updated data in data storage. It is indicated by a numerical label and the name of the process.

Data flow is a path (graphically indicated by an arrow) through which groups of objects (documents, forms, templates, etc.) pass, showing the elements between which the data flow occurs.

Data storage (file, folder, database, etc.) is used for storing data and is defined as data flow at rest, connected only to system processes via data flow. It allows for the accumulation of data flow content and is connected to processes based on the principle of input/output to data storage.

External objects used in the standard are expected to establish connections with objects outside the context of the observed system and represent sinks and/or sources of data flow.

Data flow enables a view of all activities within the process but is limited to a so-called "paged" display where the process is divided into pages related to the display format. This way, the functionality of a global overview of the process is significantly hindered, especially when complex processes are involved. Likewise, it fully covers the recognition of participants in the process but less so organizational structure. Fig. 1 shows a part of the diagram that contains process for liquid assets loan approval.

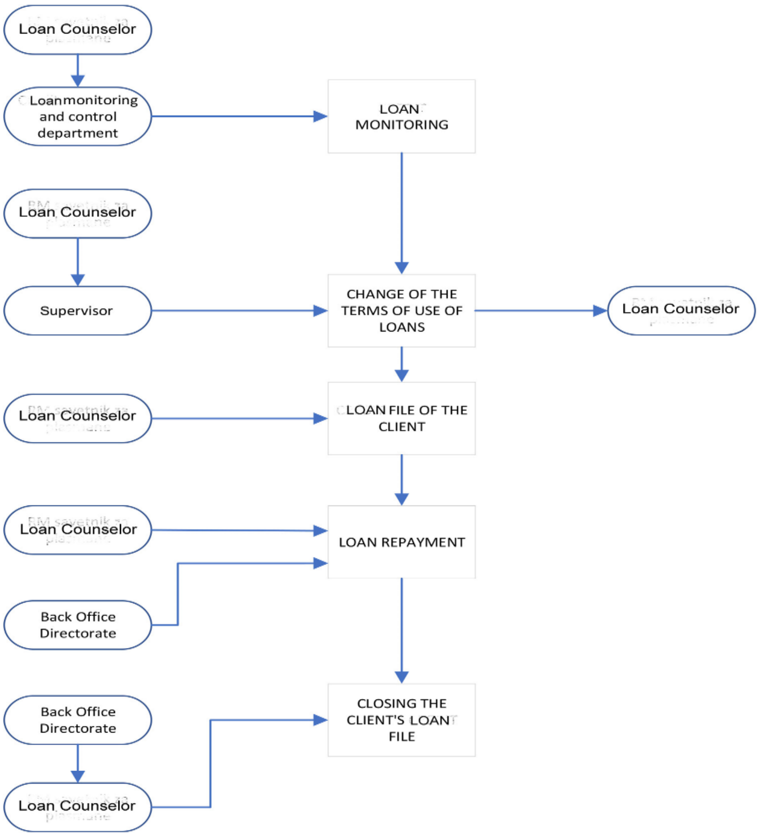

Fig. 1 Example of a part of diagram for liquid assets loan approval according to DFD standard

The DFD standard has been the only standard for decades for defining processes within a quality system and is supported by numerous (or almost all) software tools.

In addition to the mentioned limitation related to the "paged" format, another limitation occurs when there are multiple transitions from one diagram to several separate diagrams that represent parts of the process, where the global overview of the entire process is greatly hindered.The standard does not support conditional branching and merging of data flow, and does not provide insight into the duration of activities or the starting/ending time and conditional points of activities. As this standard has been in use for the longest time, numerous software tools allow for transferring recognized elements into other standards.

2.2. Icam DEFinition for Function Modeling

This standard (IDEF0) allows us to have a detailed overview of all activities by using a depth-based view, where at each deeper level we have more detail regarding activities and the flow between them. The standard enables the display of the same process depending on the depth used for observation, with the tracking of certain constraints related to grouping arrows (flow).

The disadvantage of this standard is that there is no comprehensive, unified, detailed overview of the entire model, while at the same time, it is an advantage because the designer can focus on a specific detail within the process.

When it comes to the criterion of software support, this standard has been covered by numerous high-quality tools for its application since its publication, and this remains true today.

The standard defines certain limitations that apply to the number of allowed activities per diagram (3-6, max 8), the obligation to align input/output arrows on hierarchical diagrams (also 3-6, max 8), division of arrows according to the ICOM (Inputs, Controls, Outputs, Mechanisms) rule, etc.

