The Use of Graph Theory in the Implementation of Psychodiagnostic Projects on the Example of Researching the Leadership Qualities of Participants in Software Development Teams

Dmytro Lukianov[a], Oleg Radyuk[b], Hanna Charniauskaya[c] and Irina Basinskaya[d]

[a.]*Interdisciplinary Institute for Advanced Studies and Retraining, Belarusian National Technical University, 77, Partyzansky ave., Minsk, 220107, Belarus*
[b.]*Individual Entrepreneur, Post office box 67, Minsk-134, 220134, Belarus*
[c.]*Independent Researcher, HR in IT, Rogachyovskaya str. 7-36, 220056, Minsk, Belarus*
[d.]*Belarusian State University, 4, Nezavisimosti Avenue, Minsk 220030, Belarus*

Abstract

The article proposes consider the application of visual analysis of psychological testing results through the use of directed graph representations. It is proposed to consider the method of visual analysis by means of various representations based on the analysis of the number of connections between the elements of the system, considered as the basis for the formation of a directed graph. In the example considered in the article, it is proposed to consider the scales of the integrated test technique used as the vertices of the graph. As the main views, the application of calculating centrality properties based on the number of links, the topological structure of links, and the Page Rank parameter is demonstrated. It is proposed to use the method of visual analysis of the graph as an additional to the classical method of correlation analysis used in processing the results of the application of psychodiagnostic methods. The possibility of using visual analysis to form hypotheses about the possible optimization of the structure of the scales used in the design of psychodiagnostic techniques (test batteries) is shown. In parallel, the results of the analysis of the leadership qualities of such a category of specialists as software developers (members of development teams) are presented.

Keywords [1]

leadership, psychodiagnostics, test methods design, correlation matrix, adjacency matrix, directed graph, graph theory, centrality, visual analyzes

1. Introduction

Over the past few years, there has been a growing interest in developing professional leadership skills. This is due to many reasons, however, one of the main ones is that business, technology, communications, human values today function in an era of continuous change. The sphere of professional project management is no exception. Organizations such as the International Project Management Association (IPMA) [1], and the American Institute for Project Management (PMI) [2] have incorporated "leadership" into their competency models. Many researchers have long been talking about the importance of the role of leadership in the management system, confirming this both by psychological research [3, 4] and by analyzing the structures of modern models of competencies

Information technology and interactions, December 02–04, 2020, Kyiv, Ukraine
EMAIL: dlukiano@gmail.com (D.Lukianov); 6311141@mail.ru (O.Radyuk); cbt1coach@gmail.com (H.Charniauskaya); 3075007@mail.ru (I.Basinskaya)
ORCID: 0000-0001-8305-2217 (D.Lukianov); 0000-0003-2888-9238 (O.Radyuk); 0000-0001-8778-5928 (H.Charniauskaya); 0000-0001-9640-2933 (I.Basinskaya)

[5, 6]. In modern practice of psychodiagnostics, various methods of assessing leadership qualities are widely used, including such methods as the "Five-factor personality questionnaire NEO-PI-R" [7], "Eight-factor personal leadership questionnaire 8FLQ" [8] and "Multifactorial leadership questionnaire (form 5X) "[9], which allow assessing personal qualities on a much larger number of scales than the widely used" role "techniques, such as the famous tests by R. Belbin [10] and I. Adizes [11]. Authors have more than ten years of experience in using such techniques in their work and propose to consider their approach to the visual presentation of the results of such studies.

2. Problem

Today, a wide range of approaches to the development of professional leadership qualities are being formed. Each organization, human resources specialists, consultants have their own preferred approach to leadership. But, unfortunately, there are not enough studies, the results of which could demonstrate which of the approaches is the most effective [12]. Understanding personality traits, which, for example, may be associated with transformational and charismatic leadership, can provide significant support in the selection of personnel for leadership positions. Accordingly, understanding the importance of certain properties (in the terminology of competency models of professional project managers - elements of competencies) can seriously help in choosing an approach to developing the necessary qualities. For example, if transformational leadership or charisma are associated with certain personality traits, then the organization can make a choice in the process of finding and hiring personnel in favor of an individual with these traits [13], or initiate an appropriate program to develop such abilities in the team.

A serious problem in solving such a problem is the professional choice of the concept of "leadership" among many modern approaches - in modern psychology there are at least several dozen such approaches. The presence of such a large number of theories hinders progress in practice and research, in which case it becomes necessary to consolidate leadership theories. Emmanuel Mango, author of the article "Rethinking Leadership Theories" [14] carried out a revision of 66 theories of leadership, the result of which is 22 theories, according to the author, well representing this phenomenon.

The existing methods of assessing and profiling personality traits are based both on standard tests and on the creation of our own "test batteries", collection of primary data, their processing (including using statistical methods) and interpretation of the results. This is not to say that the current state of affairs is at the "initial" stage - rather, we can talk about many years of established practice. Nevertheless, today more and more attention in the field of direct data analysis is paid to visualization. There was even such a thing as "visual data analysis". One of the most effective ways to represent data in complex integrated systems is to represent it in the form of graphs, which is extremely rare in the field of data analysis in the field of engineering psychology.

An important problem, according to the authors, is that it is extremely rare to find in practice attempts to create programs for the development of professional competencies based on the relationship between the leader's character and personal characteristics, making it as individual as possible, thereby increasing the rather low efficiency of personnel development programs, often based on the idea of "development of all" in "all directions", regardless of the account of personal characteristics.

3. Methods

As a possible approach to the construction of models of complex organizational, technical, socio-economic and other systems, it is proposed to use the graph theory toolkit, which is a constituent element of the general theory of systems in the representation of L. Bertalanffy [15]. Bertalanffy includes engineering psychology in the "applied components" block of his presentation of general systems theory, along with operations research and systems engineering.

This article proposes to consider the use of tools from another, theoretical block of the Bertalanffy structure - the toolkit of graph theory in relation to classical methods of data processing of research carried out in the field of practical psychology.

The transformation of the classical correlation matrix into an adjacency matrix is proposed for the analysis of the structure of the factors underlying some test methods, using the example of the analysis of some results that were obtained in a real study.

