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FORMING OF INTEGRATED UNDERSTANDING OF PROJECT TERMS: FAULK'S ALGORITHM AS ONE OF THE FORMALIZED APPROACHES

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Abstract. The success of the project implementation depends not only on the highly qualified professional project team. Success also depends on a clear (integrated) understanding of all project processes by all stakeholders. Integrated understanding is based on a clear understanding of project terms and concepts. Such terms and concepts are captured in conventional project management methodologies, methods, and approaches. However, they need to be understood not only by industry experts, but also by some stakeholders. Lack of an integrated understanding of terms and concepts leads to misunderstanding of project actions and, therefore, delays in project implementation, which is determined by the time of integrated understanding formation. The necessary terminological volume for stakeholders can be determined by applying a frequency dictionary approach, which allow all terms and concepts to be ranked according to their appearance and use at different stages of the project life cycle. The purpose of the article is to present a formalized approach to implementing a consistent presentation to capture project terms and concepts by stakeholders. To this end, it is proposed to use the Faulk's algorithm to construct an effective acquisition sequence. If there is a certain set of terms, each of which must be appropriately mastered, and between these terms there are certain dependencies (sequence of mastering), then the problem of constructing the best path to mastering can be solved by applying a Faulk's algorithm based on a graph theory approach.

Keywords: project management; terms; integrated understanding; Faulk's algorithm; graph theory

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Additional disciplines: information and communication; mathematics

1. Introduction

Economic processes, currently taking place in society, are based on globalization processes. The main consequence of globalization is the division of labor, migration (and, as usual, concentration) across the planet of capital, labor, production resources, standardization of legislation, economic and technological processes, as well as the approximation and merging of different countries' cultures. The process of globalization that exists at present in society, could not affect the processes of project management.

There are many methodologies, methods and approaches to project management that are well known to both professionals and beginners. Everyone knows about PMBoK, PRINCE, Agile, Scrum and etc. The purpose of methodologies, methods and approaches is to standardize certain areas of project management knowledge in order to provide a more managed approach to projects and programs. Some fields of knowledge are easily standardized. However, there are some that are more advisable from a management standpoint. Among them there are management of communications and management of stakeholders.

One of the problems as one of the effects of globalization on project management is the diversity of cultures. The diversity of cultures is reflected in the wide involvement of professionals from different countries in project management. Each country brings its cultural diversity to the project process, which can be reflected in the interpretation of well-known project approaches and the creation and use of "own". Practical experience shows that implementation of projects faces one of the important factors that directly affects the effectiveness of implementation - an integrated understanding of the identified goals, values, strategies and objectives of the project or program implementation, as well as their unambiguous use at management level. Substantial "misunderstandings" arise from the presence of various factors of influence, including the existence of different approaches to the management, interaction, communication, knowledge management and culture of the parties involved in the project and program implementation.

2. Literature review

A considerable number of terms in project management are interconnected to related disciplines. However, the interpretation of terms has its specificity. The simplest example to cite is the term "project". Turning to the dictionary (Dictionary.com), we get the following meanings:
1. something that is contemplated, devised, or planned; plan; scheme.
2. a large or major undertaking, especially one involving considerable money, personnel, and equipment.
3. a specific task of investigation, especially in scholarship.
4. to propose, contemplate, or plan.
5. to throw, cast, or impel forward or onward.

According to Project Management Institute (2013), a project is temporary in that it has a defined beginning and end in time, and therefore defined scope and resources. And a project is unique in that it is not a routine operation, but a specific set of operations designed to accomplish a singular goal. Even in this example, there can be seen the diversity of understanding of only one term. According to the theory of conceptual integration proposed by G. Gilles Fauconnier a person "uses a great deal of cognitive resources during speech, evoking numerous models and frames, although linguistic forms do not carry much information, but they are based on a chain of cognitive events in the subject's mind." (Fauconnier, G. 1999). Stakeholders have their own experience, so their thinking frames may differ, and substantially, from thinking frames of a project manager. "In cognitive linguistics, a frame is called an appropriate set of knowledge about stereotypical situations and actions, which is verbalized by linguistic means, at the same time the meanings of the terms are regarded as special structures that are based on real situations" (Alekseyeva, M., 2009).