The tool has also enabled the creation of entities at a global level, their structure through attributes, as well as CRUD (Create, Read, Update, Delete) IRUN (Insert, Retrieve, Update, Nullified) rules for their use, but this does not belong to the characteristics of the standard and is not shown in this paper. Fig. 2 presents one of the diagrams of the cost calculation process in production.

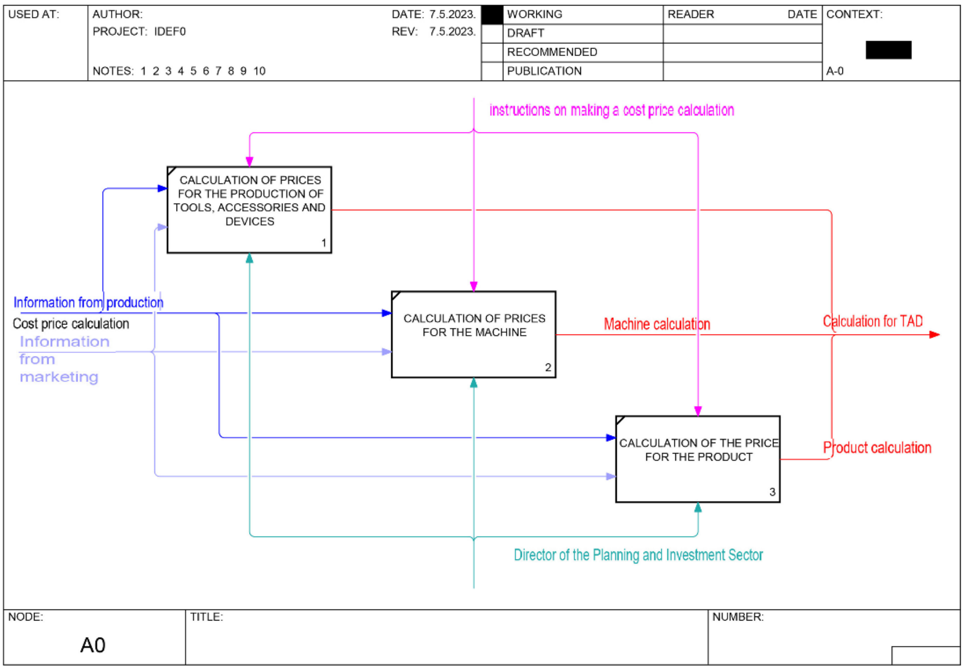

Fig. 2 Example of diagram of cost calculation according to IDEF0 standard

Given the criteria necessary for multi-criteria analysis [14, 15], the standard fully recognizes the elements related to objects (input, output, and internal), enables the identification of elements that control and manage the process, the structure of the process and description of process activities, participants in the process, and is easy to use. However, the standard performs poorly or does not recognize the sequence, branching, and objects that affect activities. Also, a major drawback is that it does not recognize the ability to define the duration of each activity and the moment of its start and end.

In the case of complex processes that have a deep hierarchical structure, it is difficult to move from level to level and understand their connectivity and activity integrity across levels.

The second constraint refers to the "stacking-positioning" of activities on the diagram, where the most important activity is positioned in the top left corner. The key constraint that has exceptional significance in interpreting the flow of the process and the impact of arrows on activities is the reversed position of the arrow entering the activity (ICOM rule), which is specific for this standard.

The standard defines the possibility of transferring entities identified in the IDEF3 standard to the IDEF1X standard (Integration DEFinition for information modeling), but this possibility is not elaborated IDEF3.

2.3. Integrated DEFinition for Process Description Capture Method

The IDEF3 standard [16] describes the behavior of a system. This model includes certain constraints of the system, including resources as well as time relationships.

The basic building blocks of IDEF3 diagram descriptions are: activities, connections, references, decision points and decompositions. Fig. 3 presents an example of one of the diagrams of equipment maintenance flow.

