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**INTERNET COMMUNITIES' INTEGRATION INDEX  
HIERARCHICAL MODEL**

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***Abstract***

The problem's complexity lies in the multilevel Internet sociality that is describing as virtual sociality. Virtual society is the world of Internet communities including the Internet economy, which is autonomously developing according to its internal laws. Along with what can be defined as the actual social segment of functioning, there are different levels of virtual sociality. The level of the real segment is rooted in real sociality, but transfers part of its interactions on the Internet and is characterized by transitions from the Internet to online and vice versa. This is the focus of this research. The research identified the following levels of analysis, which affect the level of integration process, is presented: the level of forces influence, the level of system's actors, the level of actor's indicators. the minimum set of Internet community's mobilization integration objective and reliable degree parameters include (in order of importance): internal communications number, mobilization potential, group goals and values and sociocultural aspects. "The community itself" includes cohesion level, internal communications volume, mobilization potential, volume dynamics, the group core qualitative composition, level of trust, modularity, external relations volume, community size, group age.

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**Keywords:** Hierarchy analysis, internet community, system analysis, T. Saaty method, analytic hierarchy process, automatic control.



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## 1. Introduction

In just a third of the life cycle of one generation, the Internet has been transformed from an abstract technology to an essential part of the social world. The novelty of this social phenomenon, together with the pace of its development and its impact on the society as a whole do not allow researchers to come to a common denominator in the interpretation of the world of the Internet regarding its connection with society. The multilevel Internet sociality enhances the complexity of the problem. Virtual sociality is Internet communities and Internet economy that autonomously develop governed by their internal laws. There is a feature of the level, including it in the functioning of real sociality. Therefore, it can only be considered as part of a virtual sociality. The level lies in the reality of the level of sociality. However, he transfers part of his interactions into the virtual world. Let's look at the interaction of people, take the world of the Internet as an example. Offline to online transition and vice versa characterizes this is a real level.

## 2. Problem Statement

The presence of the level of transitions from online to offline poses a difficult methodological problem - namely, should the same principles, categories, methods and logics be applied in the study of these levels, or should new ones be defined? In addition to the practical research aspect, this problem also contains a philosophical and methodological aspect. The presence of Internet research objects is one of the vivid illustrations of the so-called post-non-classical scientific rationality, based on its own scientific methodologies. Styopin (2017) as follows characterizes this type of objects as: complex self-developing systems, passing from one type of homeostasis to a more complex type of homeostasis.

The indicated problems influenced the research methodology “Building predictive models of the dynamics of the development of Internet communities”. Preliminary results of the first stage of the study are presented in this article. As an object of study, there were selected Internet communities that can be attributed to mixed type of communities, communities with offline / online transitions. At the first stage, the research group has deliberately limited the definition of Internet communities to: A community of Internet users based on international blog platforms on the global Internet (Russian-language segment). Therefore, the object of study can be defined as network communities of a mobilization type, that is, communities in which Internet communications influence the actual behavior of participants offline.

### 2.1. Application of the hierarchy analysis method in system research

To assess the influence of parameters on the integration indicator, the hierarchy analysis method of Saaty (1980, 1987) is applied. There are many examples of the hierarchy analysis method successful application in various fields: historical multidisciplinary review (Ishizaka & Labib, 2011), project management in the engineering applications development (Aguilar-Lasserre et al., 2009; Ivanco et al., 2017; Nguyen et al., 2017; Lambert, 1991; Ho & Ma, 2017), the industrial mills research for multi-stage materials processing (Zhironov, 2011), analysis of the universities indicators (Kazancev, 2010), the applications evaluation for participation in competitions for the complex systems development (Perevedentcev, 2017), the highly qualified athletes ranking (Gorokhov, 2016), improving the enterprise efficiency (Blagodatskij, 2015).

### **3. Research Questions**

The main question of this study is how and which of the elements of Internet sociality, influence the level of Internet community cohesion.

#### **3.1. Advancing a Minimal Hypothetical Model**

To obtain an objective and reliable degree of Integration of the Internet community mobilization a set of minimum necessary parameters should be defines. These are sociocultural aspects, the group goals and values, the mobilization potential and internal communications volume. This analysis is based on the Pareto principle selection of parameters.

#### **3.2. Defining variables for setting integration parameters**

It is required to select variables for turning integration parameters from the set:

- Sociocultural aspects (ritualized practices) - the proportion of posts that use hashtags (#), the number of hashtags, their own language of communication, thematic fashion;
- Goals and values of the group - dominant strategies (exclusivity / leadership / struggle / survival, etc.), political orientation (opposition / pro-government / neutral), average share of material with links to foreign content (compliance with global sociocultural trends), average share of material with links to Russian content (compliance with national sociocultural trends), the degree of specificity of goals (narrowly practical, achievable, easily measurable / abstract, broad, poorly measurable);
- The volume of internal communications - the number of views of publications in the feed for the week, the number of posts in “discussions” for the week, the number of comments in the main feed for the week;
- Mobilization potential - the geographical spread / localization of actions, the number of effective external collective actions (per month (for self-assessment)), the availability of instructions on how to act in certain situations online (per month), the average number of participants in events offline (per month (for self-assessment)).