To create an integrated understanding of project terms, the project manager must ensure the uniqueness of the "cognitive frames" of all stakeholders in the project process. It should be noted that stakeholders are unlikely to agree to take a course in basics of project management, and the project manager, in its turn, is not provided with the appropriate time resource. Lack of integrated understanding will significantly increase project implementation time, and may even lead to its closure. Therefore, it is necessary to find certain approaches that will provide the formation of an integrated understanding of the project terms by all stakeholders.

First of all we can turn to pedagogical approaches to the formation of a professional thesaurus. The following principles are applied in such approaches (Veidt, V. 2019):
1. The principle of consistency and systematicity, in which we mean the continuity of the previously studied material and the integrity of learning terms based on the construction of concepts and terms that are subordinate to a certain logic.
2. The principle of consciousness and activity, which aims at the conscious activity of learners in forming a system of knowledge, independence in the choice of ways to achieve learning outcomes.
3. The principle of strength and validity of learning outcomes, which can be realized if the learner, when memorizing new training material, refers not to mechanical memory, but to content.
4. The principle of science and fundamentality implies the selection of educational material in class so that it not only reflects the current level of development of pedagogical science, but also allows to answer the problematic questions of educational practice.

Qualitative result can be obtained due to the holistic and optimal adherence to the practice of training principles. Applying all of these principles requires time and substantial training for project managers on the implementation of such training. This is usually not possible.

Another approach that can be applied is to create a topic model. According to (Chang, J. & Blei, D.M. 2009), “topic model – is a collection of text documents that defines which topics each document refers to and what words (terms) make up each topic“. “The transition from the space of terms to the space of found topics allows to solve the synonymy and polysemy of terms, as well as solving topic tasks such as topic search, classification, summarization and annotation of document collections and news feeds“. This model is effective and widely used in areas such as machine learning and natural language processing. For a certain goal achievement, applying a topic model is not an approach that is effective enough. Because, we are not interested in the selection of certain documents by topic, but the formation of the correct thematic interpretation of concepts.

The best, in our opinion, is an approach based on creating a certain mixed mental space that will provide an integrated understanding (Verenych, O. 2016). Creating such a space is described in detail in (Verenych, O. & Dorosh, M., 2017). This approach is based on the creation and implementation of a single conceptual framework. In general, the conceptual framework is presented in detail in the framework and standard documents of project management, an example of which can be considered PMBoK (Project Management Institute, 2013).

On the other hand, in (Project Management Institute, 2013) there are more than 200 terms. As experience shows, stakeholders do not need knowledge of all these terms. Knowledge of basic terms is required for integrated understanding. In addition, it is necessary to study them as they emerge, apply, disseminate, interconnect with one another to understand the context of all project processes. One approach that can be applied to this is to use the frequency dictionary approach. Frequency dictionary approach allows you to create word sets (phrases) together with information about their appearance in texts. The use of frequency dictionaries to formulate the most commonly used terms is described in detail in (Verenych, O., 2018).

Frequency dictionaries allow you to define a pool of commonly used terms. However, approaches must be found to create a sequence of study. In this case, some formalized approaches may help. To this end, graph theory

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approaches appear to be the most appropriate. They are used to build a network model in project management, where the list of all works is represented by an oriented graph without contours and loops with inalienable weights of vertices and arcs. Also, graph theory approaches are applied to Network Analysis of Project Communication (Ohshima, N. & Akihito Kawashima, 2011). In addition, thematic modeling is based on probabilistic models, some of which are based on Bayesian networks, which are probabilistic models on oriented graphs (Soni, D., 2018).

However, the study of terms is also associated with a certain sequence. When the number of terms is small, the sequence of their study can be determined expertly. In the case of a large number of terms and the existence of certain relationships between them, determining the rationality of their study can be difficult. In this case, it is useful and efficient to consider certain methods in graph theory based on the construction of Hamilton's paths. They can also be used to study terms. Next, let's look at how to apply them.

3. Hamilton's paths and Faulk's algorithm

Using the sources (Kaufmann, A. & Faure, 1963) and (Site "Discretnaya matematica") we can give basic mathematical justifications.
We'll consider six elements, that will be defined as *A, B, C, D, E, F*. Among these elements are the relationships that are presented in table 1.