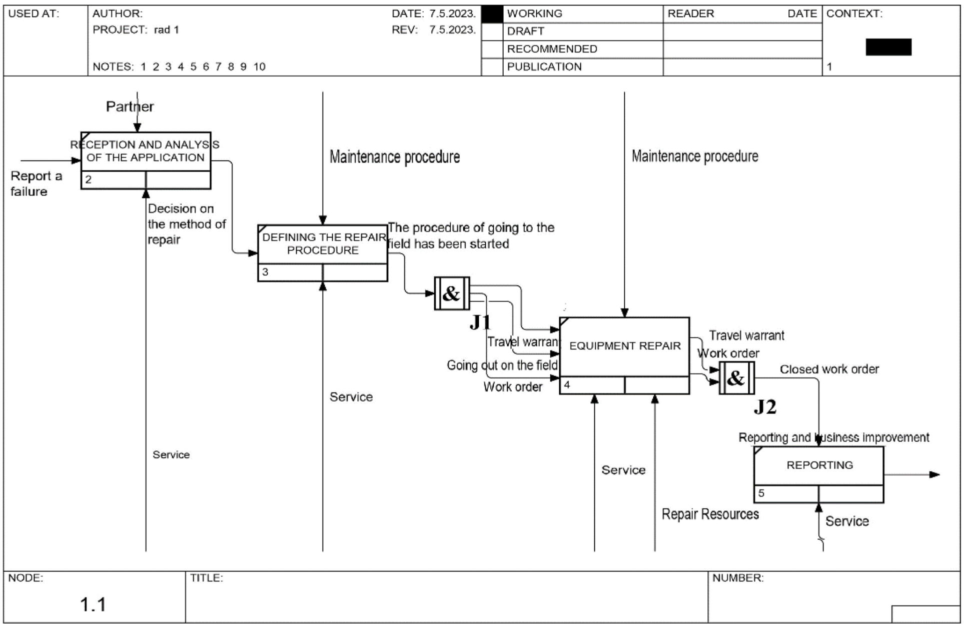

Fig. 3 First level of equipment maintenance flow according to IDEF3 standard

During the analysis, UOBs (Units of Behavior) and their mutual links that determine the dynamics of the process were identified. Through decision points, the sequence and simultaneity of activities, as well as the parallelism at the beginning and end of certain

UOBs, were defined. This allows for the determination of the shortest, longest, and optimal routes for performing certain segments of UOBs, as well as the entire observed process.

The standard enables the process and activity-structural system analysis to decompose into the atomic level of indivisible UOBs. The rules on the number of activities and arrows are the same as those in the IDEF0 standard, but unlike it, the option of determining the duration and cost of each activity is defined within the standard itself, but not the start and end times of activities. When it comes to the criterion of software tool prevalence, this standard has not been recognized to a sufficient extent by software manufacturers, so it has not had the same level of prevalence as, for example, IDEF0.

An important characteristic of this standard, which sets it apart from others, was its application for defining simultaneity and sequencing in the execution of UOBs. Based on these parameters, as well as the duration of each UOB, critical and optimal paths were defined and direct process optimization was enabled.

Within the standard, "data" objects are not provided, which on the other hand significantly limits the possibility of process analysis, especially in determining all elements that participate in the process, as well as the mutual influences of objects and UOBs.

2.4. Business Process Model and Notation

This standard (BPMN) [17] is the newest of these four and enables structural system analysis to be performed, as well as activities, flows, objects, and decision points to be recognized. In this standard, the order of activity execution is respected, so the first activity in the sequence is always on the left side and goes to the right. Arrows, which indicate flow, have inputs/outputs on the left and right sides and only serve to emphasize the process realization flow.

The specificity of this standard is the richness of graphical symbols [18] related to decision-making, as well as symbols indicating the way a particular activity is started depending on the initiator. This standard, like the previous two, has the ability to display structural system analysis, or a more detailed representation of a certain complex activity, which is decomposed [19]. According to the standard, this decomposition takes place on the same diagram, although some tools, such as PowerDesigner, allow for the generation of a separate diagram.

The standard includes objects (dataObject and dataStore) that provide a generalized description of the structure of an object involved in the process, but the standard does not define the possibility of recognizing the impact of that object on an activity and vice versa, nor does it define the structure of that object. The standard [20] also does not define or recognize the possibility of exchanging a dataStore object with a data model. Fig. 4 presents one example of BPMN Model of Data Migration.

Considering the trend in information technology, where there has been a lot of emphasis on graphic design lately, and the fact that this standard has visually appealing symbols, both in shape and possible colors, software manufacturers have produced numerous tools that use this standard as primary or one of the standards for process modeling, both in terms of quantity and quality [21].