### **4. Purpose of the Study**

First stage study purpose is to find the characteristics and parameters for measuring group integration and assessing its degree of influence. When processing the obtained results, the T. Saaty Hierarchy Analysis Method was used. The method does not require preliminary “correct” knowledge about the object of study, on the contrary it obtains its correct understanding through a process of iterations of unstructured, “unbiased” observations. The elements used in the model below, goal, acting forces and actors, were identified by sociologists during a two-month observation period as the factors affecting the integration of online communities.

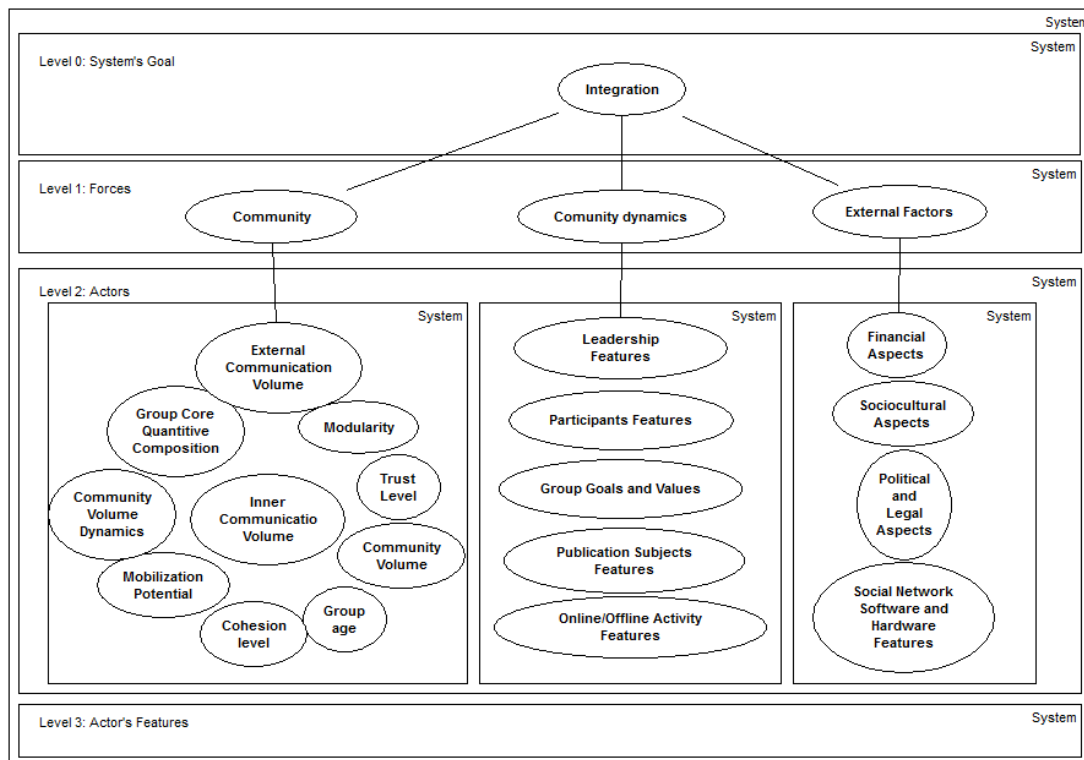
## 5. Research Methods

The grounded-theory methodology is used as the initial methodology (Glaser & Strauss, 2009). The structure and functioning of networks are described through the maximum number of features that characterize the state of the network, its integration and mobilization potential, methods of identity and the communication content. Consequently, the direct and inverse process of the hierarchy analysis method are carried out (Saaty, 1980).

Organizational research includes two groups of specialists: sociologists who act as observers, and applied mathematicians. When using mathematical methods and modeling, sociologists act as experts. The observation procedure was carried out on the following communities: Alliance of heterosexuals and LGBTB, Libraries of the development space, Green Train, League of Izhevsk brother-in-law, Dream Skis in Izhevsk, Prague Club, Pro Bono 45, Trade Union “Action”, Trade Union “University Solidarity”, Udmurtlyk. The subject of observation is defined as integration / group cohesion.

### 5.1. Representing Internet Community Integration as a Hierarchy

The desire of a social group to integrate is influenced by forces formed by the internal characteristics of the community, the dynamics of its indicators and external factors (Figure 01).