The main methods used were the following:

1. Analysis of leadership theories and construction of a system of "scales" for the development of test methods
2. Psychological testing
3. Methods of statistical data processing in the program IBM SPSS 23.0 [16]
4. Conversion of data to statistical processing into an adjacency matrix using the logic of Markov models in MS Excel [17]
5. Visualization of the obtained adjacency matrix in the form of a directed graph in the yEd environment [18]

The review and analysis of leadership theories in the work of E. Mango, as well as a broad analysis of scientific literature on leadership, was carried out in terms of the presence of six fundamental areas of leadership: the character of a leader as a whole (based on morality and ethics), special individual characteristics (mental abilities , level of extraversion, emotional intelligence, perseverance, courage, striving to achieve success) [19], leadership behavioral practices (exactly how leaders build communication with followers to achieve organizational goals) [20], institutional practices (consist in the activities of a leader to clarify goals organization or team, ways and directions of organizational development) [21], the purposefulness of the leader's activities (what is expected from leadership, and what the leader strives for) [22].

In the modern "managerial" approach (in particular, in the competency models of project managers), "skill theory" and "behavioral theory" are very common. Behavioral theory is based on a leader demonstrating certain behaviors to achieve desired goals. In behavioral practice, leaders are people-oriented in the first place, create and maintain optimal conditions for the activities and development of followers. In an organizational context, the behavior of a leader is aimed at tasks, the effectiveness of processes in the organization, in this case, leaders rely on current research and innovation [23]. Skills theory, which implies that a leader has specific skills for effective work. In the field of behavioral practices, this theory is realized in the fact that a leader must have communication skills with people. In the field of institutional practices - in the availability of technical and conceptual skills [22]. This is a fairly effective approach, which, in our opinion, first of all prepares a potential leader for “meaningful” situational leadership, which means that the leader's behavior style is determined by the current situation. A person, in the position of a leader, sets the levels of responsibilities and tasks of the followers, along with this, the development needs for the fulfillment of tasks by the followers are established. In the future, the leader chooses the leadership style that will contribute to the development of followers (coaching, support, delegation). Organizationally, leaders must clearly understand what organizational means and tools can be used to achieve the goal of developing followers [24].

In our opinion, the most effective approaches to the study of leadership are still transactional and transformational theory. These theories are well developed and relevant today. In addition, there are techniques for diagnosing the character of a leader in terms of transactional and transformational leadership, the use of which is the standard for leadership research.

Transactional leadership involves the use of transactions, rewards, and punishment to motivate followers to achieve organizational goals. In this approach, there are several ways: accompanying reward, deviation management (search for violations of agreements and contracts, the leader suggests punishment or fines), passive deviation management (the leader only takes steps to punish followers in case of failure to achieve goals) [25].

Transformational leadership refers to situations in which followers are producing more results than expected. A leader motivates followers beyond expectations. Within this theory, both the leader and the followers work together to increase the level of productivity. The behavior of leaders is characterized by ideological influence, inspiring motivation, intellectual stimulation, and an individual approach to their followers [26].

This opinion is caused, in a practical sense, by the study by the authors of the combination of such qualities as "controlling" and "leadership". The behavior of individuals with a high level of control is

characterized by a high level of organization, persistence, purposefulness, and a low level of impulsivity [27].

The "controlling" (synonym: “conscientiousness”) component includes a high level of self-discipline, productivity, ethical behavior, and striving for achievements [28]. Controlling is also positively associated with transformational leadership, although this contradicts findings from 2004 by Lim and Ployhart [29] and is supported by studies by Bono and Judge in the same year [30]. In 2014, a positive link was found between charisma (a combination of ideological influence and inspiring motivation) and controlling. Within the framework of the same study, no connection was found between controlling and individual approach (contrary to the study by Bono and Judge in 2004), this may be due to the fact that individuals with high control scores can adhere to a rational approach in communication, be extremely honest with followers and being somewhat closed off to emotional communication, which suggests that such leaders will not seek to care for their followers. In addition, in the same study, negative associations were found between controlling and inspirational motivation, as well as intellectual stimulation, that is, a controlling leader will tend to negatively represent the future and its presentation, which will also reduce the leader's ability to stimulate positive thinking about the future. from their followers [31].

Accordingly, despite the use of a number of techniques by the authors in their psychodiagnostic projects, it is proposed to consider in this article the results of using the Eight-Factor Leadership Questionnaire, which includes both the scale for assessing the factors of the "Big Five" and the scale for assessing leadership qualities, including limited, transactional and transformational leadership styles.

4. Results

As already mentioned in the Methods section, of particular interest is the analysis of the results obtained in a sample of 58 specialists of an IT companies using the Eight-Factor Leadership Questionnaire, which includes scales for assessing the Big Five factors and for assessing the limited , transactional and transformational leadership.

Table 1 shows the mean values on the Big Five scales of the eight-factor leadership questionnaire.

Based on the data obtained on the main scales of the "Big Five" of the eight-factor leadership questionnaire, described in Table 2.4, it should be noted that the lowest level on the Emotionality (N) scale was 3.96. The highest score belongs to the scale of Originality (O), 5.32.

Indicators on the scales of Emotionality (3.96), Energy (E) (4.74), Cooperation (A) (4.68), Controlling (C) (4.87) are in the range of average values. It can be concluded that study participants are able to control their impulses, cope with stress and negative emotions. In addition, the research participants have the characteristic that they do not strive to constantly be in a team, they are not very sociable individuals, however, being in a group of people, they do not experience much discomfort. If it is possible to avoid making unpopular decisions in the group, research participants tend to act in this way. In their work, research participants strive to follow the rules and requirements, but do not attach much importance to them. They tend to feel uncomfortable in an environment where there are strict rules and at the same time in an environment where there are no rules. The results of the study on the Originality scale (5.32) are in the high range. This means that the subjects practice new methods and approaches in their work, even when there are established standards, they feel comfortable in a creative environment where there is freedom of decision-making.

It should be noted that the results of the study on the eight-factor leadership questionnaire coincide with the results of the study on the NEO-PI-R questionnaire.

Table 2 presents the mean values for the leadership style scales of the eight-factor leadership questionnaire.