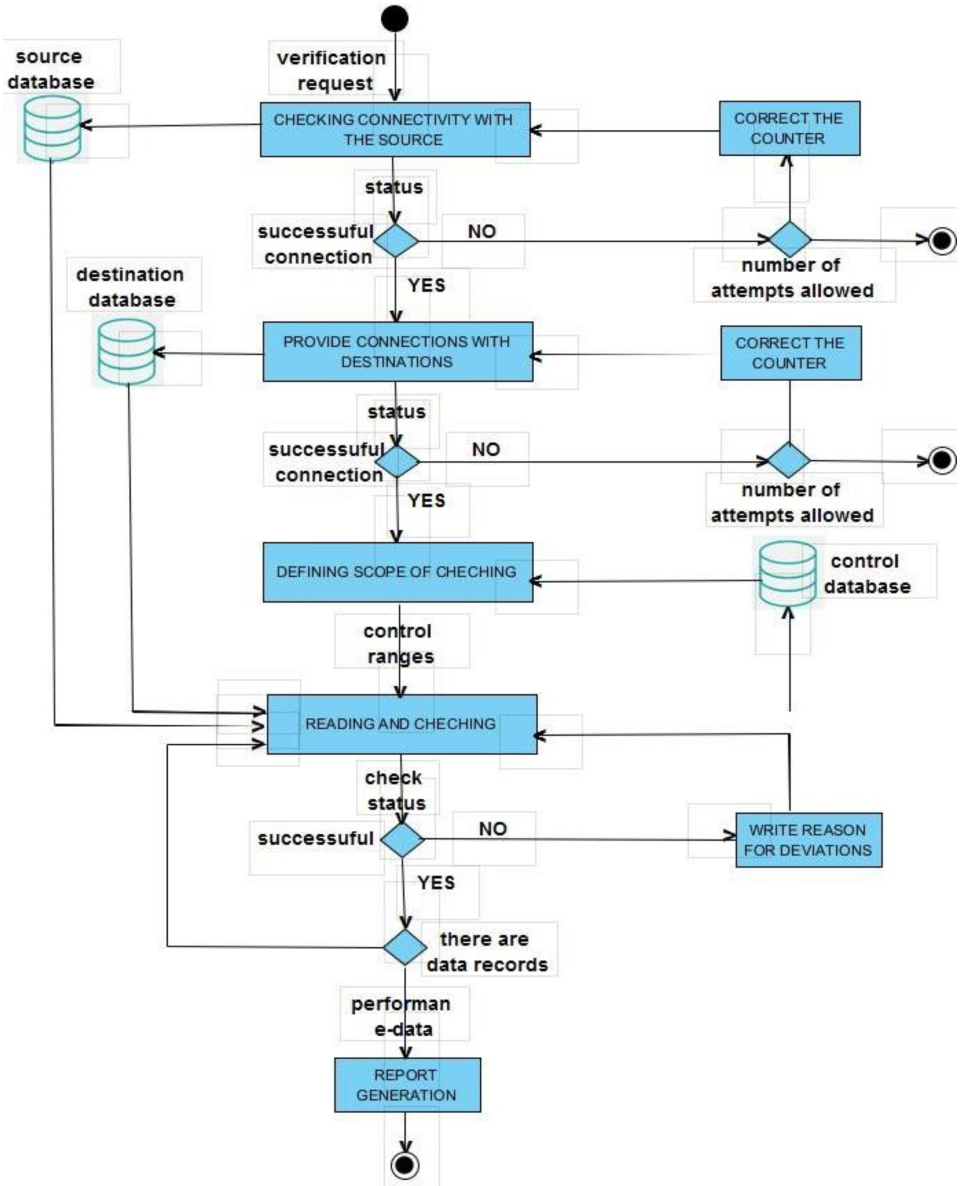

Fig. 4 An example of an external communications office activity according to BPMN standard

3. SELECTION CRITERIA AND THEIR FULFILLMENT IN STANDARDS

Based on the review of relevant literature [22, 15], and consultations with experts in this field (people with years of experience working with CASE (Computer Aided Software Engineering) tools for process recording, analysis, and improvement in various organizations with various technologies) [23, 24], we propose the following criteria with expert ratings: "how well the criteria are fulfilled by each standard".

Industry criteria, are presented in Table 1 and those are:

1. Recognition and description of objects that have emerged in the field and that enter the observed process, their structures and interactions with the process and activities within the process. These objects cannot be changed within the process,
2. Description of internal objects that are formed during the process and define the impact of objects on activities and vice versa, the impact of activities on objects, as well as their structure,
3. Description of objects that are the result of the process and exit the process, and affect the execution of other processes in the environment,
4. Recognition of all activities within the process and defining their functions,
5. Recognition of the start and end of the activity's duration,
6. Recognition of participants (owners, performers, and other stakeholders) in the process,
7. Recognition of the sequence of events, as well as parallel and simultaneous execution of activities within the observed process,
8. Recognition of branching and merging, a criterion that allows showing that certain activities can occur in parallel or sequentially,
9. The ability to structure (decompose) the process, which allows complex activities to be broken down into sub-activities,
10. Recognition of process control possibilities, which ensures the identification of control functions within the process,
11. Recognition and structuring of data storage, which enables the decomposition of data storage into basic attributes, type, and unambiguousness,
12. Recognition of the structure of an object, which enables the object to be decomposed into basic attributes, type, and unambiguousness,
13. Recognition of organizational structure, which enables the definition of the structure, interconnection, and hierarchy of an organization,
14. Recognition of relationships between systems, which enables precise and unambiguous definition of the possible connections between different processes within one system, as well as the connection of systems at a higher level.
15. Creating custom properties allows for the creation of new properties within a standard that are not otherwise provided by the standard, through the use of some existing ones,
16. Recognition of activity costs, which enables the valuation or estimation of the cost of conducting an activity,
17. Recognition of the frequency of activity occurrence enables the recognition and valuation of the number of times an activity is repeated during the process,
18. Conditioning the start of an activity enables the recognition of triggers that influence the initiation of the activity itself,
19. Conditioning the completion of an activity enables the recognition of conditions that allow the activity to be completed.