Table 1. The relationship between the elements

Relationships for A	**Relationships for B**	**Relationships for C**	**Relationships for E**	**Relationships for F**
$A<B$	$B\vert<C$	$C<D$	$E<D$	$F<D$
$A<D$	$B<D$			$F<E$
$A \not\lessgtr F$	$B \not\lessgtr E$			
	$B \not\lessgtr F$			

Source: Kaufmann, A. & Faure, 1963

We will use the next notations:
We will use the next notations:
< - defines that one element is a predecessor of another element (for example, $A<B$ defines that "the element *A* is the predecessor of the element *B*", in other words, the sequence is the element *A* and then the element *B*, not at once);
|<- defines that one element is the direct predecessor of another element (for example, $A|<B$ defines that "the element *A* is the direct predecessor of the element *B*", in other words, the sequence is the element *A* and then at once the element *B*);
$\not\lessgtr$ - defines that is explicit precedence between elements is absent (for example, $A \not\lessgtr F$ defines that "is not defined dependence precedence between elements *A* and *F*, in other words, the first element may be both the element *A* and the element *F*).
These relationships between elements can be presented in both a graph and a figure. The graph can be presented as a matrix. We will input "1" on the crossing of the row and column if elements have a connection.
For these conditions, the purpose of the problem is to find (if possible) path(-s) passing once and only once through each element and satisfy the above written relations. Such paths will be called the Hamilton's paths.
To explain, we give some definitions on graph theory (Site "Discretnaya matematica").
Definition 1. A chain is a path without repeating edges.
Definition 2. A Hamilton's graph chain is called its simple chain that passes through each vertex of the graph exactly once.

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Definition 3. The cycle of a graph passing through each of its vertices is called the Hamilton's cycle.
Definition 4. A graph is called a Hamilton's if it has a Hamilton's cycle.
We present the relation of Table 1 in the form of a graph (Fig. 1) and a matrix *M*.

$$M = \begin{array}{c|cccccc} & A & B & C & D & E & F \\ \hline A & 1 & 1 & 0 & 1 & 0 & 1 \\ B & 0 & 1 & 1 & 1 & 1 & 1 \\ C & 0 & 0 & 1 & 1 & 0 & 0 \\ D & 0 & 0 & 0 & 1 & 0 & 0 \\ E & 0 & 1 & 0 & 1 & 1 & 0 \\ F & 1 & 1 & 0 & 1 & 1 & 1 \end{array}$$

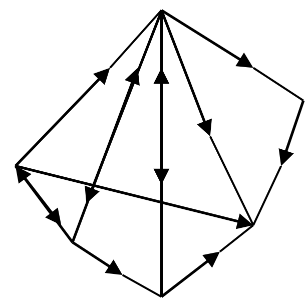

Fig 1. The ratios represented as a graph
Source: (Kaufmann, A. & Faure, 1963) and (Site "Discretnaya matematica")

The study of the graph shows that the element *D* is the absolute end point of each Hamilton's path (if one exists), since no arc has this element at its beginning, whereas an arc coming from any other element reaches element *D*. This property is expressed by the presence of units throughout column *D* and zeros throughout row *D* (obviously, with the exception of their intersection).

The opposite may also be the case: if for some element the whole row is made up of units and the whole column, except for the intersection, is made of zeros, this element is the beginning of each Hamilton's path (if one exists). The graph matrix can be simplified by pre-plotting all pairs of rows and columns corresponding to either the beginning or the end of each Hamilton's path.

In this case, row and column *D* can be omitted in advance. The matrix M' is the matrix *M* without the column and the row for the element *D*.

$$M' = \begin{array}{c|ccccc} & A & B & C & E & F \\ \hline A & 1 & 1 & 0 & 0 & 1 \\ B & 0 & 1 & 1 & 1 & 1 \\ C & 0 & 0 & 1 & 0 & 0 \\ E & 0 & 1 & 0 & 1 & 0 \\ F & 1 & 1 & 0 & 1 & 1 \end{array}.$$

Now we want to determine if there is such a path between some element serving as an input and some element serving as an output. The path should make a possibility to connect all the elements in such a way that it passes through each element only once.

To solve this problem, it is necessary to multiply the matrix M' by itself, replacing the usual arithmetic sum by the Boolean sum of elements.
T
he logical algebra (Boolean algebra) is a branch of mathematics that studies statements considered from the side of their logical values (truth or falsehood) and logical operations on them. The logical algebra allows encoding

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any statements whose truth or falsity are needed to prove, and then manipulate them like ordinary numbers in mathematics.