Based on the data obtained on the scales of styles and consequences of leadership of the eight-factor leadership questionnaire, described in Table 2.5, it should be noted that the lowest level on the Laissez-Faire scale was 2.90. The highest score belongs to the Idealized Influence (behavior) scale, 5.54.

Table 1

Average values of the data obtained on the Big Five scales of the eight-factor leadership questionnaire

Scale ID	Average (M)	Standard error (m)	Average deviation (б)	Factors for visual analysis
O 8FLQ	5.32	0.07	0.50	F01
C 8FLQ	4,87	0,10	0,73	F02
E 8FLQ	4,74	0,11	0,79	F03
A 8FLQ	4,68	0,10	0,68	F04
N 8FLQ	3,96	0,14	0,97	F05
O1 8FLQ	5,44	0,15	1,10	-
O2 8FLQ	5.70	0.13	0.95	-
O3 8FLQ	5,46	0,13	0,91	-
O4 8FLQ	4,75	0,12	0,82	-
O5 8FLQ	5,10	0,14	1,00	-
O6 8FLQ	5.66	0.08	0.59	-
C1 8FLQ	5.21	0.12	0.85	-
C2 8FLQ	4,66	0,16	1,15	-
C3 8FLQ	5,49	0,11	0,81	-
C4 8FLQ	5,01	0,14	0,99	-
C5 8FLQ	4,37	0,17	1,22	-
C6 8FLQ	4,55	0,17	1,18	-
E1 8FLQ	5,14	0,15	1,05	-
E2 8FLQ	4,06	0,19	1,34	-
E3 8FLQ	4,70	0,15	1,09	-
E4 8FLQ	4.51	0.16	1.16	-
E5 8FLQ	4,95	0,15	1,04	-
E6 8FLQ	5,16	0,16	1,14	-
A1 8FLQ	4,34	0,15	1,06	-
A2 8FLQ	4,94	0,20	1,41	-
A3 8FLQ	5,00	0,10	0,71	-
A4 8FLQ	4,36	0,16	1,16	-
A5 8FLQ	4,80	0,17	1,24	-
A6 8FLQ	4,53	0,13	0,93	-
N1 8FLQ	4.63	0.17	1.21	-
N2 8FLQ	4.18	0.16	1.18	-
N3 8FLQ	3,81	0,19	1,38	-
N4 8FLQ	4,23	0,17	1,23	-
N5 8FLQ	3,61	0,21	1,49	-
N6 8FLQ	3,22	0,16	1,11	-
MO 8FLQ	3,75	0,08	0,57	F06

Table 2
The average values of these leadership styles

Scale ID	Average (M)	Standard error (m)	Average deviation (б)	Factors for visual analysis
LL_8FLQ	3,09	0,12	0,87	F07
TA_8FLQ	4,95	0,12	0,83	F08
TF_8FLQ	5,13	0,09	0,67	F09
LL_NE_8FLQ	2,90	0,13	0,93	F10
LL_RU_8FLQ	3,35	0,17	1,18	F11
TA_PU_8FLQ	4,67	0,16	1,13	F12
TA_SV_8FLQ	5,23	0,11	0,82	F13
TF_VM_8FLQ	4,98	0,15	1,06	F14
TF_IP_8FLQ	5,50	0,10	0,69	F15
TF_IS_8FLQ	4,97	0,14	0,96	F16
TF_IV_8FLQ	5,10	0,11	0,78	F17
TF_LV_8FLQ	4,67	0,15	1,08	F18
TF_PV_8FLQ	5,54	0,11	0,76	F19

Indicators on the Limited Leadership (3.09), Passive Management-by-Exception (3.35) and Laissez-Faire (2.90) scales fall within the range of medium and low values. This means that subjects are less likely to resort to these leadership styles than to transactional and transformational ones. Rarely does their behavior show aloofness from communication with followers, unwillingness and lack of desire to understand the needs of followers, as well as a lack of assistance to satisfy them. The subjects are not inclined to use a system of penalties and sanctions against followers. Indicators on the scales Transactional Leadership (4.95), Proactive Management-by-Exception (4.67) are in the range of average values, it can be concluded that the subjects tend to control the performance of tasks by their followers, as well as take proactive actions when problems arise, another indicator of transactional Leadership, Contingent Reward (5.23), Scale scores are in the high range, which means that subjects tend to reward followers for successful tasks and other expected results. Most often, subjects use styles related to Transformational Leadership (5,13), among them, an Individualized Consideration (5.50), Idealized Influence (5.10) and in particular Behavioral Influence (5.54), this means that the behavior of the subjects, characterized by a trusting attitude towards followers, understanding of their intellectual needs and the ability to satisfy them, purposefulness, perseverance, is a reference and arouses respect from followers. Inspirational Motivation (4.98), Intellectual Stimulation (4.97), and Idealized Influence (attributed) (4.67) are somewhat less common, however, the indicators of these factors border on high. This means that the subjects are able to predict the future of joint activities with followers from a positive side, as well as effectively broadcast this point of view. It should be noted that the results of the 8FLQ Eight-Factor Leadership Questionnaire are similar to the results on the Multifactor Leadership Questionnaire in that subjects rarely resort to hands-off and tend to resort to transactional leadership styles more often when communicating with followers. As a result of the correlation analysis of the data, relationships were found between the personality traits of the Big Five NEO-PI-R and the leadership qualities of the eight-factor leadership questionnaire, the personality characteristics of the Big Five and the leadership styles of the eight-

factor leadership questionnaire. The variables were tested for normal distribution, since a number of variables had a distribution that differed from the normal one; later, a nonparametric method of statistical analysis, the Spearman method, was chosen. So, Figure 1 shows a table with the results of the correlation analysis of the Big Five data of the NEO-PI-R questionnaire and the leadership qualities of the eight-factor leadership questionnaire. Negative correlations are indicated in red, positive correlations are in green. The cells contain Spearman's correlation coefficient and the significance level below the coefficient. The sign * marks the presence of the significance of correlation (bilateral) at the level of 0.05, and ** - at the level of 0.01.