Table 1 Industry criteria - criteria with expert ratings

Criteria	DFD	IDEF0	IDEF3	BPMN
C_1	1.0	1.0	1.0	1.0
C_2	1.0	1.0	1.0	1.0
C_3	1.0	0.7	0.8	0.9
C_4	0.8	0.8	0.8	0.9
C_5	0.8	0.8	0.9	0.9
C_6	0.8	0.8	0.2	0.4
C_7	1.0	0.4	0.7	1.0
C_8	0.0	0.1	0.8	0.2
C_9	0.1	0.7	0.7	0.9
C_{10}	0.5	0.5	0.4	0.7
C_{11}	1.0	0.0	0.0	1.0
C_{12}	0.6	0.0	0.0	0.5
C_{13}	0.0	0.0	0.5	0.0
C_{14}	0.3	0.8	0.6	0.7
C_{15}	0.0	0.5	0.5	0.0
C_{16}	0.0	0.2	0.7	0.0
C_{17}	0.0	0.0	0.3	0.0
C_{18}	0.0	0.0	0.7	0.7
C_{19}	0.0	0.0	0.7	0.7

General criteria, are presented in Table 2 and those are:

20. The prevalence of software tools and their quality and degree of support for the standard,
21. Simplicity, a criterion that indicates an easy, intuitive, and graphically acceptable standard to users,
22. Upgradeability is a criterion that depends on options available in the standard itself,
23. Universality of standard application to different types of processes,
24. Application in military projects, which have their own specificity,
25. Application in quality systems, which have their own specificity,
26. Application in complex projects,
27. Required designer experience defines how much experience a designer needs to be able to apply the standard,
28. Multiplication of projects gives value to the possibility of multiplying the standard by transferring recognized elements to another standard.

Table 2 General criteria

Criteria	DFD	IDEF0	IDEF3	BPMN
C_{20}	0.9	0.3	0.6	0.9
C_{21}	0.9	0.9	0.3	0.8
C_{22}	1.0	0.2	0.3	0.7
C_{23}	0.3	1.0	0.5	0.5
C_{24}	1.0	0.6	0.4	0.5
C_{25}	0.9	0.8	0.7	0.5
C_{26}	0.5	0.8	0.6	0.9
C_{27}	0.8	0.8	0.6	0.7
C_{28}	0.4	0.8	0.6	0.9

According to the experiences of experts, these criteria have emerged in cases of organizations and institutions that they have observed and worked in as system analysts. In the case of a need for new criteria in a particular organization, they could be introduced into the model in the same way as those listed [25, 26]. In this paper, we limit ourselves to the criteria listed.

4. Standard Selection

4.1. Criteria and Weight Coefficient Selection

One of the newer methods for determining weight coefficients of the criteria is LBWA method. Žižović and Pamučar [10] were the first authors who demonstrated the method. Characteristics of this method are that it can be used in both individual and group decision-making, it is a relatively simple mathematical calculation and rational mathematical algorithm, where the simplicity of the method does not depend on the number of criteria [10]. The first thing we do while using LBWA method is defining criteria. If k is the number of criteria, then we have a set of criteria S = {C1, C2, ... , C_k}. After that, we start using the LBWA method according to the steps by Žižović and Pamučar [10].

The choice of criteria is made within the organization that is undergoing organizational change [27, 28, 29]. Which of the listed 28 criteria the organization will take into account depends on various factors. Primarily, it is a question of what needs to be changed, what is the technology of work, what are the work processes in the organization, what are the suggestions of analysts, what are the desires and ambitions of management, what are the requirements of the organization's owner, etc.

In this paper, we assume that the organization, together with the analyst, has chosen k criteria (this number is generally less than or equal to 28).