In Boolean algebra, logical factum and sums are represented as follows:
$0 \cdot 0 = 0, 0 \cdot 1 = 0, 1 \cdot 0 = 0, 1 \cdot 1 = 1, 0 \dot{+} 0 = 0, 0 \dot{+} 1 = 1, 1 \dot{+} 0 = 1, 1 \dot{+} 1 = 1$.
The point means "and" (not a multiplication) and the sign plus with point means conjunction "and/or" (not an adding).
What is the logical sence of the matrix's M' elements. $M^{[2]}$Suppose, we have to go from *A* to *C*.
Then:

a) there is no direct path from A to C;
b) there is a straight path leading from A to B and a path from B to C; accordingly, there is a path of length 2 from A to C;
c) there is no direct path from A to C;
d) there is no direct path from A to F, no path from F to C exists.

Since we are looking for a path that connects different points of a graph, instead of generating an arithmetic sum, like in a regular matrix product, we add a boolean sum.
The general approach to the multiplication a matrix on a matrix is presented below (for a matrix 2X2, but the general principle is the same):

$$\begin{bmatrix} a & b \\ c & d \end{bmatrix} * \begin{bmatrix} e & f \\ g & h \end{bmatrix} = \begin{bmatrix} a*e+b*g & a*f+b*h \\ c*e+d*g & c*f+d*h \end{bmatrix}.$$

After mathematical operations, we obtain the matrix $M^{[2]}$, all 1 of which denote the existence of paths of length less than or equal to 2, and zeros - their absence.

$$M'^{[2]} = \begin{array}{c|ccccc} & A & B & C & E & F \\ A & 1 & 1 & 1 & 1 & 1 \\ B & 1 & 1 & 1 & 1 & 1 \\ C & 0 & 0 & 1 & 0 & 0 \\ E & 0 & 1 & 1 & 1 & 1 \\ F & 1 & 1 & 1 & 1 & 1 \end{array}.$$

From the matrix $M^{[2]}$ we obtain that point *C* is the extreme point of the Hamilton's path, if one exists. Again, we discard row and column *C*, thus we obtain

$$M''^{[2]} = \begin{array}{c|cccc} & A & B & E & F \\ A & 1 & 1 & 1 & 1 \\ B & 1 & 1 & 1 & 1 \\ E & 0 & 1 & 1 & 1 \\ F & 1 & 1 & 1 & 1 \end{array}.$$

Just as it was, calculating $M''^{[2]}$, a path of length not less than or equal to 2 was found, we find a path of length not less than or equal to 3 by calculating $M''^{[3]}$.

$$M''^{[3]} = \begin{array}{c|cccc} & A & B & E & F \\ A & 1 & 1 & 1 & 1 \\ B & 1 & 1 & 1 & 1 \\ E & 1 & 1 & 1 & 1 \\ F & 1 & 1 & 1 & 1 \end{array}.$$

The matrix $M''^{[3]}$ has only 1s, this proves the existence of paths less than or equal to 3 between all *ABEF* points taken by two.

In the general case, when consecutive symbolic powers of *M* are calculated, we can dwell on *n* for which $M^{[n+1]} = M^{[n]}$, since this means that *M* does not have a path that exceeds *n*. The matrix $M^{[3]}$, obtained by returning rows and columns *C* and *D* can be rearranged so that all zeros are located below the main diagonal and the units above it.
Square matrices consisting of units based on the main diagonal create *equivalence classes* regarding to the law: point *X* is connected to point *Y* and vice versa

	A	***B***	***C***	***D***	***E***	***F***
A	1	1	1	1	1	1
B	1	1	1	1	1	1
C	1	1	1	1	1	1
D	1	1	1	1	1	1
E	0	0	0	0	1	1
F	0	0	0	0	0	1

For example, *A* is connected to *E* via *B* or *F* or *F&B; E* is connected to *A* through *B* and *F*. Let's simplify the original graph and break it into classes. Determining the single Hamilton's path AFEBCD becomes quite simple.
Remark. It is clear that when *order* ratios are written (such as, for example, the preceding ratio) in some plural, Faulk's algorithm is one way of finding out their compatibility (since there should be no cycle). It also allows to find all order relations between two elements, that are deduced from the assumptions due to the transitivity of order relations (from *A*<*B* and *B*<*C* it follows that *A*<*C*, though this relationship has not been explicitly presented previously).
Only when there is no relation between the points in the form of a relation, legitimate relation of indifference $\gtrless$ can be entered.
However, in practice, it is often necessary to deal with a partial ordering arrangement that allows for cycles. In this case, this algorithm provides us with a method, well suited for solving problems.