**Figure 01.** The influence of actors on integration processes in the Internet community

Definition 1. (Hierarchical model of the indicator of integration of the Internet community) We will consider the characteristics of the Internet community as a hierarchical system. We distinguish many levels in the system, represented as:

$$I = \{I_i\}, i = \overline{1, m} \quad (1)$$

We observe complex interactions with higher hierarchy levels at each hierarchy level. We apply the method of hierarchy analysis of Saaty (1980) to formalize the decision-making process to Internet community integration. Consider system levels  $I$ . The  $I_0$  level is the goal of the system, that integration in the online community.

Definition 2. (Level of influence of forces) At the first level of system  $I_1$ , we distinguish the forces influencing the integration process in the online community as (2):

$$W_{I_1} = \{W_{I_1j}\}, j = \overline{1, n_{I_1}}, \quad (2)$$

As already noted, the forces are: the community itself ( $W_{I_11}$ ), community dynamics ( $W_{I_12}$ ), external factors ( $W_{I_13}$ ).

Definition 3. (Level of active elements of the system) The active elements (actors) that drive the forces put at the second level of system  $I_2$  (2):

$$W_{I_2} = \{W_{I_2j}\}, j = \overline{1, n_{I_2}}, \quad (2)$$

where  $W_{I_21}$  – group age,  $W_{I_22}$  – community volume dynamics,  $W_{I_23}$  – quantitative composition of the core of the group,  $W_{I_24}$  – mobilization potential,  $W_{I_25}$  – modularity,  $W_{I_26}$  – external communication volume,  $W_{I_27}$  – internal communication volume,  $W_{I_28}$  – community volume,  $W_{I_29}$  – trust level,  $W_{I_210}$  – cohesion level,  $W_{I_211}$  – leadership features,  $W_{I_212}$  – participants features,  $W_{I_213}$  – publications subject features,  $W_{I_214}$  – group goals and values,  $W_{I_215}$  – online and offline activity features,  $W_{I_216}$  – social network software and hardware features,  $W_{I_217}$  – political and legal aspects,  $W_{I_218}$  – financial aspects,  $W_{I_219}$  – sociocultural aspects.

Definition 4. (Actors impact indicators level) At the third level, there are many indicators characterizing the actors that drive the forces that influence the Internet communities' integration process. Highlight the level of indicators  $I_3$  and its elements (3):

$$W_{I_3} = \{W_{I_3j}\}, j = \overline{1, n_{I_3}}. \quad (3)$$

## 5.2. Hierarchy analysis method application to identify the Internet community elements weights

Set the influence of level's  $I_1$  forces  $I_1 \rightarrow I_0$  to the system's goal  $I_0$ . First: weight the importance of the elements in pairs  $W_{I_1} = \{W_{I_1j}\}, j = \overline{1, n_{I_1}}$ , where the dominance of the element  $W_{I_1k}$  in relation to  $W_{I_1m}$  is denoted by an integer from the relationship scale  $a_{km}$ . Second: get the matrix  $A_{I_1} = [a_{ij}]$  of pairwise comparisons and of  $n_{I_1} \times n_{I_1}$  dimensions is filled in after  $C_{n_{I_1}}^2$  comparisons.

It is necessary to answer the question about the integration coefficient's relevance for filling the matrix  $A_{I_1}$  using the elements of  $I_1$  levels, that we take in pairs. Level  $I_1$  consists of 3 elements: the community itself ( $W_{I_11}$ ), community dynamics ( $W_{I_12}$ ), external factors ( $W_{I_13}$ ). The comparisons are presented in Table 01.

**Table 01.** Level  $I_1$  forces influence  $I_1 \rightarrow I_0$  to system's goal  $I_0$

№	Comparison	Result	Explanation
1	$W_{I_1} & W_{I_2}$	$a_{12} = 1$	Equal influence
2	$W_{I_1} & W_{I_3}$	$a_{13} = 1$	Equal influence
3	$W_{I_2} & W_{I_3}$	$a_{23} = 1$	Equal influence

Fill the matrix  $A_{I_1}$ , taking according to Saaty that comparing the effect  $W_{I_1,k}$  to  $I_0$  towards to  $W_{I_1,m}$

is inverse influence  $W_{I_1,m}$  to  $I_0$  towards to  $W_{I_1,k}$ :  $a_{mk} = \frac{1}{a_{km}}$ . Note that the element comparison with itself

$a_{kk} = 1$  shows equal importance. The system's goal forces influence pairwise comparison shown in Table 02.