Therefore, let's assume that the criteria have been selected and arranged in order of importance for the decision maker, i.e., top management of the organization:

$$C_{X1}, C_{X2}, \ldots C_{Xk} \tag{1}$$

As we assumed that these *k* criteria were selected from the listed 28, it means that we can represent the problem of choosing the most optimal standard as a multi-criteria model of the following form, as presented in Table 3.

Table 3 Multi-criteria model

		CRITERIA			
		C_{x1}	C_{x2}	. . .	C_{xk}
STANDARDS	A_1	p_{11}	p_{12}		p_{1k}
	A_2	p_{21}	p_{22}		p_{2k}
	. . .				
	A_t	p_{t1}	p_{t2}		p_{tk}

In our case t = 4, i.e. $A_1 \equiv$ DFD, $A_2 \equiv$ IDEF0, $A_3 \equiv$ IDEF3, $A_4 \equiv$ BPMN, and p_{1r}, p_{2r}, p_{3r}, p_{4r} (r = 1, ... , k) are the corresponding values provided in the preceding part.

In order to set the procedure for this problem, it is necessary to determine the weight coefficients of the criteria C_{x1}, ... C_{xk}, i.e. to determine numbers W_{x1}, ... , W_{xk}, $((Wxi > 0)$ and $\sum_{i=1}^{k} Wxi = 1)$.

The procedure will be set using LBWA method provided in [10]. As the criteria C_{x1}, ... C_{xk} are ordered by strength, it follows that:

$$Wx1 \geq Wx2 \geq \ldots \geq Wxk > 0$$

Following the LBWA method, the criteria are to be grouped as follows:

- Group 1 are criterion C_{x1} and criteria that are of equal strength or between that and half of C_{x1}
- Group 2 are criteria that are exactly half of C_{x1} and between that and one third of C_{x1},
- Group 3 are criteria that are exactly one third of C_{x1} and between that and one quarter of C_{x1},
- ...

Group x Grouping ends with a group in which we place the weakest criterion C_{xk}. Then, we select number $r_0 \in R$, such that it is higher than the number of criteria in any of the previous groups.

Furthermore, let an optional group *m* be made out of criteria:

$$Cxp, \ldots\ Cxq \tag{2}$$

which are such that criterion C_{xj} $(Ip \leq Ij \leq Iq)$ is assigned number

$$f(C_{xj}) = \frac{r_0}{mr_0 + I_{xj}} \tag{3}$$

where $0 \leq I_{xj} < r_0$, and with r_o being the selected fixed positive number and where:

$$0 \leq I_{xp} \leq \ldots \leq I_{xj} \leq \ldots \leq I_{xq} < r_o \tag{4}$$

For C_{x1} it is understood that $I_{x1} = 0$, $f(C_{x1}) = \frac{r_0}{r_0} = 1$)

Then the criterion C_{x1} is assigned number W_{x1},

$$W_{x1} = \frac{1}{1 + f(C_{x2}) + \cdots + f(C_{xk})} \tag{5}$$

and criterion C_{xk} is assigned number

$$W_{xk} = f(C_{xi}) * W_{x1} \quad (i = 2, 3, ..., k) \tag{6}$$

NB 1: It is obvious that the selection I_{xj} in the requested range is reached as

$$W_{xj} = \frac{1}{m} W_1 \quad \text{for} \quad I_{xj} = 0$$

For $0 < I_{xj} < r_o$ we get $\frac{1}{m+1} < W_{xj} < \frac{1}{m}$.

For $0 < I_{xj} < I_{xj} + 1 < r_o$ we get $\frac{1}{m+1} < W_{xj} + 1 << W_{xj} < \frac{1}{m}$

If W_{xj} is to be in the first half of the interval ($\frac{1}{m+1} < \frac{1}{m}$), I_{xj} must be selected so that

$$I_{xj} \in \left(\frac{r_o}{2m+1}, r_o\right) \tag{7}$$

If W_{xj} is to be in the second half of the interval ($\frac{1}{m+1} < \frac{1}{m}$), I_{xj} must be selected so that

$$I_{xj} \in (0, \frac{mr_o}{2m+1}) \tag{8}$$

In a similar way, the interval ($\frac{1}{m+1}$, $\frac{1}{m}$) can be set to four equal parts by selecting points from the interval (0, r_o) that will be reflected in the appropriate points,

$$(0, \frac{mr_o}{4m+3}, \frac{2mr_o}{2m+1}, \frac{3mr_o}{4m+3}, r_o) \tag{9}$$

and selecting appropriate points for I_{xj} depending on where we want W_{xj} to be located. Clearly, this is possible for any for any desired division of the interval ($\frac{1}{m+1}$, $\frac{1}{m}$).