4. Practical application of the Faulk's algorithm to manage the project manager's workflows when learning terms and concepts

Consider an example of using the Fowls algorithm to study terms by stakeholders, that a project manager should provide for them to create an integrated understanding.
Consider using a simple example of term study «work breakdown structure» (nextly - WBS) and related terms.
According to the presented theoretical base (Section 3 of the article) our sequence of actions is the next:
1. Choose a list of terms that are connected with WBS;
2. Encode the terms (it is doing next actions more ease);
3. Define dependencies between terms;
4. Present dependences as a matrix;
5. Change matrixes for as long as $M^{[n+1]} = M^{[n]}$;
6. Analyze the result;
7. Build sequences terms on the base of the calculations.

Using this sequence of actions for our example.

1. Choose a list of terms that are connected with WBS. The list of terms is taken from the glossary of basic terms given in PMBoK of 5th edition (Project Management Institute, 2013). Arrange the terms alphabetically (as they appear in the original source).

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2. Encode the terms. Encode the terms by numbering them:

1. Create WBS – the process of dividing project results and project work into smaller, more manageable components.
2. Decomposition – methodology used to separate and divide project volumes and project output into smaller, more manageable parts.
3. WBS Dictionary - a document that provides detailed information on the outcome, activities and planning of each component in the WBS.
4. Work Breakdown Structure (WBS) - hierarchical breakdown of the total amount of work undertaken by the project team to achieve the project objectives and produce the intended results.
5. Work Breakdown Structure Component – a separate entry in the WBS, which can be at any level.
6. Work Package – a work defined at the lowest level of WBS for which cost and duration are determined.

3. Define dependencies between terms. We can immediately evaluate that concept (4) must be presented and clarified first. Without a basic definition of the structure itself and the purpose of its creation, all other terms relevant to it do not make any sense. So there are 5 terms left.

These terms can be represented in 5! sequences, ie 1*2*3*4*5=120 combinations. Let's try to find this sequence of presentation and learning terms, so they make up Hamilton's way.

The relationships of these terms look like this:

- (1) immediately preceded (3), (5) and (6);
- between (1) and (2) there is no some dependency;
- (2) immediately preceded (3);
- between (5) and (6) there is no some dependency;
- (5) and (6) preceded (3).

4. Present dependences as a matrix. Let us present the following relationships in the form of a matrix *M*. It is immediately clear that term (3) is the endpoint of the Hamilton's path (if one exists). This follows from the fact that all values in the column are equal to 1, and in the row - 0, except for the intersection of the row and column.

$$M = \begin{matrix} & 1 & 2 & 3 & 5 & 6 \\ 1 & 1 & 1 & 1 & 1 & 1 \\ 2 & 1 & 1 & 1 & 0 & 0 \\ 3 & 0 & 0 & 1 & 0 & 0 \\ 5 & 0 & 0 & 1 & 1 & 1 \\ 6 & 0 & 0 & 1 & 1 & 1 \end{matrix}.$$

So we can omit this row and this column and get the matrix M':

$$M' = \begin{matrix} & 1 & 2 & 5 & 6 \\ 1 & 1 & 1 & 1 & 1 \\ 2 & 1 & 1 & 0 & 0 \\ 5 & 0 & 0 & 1 & 1 \\ 6 & 0 & 0 & 1 & 1 \end{matrix}.$$

Let's create elementary productions of row elements into column elements for calculation $M^{[2]}$. Because the paths connecting different vertices of the graph are searched, then instead of the arithmetic sum, as in a regular matrix product, we add a boolean sum and get:

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$$M'^{[2]} = \begin{array}{c|cccc} & 1 & 2 & 5 & 6 \\ \hline 1 & 1 & 1 & 0 & 0 \\ 2 & 1 & 1 & 0 & 0 \\ 5 & 1 & 1 & 1 & 1 \\ 6 & 1 & 1 & 1 & 1 \end{array}.$$