8FLQ		N	E	O	A	C
LL_8FLQ	r_s	0,358**	-0,388**			-0,509**
	p	0,010	0,005			0,000
TA_8FLQ	r_s					0,506**
	p					0,000
TF_8FLQ	r_s	-0,506**	0,506**			0,643**
	p	0,000	0,000			0,000
LL_NE_8FLQ	r_s	0,427**				-0,494**
	p	0,002				0,000
LL_RU_8FLQ	r_s		-0,432**			-0,366**
	p		0,002			0,008
TA_PU_8FLQ	r_s					0,444**
	p					0,001
TA_SV_8FLQ	r_s		0,378**			0,464**
	p		0,006			0,001
TF_VM_8FLQ	r_s	-0,438**	0,386**			0,441**
	p	0,001	0,005			0,001
TF_IP_8FLQ	r_s		0,356*			0,314*
	p		0,010			0,025
TF_IS_8FLQ	r_s	-0,386**	0,404**		-0,350*	0,350*
	p	0,005	0,003		0,012	0,012
TF_IV_8FLQ	r_s	-0,423**	0,435**			0,701**
	p	0,002	0,001			0,000
TF_LV_8FLQ	r_s	-0,515**	0,533**			0,663**
	p	0,000	0,000			0,000
TF_PV_8FLQ	r_s					0,486**
	p					0,000

Figure 1: Correlations between the Big Five NEO-PI-R and the leadership qualities of the eight-factor leadership questionnaire

The complete correlation matrix in this study is a 198x198 array, a fragment of which is shown in Figure 2. It is clear that in such a presentation, it is poorly suitable for visualization or presentation by any other alternative means. On the other hand, it seems possible to transform it into an adjacency matrix by transforming it according to a simple rule - if there is a significant relationship between elements in the direction from “row” to “column”, the presence of such a relationship can be displayed as “1”, and the absence - as “0".

An adjacency matrix can serve as a basis for constructing a directed graph for subsequent analysis.

As known, a system that combines sets of some entities, for example

$$S\{s1, s2, \ldots, sm\}, \quad (1)$$

which are vertices of an oriented graph connected by oriented arcs

$$G\{g_1, g_2, \ldots, g_r\}, \quad (2)$$

can be displayed using the adjacency matrix

$$[c_{ij}]_S = [i, j], \quad (3)$$

each line of which shows the connections of one vertex with other vertices of the graph [32]. The element $c_{ij} = 1$, then it reflects the arc between the vertices S_i and S_j. If $c_{ij} = 0$, then the arc directly between the vertices of the graph i and j is absent.

For the analysis of such structures use the adjacency matrix, which has specific properties [32]. In the case of successive reduction of the adjacency matrix in the degree $n = 2, 3$ ... the elements of the n-th degree $(c_{ij})^n$ show the path containing n arcs between the i-th and j-th vertices of the graph.

To formalize the adjacency matrix obtained by the method described above, it is proposed to use the Microsoft Excel [17] software, in particular, so that other actions can be performed in the same

computing environment to simulate the behavior of the system under study. In particular, due to the fact that this software in its basic functionality supports the necessary set of operations with matrices. For further visualization and presentation in the form of a graph, it is proposed to use the yEd [18] software.

		D_VOZRAST	N_NEO	E_NEO	O_NEO	A_NEO	C_NEO	N1_NEO	N2_NEO	N3_NEO	N4_NEO	N5_NEO
D_VOZRAST	r_s	1,000	-0,316*	0,247	0,015	-0,007	0,275	-0,205	-0,183	-0,398**	-0,293*	-0,017
	p		0,024	0,081	0,914	0,961	0,051	0,149	0,199	0,004	0,037	0,905
N_NEO	r_s	-0,316*	1,000	-0,337*	-0,045	-0,013	-0,428**	0,838**	0,756**	0,791**	0,789**	0,580**
	p	0,024		0,016	0,753	0,926	0,002	0,000	0,000	0,000	0,000	0,000
E_NEO	r_s	0,247	-0,337*	1,000	0,150	0,021	0,486**	-0,159	-0,287*	-0,395**	-0,341*	-0,039
	p	0,081	0,016		0,295	0,885	0,000	0,265	0,041	0,004	0,014	0,788
O_NEO	r_s	0,015	-0,045	0,150	1,000	0,078	-0,190	-0,104	-0,068	0,027	-0,219	0,108
	p	0,914	0,753	0,295		0,585	0,181	0,468	0,636	0,852	0,123	0,452
A_NEO	r_s	-0,007	-0,013	0,021	0,078	1,000	-0,055	-0,013	-0,164	0,080	0,151	-0,228
	p	0,961	0,926	0,885	0,585		0,704	0,928	0,250	0,575	0,291	0,108
C_NEO	r_s	0,275	-0,428**	0,486**	-0,190	-0,055	1,000	-0,301*	-0,184	-0,392**	-0,303*	-0,342*
	p	0,051	0,002	0,000	0,181	0,704		0,032	0,196	0,004	0,031	0,014
N1_NEO	r_s	-0,205	0,838**	-0,159	-0,104	-0,013	-0,301*	1,000	0,538**	0,635**	0,650**	0,362**
	p	0,149	0,000	0,265	0,468	0,928	0,032		0,000	0,000	0,000	0,009
N2_NEO	r_s	-0,183	0,756**	-0,287*	-0,068	-0,164	-0,184	0,538**	1,000	0,465**	0,523**	0,490**
	p	0,199	0,000	0,041	0,636	0,250	0,196	0,000		0,001	0,000	0,000
N3_NEO	r_s	-0,398**	0,791**	-0,395**	0,027	0,080	-0,392**	0,635**	0,465**	1,000	0,692**	0,237
	p	0,004	0,000	0,004	0,852	0,575	0,004	0,000	0,001		0,000	0,094
N4_NEO	r_s	-0,293*	0,789**	-0,341*	-0,219	0,151	-0,303*	0,650**	0,523**	0,692**	1,000	0,318*
	p	0,037	0,000	0,014	0,123	0,291	0,031	0,000	0,000	0,000		0,023
N5_NEO	r_s	-0,017	0,580**	-0,039	0,108	-0,228	-0,342*	0,362**	0,490**	0,237	0,318*	1,000
	p	0,905	0,000	0,788	0,452	0,108	0,014	0,009	0,000	0,094	0,023	
N6_NEO	r_s	-0,318*	0,748**	-0,245	0,030	-0,105	-0,456**	0,558**	0,543**	0,545**	0,373**	0,501**
	p	0,023	0,000	0,083	0,835	0,462	0,001	0,000	0,000	0,000	0,007	0,000
E1_NEO	r_s	-0,016	-0,179	0,634**	0,182	0,276*	0,290*	-0,129	-0,197	-0,073	-0,151	-0,150
	p	0,914	0,208	0,000	0,201	0,050	0,039	0,368	0,165	0,611	0,290	0,294
E2_NEO	r_s	0,210	-0,074	0,673**	-0,060	-0,083	0,314*	0,018	-0,174	-0,183	-0,075	0,066
	p	0,139	0,608	0,000	0,676	0,562	0,025	0,900	0,222	0,198	0,599	0,646
E3_NEO	r_s	0,324*	-0,441**	0,617**	-0,008	-0,246	0,462**	-0,273	-0,191	-0,560**	-0,539**	-0,036
	p	0,020	0,001	0,000	0,953	0,082	0,001	0,053	0,180	0,000	0,000	0,800