4.2. Ranking Alternatives (Standards)

The next step in the standard selection process is the matrix transformation Table 3 by multiplying each column in the matrix Table 3 with the weight coefficient matching the criterion in the column, as presented in Table 4. So we form the new matrix:

Table 4 Matrix of decision making

		CRITERIA			
		C_{x1}	C_{x2}	. . .	C_{xk}
STANDARDS	A_1	$W_{x1}*p_{11}$	$Wx2*p_{12}$		$W_{xk}*p_{1k}$
	A_2	$W_{x1}*p_{21}$	$Wx2*p_{22}$		$W_{xk}*p_{2k}$
	. . .				
	A_t	$W_{x1}*p_{t1}$	$W_{x2}*p_{t2}$		$W_{xk}*p_{tk}$

An exception to the previous one is the case when t = 4, as presented in the example in Table 5.

Table 5 Matrix of decision making - example

		CRITERIA			
		C_{x1}	C_{x2}	. . .	C_{xk}
STANDARDS	A_1	$W_{x1}*p_{11}$	$W_{x2}*p_{12}$		$W_{xk}*p_{1k}$
	A_2	$W_{x1}*p_{21}$	$Wx2*p_{22}$		$W_{xk}*p_{2k}$
	A_3	$W_{x1}*p_{31}$	$W_{x2}*p_{32}$		$W_{xk}*p_{3k}$
	A_4	$Wx1*p_{41}$	$W_{x2}*p_{42}$		$W_{xk}*p_{4k}$

Therefore, in this matrix we add up all the elements for each type and we get

$$V(A_i) = \sum_{j=1}^{k} W_{xj} P_{ij} \tag{10}$$

It is obvious that $0 \le W(A_i) \le 1$ (because $\sum_{j=1}^{k} Wxi = 1$ i $0 \le p_{ij} \le 1$ for each j = 1, ...k i i=1, ..., s. Additionally we define that A_i is better than A_j if and only if $V(A_i) > V(A_j)$.

In case that $V(A_i) = V(A_j)$ the better alternative is the one with higher value according to the first criterion. If both values are equal, then the better alternative is the one with higher value according to the second criterion and so on until the last criterion.

If $V(A_i) = V(A_j)$ and all values are equal, then the selection is random.

This selection method is called simple additive weighting [30]. Naturally, the best ranked standard is selected.

Example 1: let us assume that system analysts and managers of an organization have selected the criteria:

$C_1, C_2, C_4, C_5, C_6, C_9, C_{10}, C_{14}, C_{15}, C_{26}$ i C_{27}

from the criteria list and ordered them in strength:

$C_1 \rightarrow C_2 \rightarrow C_4 \rightarrow C_5 \rightarrow C_{14} \rightarrow C_{15} \rightarrow C_{26} \rightarrow C_{27} \rightarrow C_6 \rightarrow C_9 \rightarrow C_{10}$

and then determined that group 1 contains the criteria C_1, C_2, C_4, C_5, while the remaining criteria are in group 2, where C_{14}, C_{15}, C_{26} are exactly half of the strongest, C_6 and C_{27} so that they are equal in the first quarter to C_1, while C_9 and C_{10} are equal in the second quarter to C_1.

This is some examples how to selecting the best standard!

Solution: We select $r_0 = 10$. From the problem, it follows that the first four are in group 1

$$I_1 = 0,\ I_2 = 0,\ I_3 = 0,\ I_4 = 0 \quad \Rightarrow \quad f(C_1) = f(C_2) = f(C_3) = f(C_4) = 1$$

The rest are in group 2, such that:

$$I_{14} = 0,\ I_{15} = 0,\ I_{26} = 0 \quad \Rightarrow \quad f(C_{14}) = f(C_{15}) = f(C_{26}) = \frac{10}{2*10} = 0.5$$

Interval [0, 10] is divided by points $\frac{20}{11}, \frac{20}{5}, \frac{60}{9}$ and we arrive at $(0, \frac{20}{11}, \frac{20}{5}, \frac{60}{9}, 10)$

According to the problem, we select I_{27} i I_6 from the first quarter $0, \frac{20}{11}$, $I_{27} = I_6 = 1$,

while we select I_9 i I_{10} from the second quarter $I_0 = I_{10} = 2$ and we get $\frac{20}{11}, \frac{20}{5}$.

$$f(c_{27}) = f(c_6) = \frac{10}{21} = 0.476 \text{ as well as}$$

$$f(c_9) = f(c_{10}) = \frac{10}{22} = 0.455 \text{ so that}$$

$$W_1 = \frac{1}{1+f(C_2)+f(C_4)+f(C_5)+f(C_{14})+f(C_{15})+f(C_{16})+f(C_{27})+f(C_6)+f(C_9)+f(C_{10})} = \frac{1}{7.362}$$

$$W_1 = 0.136$$

i.e.:$W2 = 0.136, W4 = 0.136, W5 = 0.136, W14 = 0.068, W15 = 0.068, W26 = 0.068, W27 = 0.065, W6 = 0.065, W9 = 0.062$ i $W10 = 0.062$.