We define the elements of matrices $M^{[3]}$ and $M^{[4]}$:

$$M'^{[3]} = \begin{array}{c|cccc} & 1 & 2 & 5 & 6 \\ \hline 1 & 1 & 1 & 1 & 1 \\ 2 & 1 & 1 & 1 & 1 \\ 5 & 0 & 0 & 1 & 1 \\ 6 & 0 & 0 & 1 & 1 \end{array}, \qquad M'^{[4]} = \begin{array}{c|cccc} & 1 & 2 & 5 & 6 \\ \hline 1 & 1 & 1 & 0 & 0 \\ 2 & 1 & 1 & 0 & 0 \\ 5 & 1 & 1 & 1 & 1 \\ 6 & 1 & 1 & 1 & 1 \end{array}.$$

We can see that the matrix $M^{[4]}$ exactly repeats the matrix $M^{[2]}$. Therefore, we can stop calculations.

5. Analyse the result. Analys of the results showed that there were two classes: (1)-(2) and (5)-(6). This flows out from the calculation – values of these classes don't change in the frame of the calculate.

$$M' = \begin{array}{c|cccc} & 1 & 2 & 5 & 6 \\ \hline 1 & 1 & 1 & 1 & 1 \\ 2 & 1 & 1 & 0 & 0 \\ 5 & 0 & 0 & 1 & 1 \\ 6 & 0 & 0 & 1 & 1 \end{array} \quad M^{[2]} = \begin{array}{c|cccc} & 1 & 2 & 5 & 6 \\ \hline 1 & 1 & 1 & 0 & 0 \\ 2 & 1 & 1 & 0 & 0 \\ 5 & 1 & 1 & 1 & 1 \\ 6 & 1 & 1 & 1 & 1 \end{array} \quad M^{[3]} = \begin{array}{c|cccc} & 1 & 2 & 5 & 6 \\ \hline 1 & 1 & 1 & 1 & 1 \\ 2 & 1 & 1 & 1 & 1 \\ 5 & 0 & 0 & 1 & 1 \\ 6 & 0 & 0 & 1 & 1 \end{array} \quad M^{[4]} = \begin{array}{c|cccc} & 1 & 2 & 5 & 6 \\ \hline 1 & 1 & 1 & 0 & 0 \\ 2 & 1 & 1 & 0 & 0 \\ 5 & 1 & 1 & 1 & 1 \\ 6 & 1 & 1 & 1 & 1 \end{array}$$

6. Build sequences terms on the base of the calculations. Therefore, such sequences of presentation and study of terms are appropriate (the classes (1)-(2) and (5)-(6) are variability between each other):

(4) – (1) – (2) – (5) – (6) – (3) = Work Breakdown Structure - Create WBS – Decomposition - Work Breakdown Structure Component - Work Package - WBS Dictionary;

(4) – (2) – (1) – (5) – (6) – (3) = Work Breakdown Structure - Decomposition - Create WBS - Work Breakdown Structure Component - Work Package - WBS Dictionary;

(4) – (1) – (2) – (6) – (5) – (3) = Work Breakdown Structure - Create WBS – Decomposition - Work Package - Work Breakdown Structure Component - WBS Dictionary;

(4) – (2) – (1) – (6) – (5) – (3) = Work Breakdown Structure - Decomposition - Create WBS - Work Package - Work Breakdown Structure Component - WBS Dictionary.

Summary

Management processes are complex processes that cannot always be applied by formalized approaches because of their poor formalization. This is especially true for human resources management and organization of communication. Different communication technology approaches offer expert and approximate methods. They are quite effective. However, certain aspects of management can be clearly stated and formalized approaches can be applied to them.

Formalization in project management is first and foremost related to the creation of a workflow network. More than 50 years ago this approach allowed to provide project management as a separate area of science and to lay the groundwork for further finding approaches to formalize and apply mathematical approaches to better project management and project success. The approach proposed in the article allows to formalize certain aspects of the management process at the level of creating an integrated understanding of all project processes among all stakeholders. In fact, it can be seen as one way of organizing effective communication of the project manager with the stakeholders, which is a prerequisite for the success of the project.

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