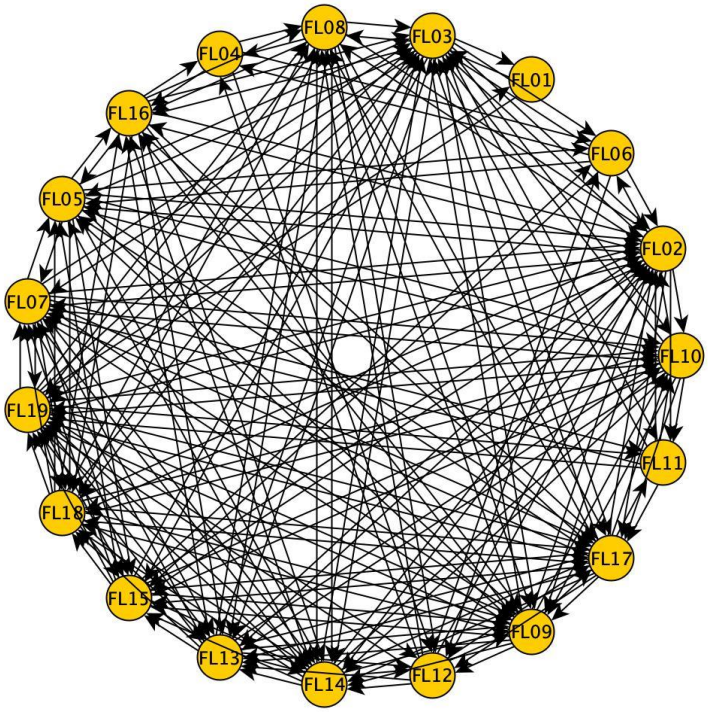
Figure 2: Complete correlation matrix for the data of the conducted study on all scales (fragment)

Correlations between the selected factors F01-F19, noted in Tables 1 and 2, based on a sample of the relevant data from the full correlation matrix (Figure 2), using the above rules, can be represented as the following adjacency matrix (Figure 3).

An adjacency matrix can serve as the basis for constructing a directed graph for subsequent analysis. For further visual analysis of the resulting graph, it is proposed to use such well-known and open-source software as yEd, which allows modeling various kinds of complex structures, in particular, using a wide range of different graph representations. Figure 4 shows the structure of a graph created in the yEd environment using the standard Shape Nodes template of structural

FID	to	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19
from	FCODE	O_8FLQ	C_8FLQ	E_8FLQ	A_8FLQ	N_8FLQ	MO_8FLQ	LL_8FLQ	TA_8FLQ	TF_8FLQ	LL_NE_8FLQ	LL_RU_8FLQ	TA_PU_8FLQ	TA_SV_8FLQ	TF_VM_8FLQ	TF_IP_8FLQ	TF_IS_8FLQ	TF_IV_8FLQ	TF_LV_8FLQ	TF_PV_8FLQ
F01	O_8FLQ	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
F02	C_8FLQ	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
F03	E_8FLQ	1	1	0	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1
F04	A_8FLQ	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	1	0	0	0
F05	N_8FLQ	0	1	1	0	0	1	1	0	1	1	0	0	0	1	1	1	1	1	0
F06	MO_8FLQ	0	1	1	1	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0
F07	LL_8FLQ	0	1	1	0	1	0	0	0	1	1	1	0	1	1	1	0	1	1	1
F08	TA_8FLQ	0	1	1	1	0	0	0	0	1	0	0	1	1	1	0	1	1	1	1
F09	TF_8FLQ	0	1	1	0	1	0	1	1	0	1	0	1	1	1	1	1	1	1	1
F10	LL_NE_8FLQ	0	1	1	0	1	0	1	0	1	0	1	0	1	1	1	0	1	1	1
F11	LL_RU_8FLQ	0	1	1	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	1
F12	TA_PU_8FLQ	0	1	0	1	0	1	0	1	1	0	0	0	1	1	0	0	1	0	1
F13	TA_SV_8FLQ	0	1	1	0	0	0	1	1	1	1	0	1	0	1	1	1	1	1	1
F14	TF_VM_8FLQ	0	1	1	0	1	0	1	1	1	1	0	1	1	0	1	1	1	1	1
F15	TF_IP_8FLQ	0	1	1	0	1	1	1	0	1	1	0	0	1	1	0	0	1	1	1
F16	TF_IS_8FLQ	0	1	1	1	1	0	0	1	1	0	0	0	1	1	0	0	1	1	0
F17	TF_IV_8FLQ	0	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1
F18	TF_LV_8FLQ	0	1	1	0	1	0	1	1	1	1	0	0	1	1	1	1	1	0	1
F19	TF_PV_8FLQ	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	0	1	1	0

Figure 3: Formation of a first-order adjacency matrix for F01-F19 elements (screenshot fragment)



e

Figure 4: Directed graph for FL01-FL19 subsystem model implemented in yEd (screenshot fragment)

As you can see from the presented figure 4, yEd allows you to visualize the links (edges) between the elements of the model (the vertices of the graph), including the direction of these links. Nodes FL in this graph correspond to the elements F from adjacency matrix for F01-F19 elements

Unfortunately, such a basic view does not allow making any analytical conclusions. It is worth using other representations to analyze the graph. In particular, the simplest next step can also be a "circular representation", but with the visualization of the weights of the vertices based on the number of their connections with other vertices of the graph, as shown in Figure 5 (normalized with respect to the element FL02 with the maximum number of connections).