As the starting matrix of the problem is provided in a Table 6, it follows:

Table 6 Starting matrix of problem

	C_1	C_2	C_4	C_5	C_{14}	C_{15}	C_{26}	C_{27}	C_6	C_9	C_{10}
A_1	1.0	1.0	0.8	0.8	0.3	0.0	0.5	0.8	0.8	0.1	0.5
A_2	1.0	1.0	0.8	0.8	0.8	0.5	0.8	0.8	0.7	0.7	0.5
A_3	1.0	1.0	0.8	0.9	0.6	0.5	0.6	0.6	0.2	0.7	0.4
A_4	1.0	1.0	0.9	0.9	0.7	0.0	0.9	0.7	0.4	0.9	0.7

By multiplying elements of each column with the previously calculated matching weight coefficients, we get the complete matrix of the problem, Table 7:

Table 7 Matrix of decision making

	C_1	C_2	C_4	C_5	C_{14}	C_{15}	C_{26}	C_{27}	C_6	C_9	C_{10}
A_1	0.136	0.136	0.109	0.109	0.020	0.000	0.034	0.052	0.052	0.006	0.031
A_2	0.136	0.136	0.109	0.109	0.054	0.034	0.054	0.052	0.052	0.043	0.031
A_3	0.136	0.136	0.109	0.122	0.041	0.034	0.041	0.039	0.013	0.043	0.025
A_4	0.136	0.136	0.122	0.122	0.048	0.000	0.061	0.046	0.026	0.056	0.043

By adding up lines, we get:

$$V(A_1) = 0.685$$

$$V(A_2) = 0.810$$

$$V(A_3) = 0.739$$

$$V(A_4) = 0.796$$

Therefore, the best standard is A_2, i.e. IDEF0, followed by BPMN, IDEF3 and finally DFD.

5. Conclusion

Management of business processes in any business segment or development is crucial for achieving maximum efficiency and attaining strategic objectives [31,32]. Standards for modeling business processes are always a current topic, and there has always been an effort towards their improvement. Standards define the documentation, analysis, and reengineering of existing processes. They serve as a foundation for generating program code to support business operations or the development of new systems. Additionally, they are used as a basis for blockchain algorithms in creating smart contracts and serve as a foundation for implementing Robotic Process Automation (RPA) and other related technologies.

The system analyst plays a crucial role in organizing the modeling of business processes, selecting and implementing standards, as well as choosing analytical methods for system design to solve business problems and improve operations [33]. The selection of criteria depends on various factors such as work technology, organizational workflows, organizational changes, organization goals, management experience, the architecture of the developing system, and more. These factors directly influence the choice of standards. In the paper, 28 key criteria covering IT activities were mapped. Experts, system analysts for selecting standards for business process modeling, provided assessments of the representation of these criteria in the proposed standards (DFD, IDEF0, IDEF3, and BPMN). Based on their needs and capabilities, the company proposed the use of a multi-criteria model for determining weight coefficients for the selected criteria, known as the Level-Based Weight Assessment (LBWA) model. After selecting the criteria and determining the weight coefficients, the alternatives, in this case, the standards, were ranked using the simple weighted sum method.

The paper presents four different scenarios for ranking the standards. According to the first scenario, the best standard is IDEF0, followed closely by BPMN. In the second scenario, BPMN is determined to be the best standard. In the third scenario, IDEF3 is identified as the best standard. Finally, in the fourth scenario, the DFD standard is ranked as the best. In cases where two standards have the same significance, the final decision regarding the choice will be left to the decision-maker.

With the development of technologies and the conceptualization of new business requirements and goals, it is inevitable that the list of standards will expand and evolve with new ones. In the era of artificial intelligence, the aim is to map the way humans work, think, and reason. The paper presents a methodology for determining a series of key criteria that the system analyst considers when making decisions about selecting standards for modeling processes in a specific business environment [34]. Based on everything presented, there is a clear trend towards the development and implementation of intelligent systems for decision-making regarding the choice of standards for the development of specific business systems and processes.

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