As can be seen in the presented figure 5, yEd allows visualizing the weights of vertices (model elements) based on information about the number of edges (links), which makes such a representation much more information-rich than the primary representation of the model in the form of a graph presented in Figure 4. Nevertheless, such a representation, although it already allows you to form some hypothesis based on the visualization of the parameters of the system of links, in particular, to allow ranking the vertices by the number of links, but any spreadsheet editor in which you can sum up values in rows and columns of the original adjacency matrix (Figure 3) or primary corellation matrix (Figure 2). In graph analysis, one of the key concepts is centrality. Accordingly, visualization of representations of such a parameter as "centrality" will be of undoubted interest. At the same time, "centrality" can be considered both "structural" and "weighted". In particular, thanks to such a representation as "Weighted Centrality" (Figure 6), it is possible to assess the importance for the entire structure as a whole, for FL02 element. This representation allows one to form a number of hypotheses regarding the role of elements FL01 and F04 presented in the "far orbit" in the system under consideration, in addition to other assumptions that can be formed on the basis of the visualization presented in Figure 5. In any case , it is obvious that the information content of such a representation is much higher than that of Figure 4 or Figure 5. The visualization capabilities allow you to assess "centrality" directly from a structural point of view as shown in Figure 7. In particular, such a representation allows us to develop the previous hypothesis - the absence of significant relationships of the FL01 element in the structure of the fragment under consideration is visible, which suggests the possibility of excluding this element from consideration (accordingly, to further optimize the set of scales for further use of the already initially optimized method). Moreover, judging by the visual representation of the links of the FL04 element, such an exception for this element may not be worth making.

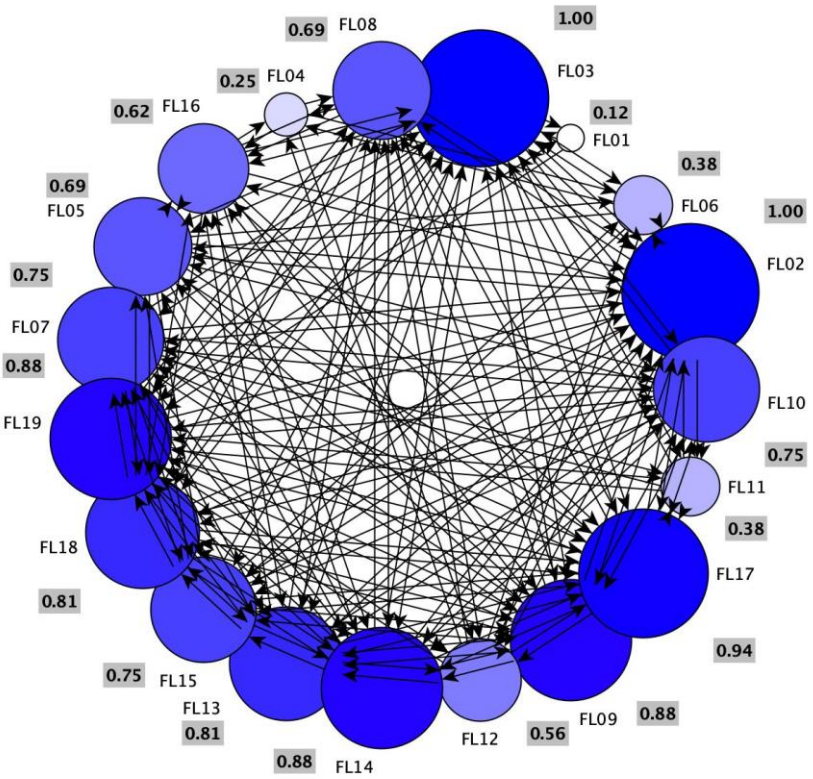


Figure 5: Directed graph for FL01-FL19 subsystem model, implemented in yEd (Circular Layout - Single Cycle representation)

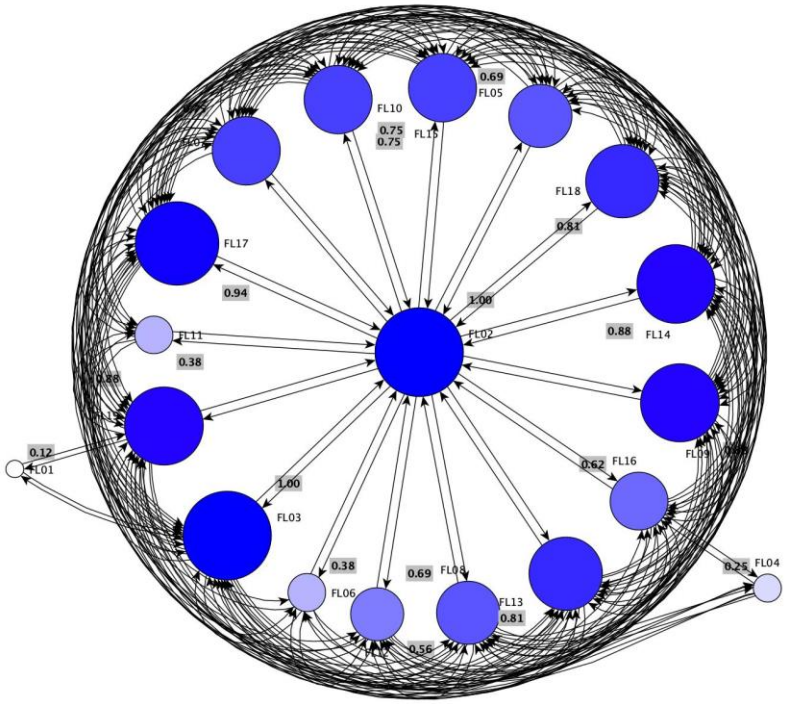


Figure 6: Visualization of some structural indicators (fragment) for a directed graph for FL01-FL19 subsystem model in the yEd environment in the Radial Layout view for Weighted Centrality (Distance From Center)

5. Discussion

The approach proposed in the article significantly expands the previously described [33] approach to the analysis of the properties of structural models. Nevertheless, the visual representation of the

"centrality" properties, from our point of view, significantly expands the possibilities of understanding the features of the systems under study. As can be seen from the views in Figures 6 and 7, they are fundamentally different from the “descriptive” view in Fig. 4. Although they are still representations of the same system.

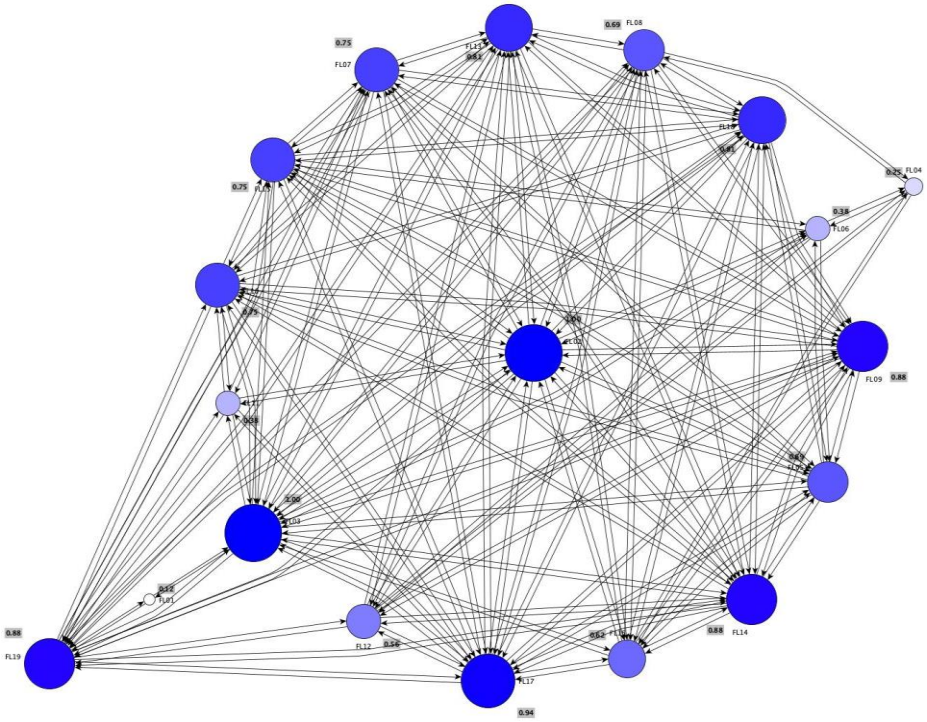


Figure 7: Visualization of some structural indicators (fragment) for a directed graph for FL01-FL19 subsystem model in the yEd environment in the Radial Layout view for Centrality (Distance From Center)

In our opinion, the use of such powerful tools for versatile visualization of the graphs of the studied models allows us to look somewhat differently at the systems under study than only through the prism of analytical indicators presented in a matrix (tabular) form. Based on the information presented graphically, it becomes possible not only to propose new hypotheses regarding the structural relationships of the systems under study, but also to “quickly test” them by visual means. The presented visualizations certainly provide a lot of information, at least for the formation of hypotheses. it is obvious that some of these hypotheses, in principle, could not have appeared without visualization, similar to the one shown in the screenshots of the model views made in the yEd environment. It is of interest to consider other possible representations that are possible for visualization in the yEd environment. In particular, when calculating the weight characteristics, taking into account not only the presence of the number of links, but also their structure, as suggested by the Page Rank method [34], we can conclude about another element that is very significant for the system as a whole - FL03 (Figure 8).

6. Conclusion

The presented approach to the use of graphical representations, according to the authors, can be used in the analysis of any other complex systems, where a sufficiently large number of mutually influencing elements can be identified. In order for the analysis of such systems to be as effective as possible, it is necessary to use the appropriate systems that automate the work on the primary processing and visual presentation of information. Such an effective tool for an analyst's work can be software with functionality similar to the example of using the yEd product presented in the article. Perhaps this approach will allow a more “instrumental” approach to assessing the importance of individual elements, incl. by modeling situations such as “excluding” a number of nodes or edges

(elements of the studied systems or connections between them), and “adding” (predicting the need for a real but previously unidentified element or a connection between identified elements), which will allow a more professional and objectively approach the assessment of complex systems.

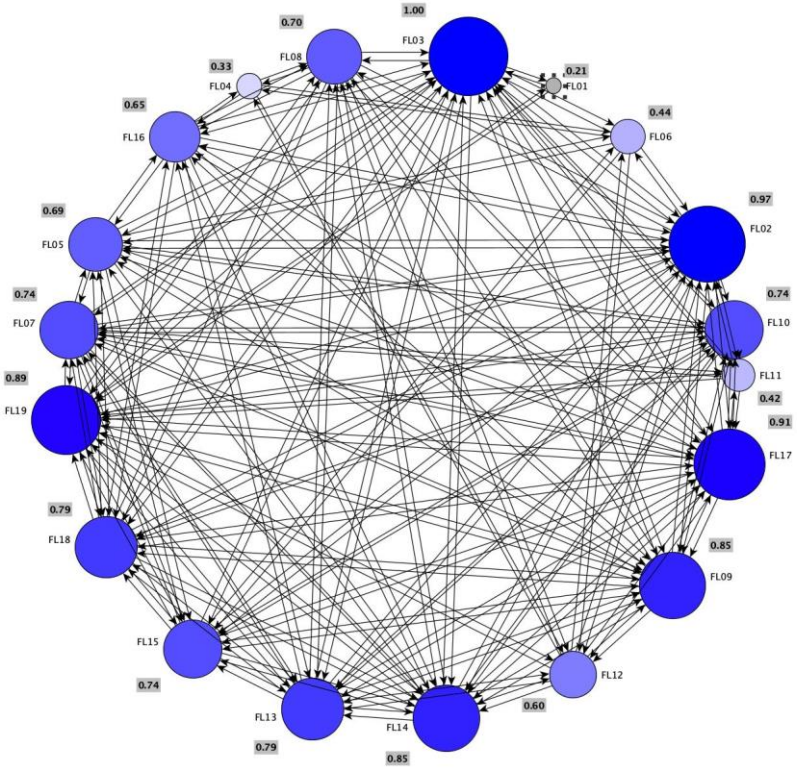


Figure 8: Visualization of some structural indicators (fragment) for a directed graph for FL01-FL19 subsystem model in the yEd environment in the Radial Layout view for Centrality (Page Rank)

7. Acknowledgment

I would like to express my gratitude to the developers of the yEd software, thanks to which today any computer user has the opportunity to perform a visual analysis of complex systems, which can be converted into a graph form. I would also like to express my gratitude to prof. V.D. Gogunsky (ONPU), thanks to whom the topic of using methods of graph theory appeared in the works of the authors.

8. References

[1]. IPMA, 2019 URL: https://www.ipma.world/
[2]. PMI, 2020 URL: https://www.pmi.org/
[3]. B. Avolio, B. Bass, D. Jung Re-examining the components of transformational and transactional leadership sing the multifactor leadership questionnaire, Journal of Occupational and Organizational Psychology. Vol. 72, iss. 4, (1999): 411–422.
[4]. J. Barling, T. Weber, E. K. Kelloway, Effects of transformational leadership training on attitudinal and financial outcomes: a field experiment, Journal of Applied Psychology. Vol. 81, № 6, (1996): 827–832.
[5]. Lukianov, D., Mazhei, K., Gogunskii, V. Transformation of the International Project Management Association Project Managers Individual Competencies Model, IEEE International Conference on Advanced Trends in Information Theory, (2019): 506-512
[6]. Sherstiuk O., Kolesnikov O., Lukianov D. Team Behaviour Model as a Tool for Determining the Project Development Trajectory. IEEE International Conference on Advanced Trends in Information Theory, (2019): 496-500.

[7]. V.E.Orel, I.H. Senin Personality questionnaire NEO PI-R: Yaroslavl: Psychodiagnostics, 2006. (In Russian)
[8]. Chernyavskaya A.L. Creation of an individual program for the development of professional competencies: dis.Master of Psychology. Belarusian State University, Minsk, 2019. (In Russian)
[9]. Leadership scales. Multifactorial Leadership Questionnaire (5X form), 2019. URL: http://moodle.herzen.spb.ru/pluginfile.php/23414/mod_folder/content/0/Методики/Шкалы лидерства.pdf (In Russian)
[10].The Nine Belbin Team Roles, 2020. URL: https://www.belbin.com/about/belbin-team-roles/
[11].Adizes I.K. Ideal leader: Why you can't become one and what follows from this. Alpina Publisher, 2013.
[12].Northouse, P. Leadership theory and practice. Thousand Oaks : Sage, 2016.
[13].T. P. Johnson, M. Fendrich. A validation of the Crowne-Marlowe social desirability scale. 57th Annual Meeting of the American Association for Public Opinion Research, St. Pete Beach, FL, (2002): 1661–1666.
[14].Mango Em. Rethinking Leadership Theories, 2018
[15].Bertalanffy, L. History and status of the general theory of systems. Systems research: Yearbook, Moscow: Nauka, (1973): 20–37.
[16].IBM SPSS Statistics 23 Documentation, 2020. URL: https://www.ibm.com/support/pages/node/595837
[17].Excel, 2020. URL: https://www.microsoft.com/en-us/microsoft-365/excel
[18].yEd, 2020. URL: https://www.yworks.com/products/yed
[19].D. Hambrick, P. Mason. Upper echelons: the organization as a reflection of its top managers. The Academy of Management Review. Vol. 9, issue 2, (1984): 193–206.
[20].J. van Muijen, J. Schaveling. Leiderschap: een theoretisch overzicht. M&O, Tijdschrift voor Management & Organisatie. Vol. 65, iss. 4, (2011): 6–24.
[21].R. R. McCrae, P. T. Costa. Personality trait structure as a human universal. American Psychologist.Vol. 52, iss 5, (1997): 509–516.
[22].A. Zaleznik, M. F. R. Kets de Vries. Power and the corporate mind. Boston, Mass : Houghton Mifflin, 1975.
[23].R. Blake, J. Mouton. The managerial grid: the key to leadership excellence. Houston : Gulf Publ. Co., 1964.
[24].P. Hersey, K. Blanchard. Management of organizational behaviour: utilizing human resource. Englewood Cliffs : Prentice Hall, 1977.
[25].B. Bass et al. Predicting unit performance by assessing transformational and transactional leadership. Journal of Applied Psychology.Vol. 88, iss 2, (2003): 207–218.
[26].Bass, B. M. Leadership and performance beyond expectations. New York: Free Press, 1985.
[27].R. R. McCrae, P. T. Costa. Validation of the five-factor model of personality across instruments and observers Journal of Personality and Social Psychology. Vol. 52, iss. 1, (1987): 81–90.
[28].M. S. Allen, I. Greenlees, M. V. Jones. An investigation of the five factor model of personality and coping behaviour in sport. Journal of Sports Sciences.Vol. 29, iss 8, (2011): 841–850.
[29].B.-C. Lim, R. E. Ployhart. Transformational leadership: relations to the five-factor model and team performance in typical and maximum contexts. Journal of Applied Psychology. Vol. 89, iss. 4, (2004): P. 610–621.
[30].J. E. Bono, T. A. Judge. Personality and transformational and transactional leadership: ameta-analysis. The Journal of Applied Psychology.Vol. 89, iss. 5, (2004): 901–910.
[31].A. Deinert et al. Transformational leadership sub-dimensions and their link to leaders' personality and performance. The Leadership Quarterly. Vol. 26, iss 6, (2014): 1095–1120.
[32].Kolesnikova, K. V., & Lukyanov, D. V. Analysis of the structural model of competencies in project management of a national standard Ukraine. Management of development of complex systems, vol. 13, (2013): 19 – 27.
[33].Lukianov D. et al. Analysis of the structural models of competencies in project management. Technology audit and production reserves., vol. 2. Iss. 2, (2017): 4 – 11.
[34].Brin S., Page L. The anatomy of a large-scale hypertextual web search engine, 1998.