**Table 02.** The system's goal forces influence pairwise comparison (increase integration in the community)

$A_{I_1}$	$W_{I_1}$	$W_{I_2}$	$W_{I_3}$
$W_{I_1}$	1	$a_{12} = 1$	$a_{13} = 1$
$W_{I_2}$	$\frac{1}{a_{12}} = \frac{1}{1}$	1	$a_{23} = 1$
$W_{I_3}$	$\frac{1}{a_{13}} = \frac{1}{1}$	$\frac{1}{a_{23}} = 1$	1

The result of solving equation (4) is right eigenvector  $\omega'_{I_1}$  of matrix  $A_{I_1}$ , corresponding to the maximum eigenvalue:

$$A_{I_1} \omega'_{I_1} = \lambda_{\max I_1} \omega'_{I_1} \quad (4)$$

Maximum eigenvalue vector can be found through an iterative procedure (Kalitkin, 1990):

- 1) Let  $y^{(0)} = \{1, \dots, 1\}$  unit vector of  $n_{I_1}$  dimension.
- 2) Run the iterative process  $y^{(k)} = A_{I_1} y^{(k-1)} = A_{I_1}^{k-1} y^{(0)}$  before reaching (5)

$$\varepsilon^{(k)} = \left| \frac{y_j^{(k)}}{y_j^{(k-1)}} - \frac{y_j^{(k-1)}}{y_j^{(k-2)}} \right| \leq \varepsilon, \quad (5)$$

where  $\varepsilon$  is the calculation error  $\lambda_{\max I_1} = \frac{y_j^{(k)}}{y_j^{(k-1)}}$ .

The vector obtained at the last step of the iterative process  $y^{(k)}$  is the solution to the equation

$$A_{I_1} \omega'_{I_1} = \lambda_{\max I_1} \omega'_{I_1}.$$

We get the vector (6) after vector's coordinates normalizing  $\omega'_{I_1}$  :

$$\omega_{I_1} = \left\{ \frac{\omega'_{I_1 i}}{\sum_{j=1}^{n_{I_1}} \omega'_{I_1 j}} \right\}, i = \overline{1, n_{I_1}}, \quad (6)$$

where  $\omega_{I_1}$  is vector of influence  $I_1$  to  $I_0$ .

We obtain influence of forces on the goal of the system  $\omega_{I_1} = (1/3; 1/3; 1/3)$ . Integration processes is equal influenced by the Forces (Table 3).

**Table 03.** The influence of forces on the goal of the system

$A_{I_1}$	$I_0$
Forces	$\omega_{I_1}$
Community itself ( $W_{I_1,1}$ )	1/3
Community dynamics ( $W_{I_1,2}$ )	1/3
External factors ( $W_{I_1,3}$ )	1/3

$$CR = 0,05 < 0,1$$

As a measure of correctness of judgment, the relation of consistency is introduced ( $CR$ ) is the consistency index ratio ( $CI$ ) of pairwise matrix  $A_{I_j}$  to random index ( $RI$ )  $CR=CI/RI$ .  $RI$  is a  $CI$  to square matrix of  $n \times n$  dimension filled by random numbers. For  $n \times n$  matrixes  $CI$  is calculated by formula

$$CI = \frac{\lambda_{\max} - n}{n - 1}. \quad CR \leq 0,1 \text{ considered valid for matching matrix paired comparisons.}$$

Carrying out similar calculations, we obtain all vectors  $\omega_{I_j}, j = \overline{1, 4}$  level elements influence  $I_j \rightarrow I_{j-1}$  through entire hierarchy  $I$ .

### 5.3. Evaluation matrix forming

The hierarchy of levels in a downward process is then considered. Starting from level  $I_2$  and considering the influence of its elements on a higher level (Table 04).

**Table 04.** The influence of actors on community dynamics

№	Comparison	Result	Explanation
1	$W_{I_2,11}$ & $W_{I_2,12}$	3	More systematic characteristic, less random
2	$W_{I_2,11}$ & $W_{I_2,13}$	1/3	The theme unites the participants

3	$W_{I_2,11}$ & $W_{I_2,14}$	1/5	Observation showed that goals and values are set by different types of groups - from protecting elementary interests to promoting innovative behavior. These types bring people together in different ways
4	$W_{I_2,11}$ & $W_{I_2,15}$	1/3	Activities stem from goals and values and also clearly define the type of group
5	$W_{I_2,12}$ & $W_{I_2,13}$	1/5	Theme is what causes or does not cause the observed reaction. The same people react differently to different topics
6	$W_{I_2,12}$ & $W_{I_2,14}$	1/5	Participants' properties are derived from goals and values
7	$W_{I_2,12}$ & $W_{I_2,15}$	1/5	Participants' properties are derived from goals and values
8	$W_{I_2,13}$ & $W_{I_2,14}$	3	More susceptible to direct observation, although related
9	$W_{I_2,13}$ & $W_{I_2,15}$	1	Intersect in terms of online activity, it's hard to compare
10	$W_{I_2,14}$ & $W_{I_2,15}$	3	Activity is derived from goals and values

According to Table 04, a matrix of pairwise comparisons in constructed (Table 05).

**Table 05.** Pairwise comparison matrix  $A_{I_2,2}$  and normalized mean geometric value of the influence vector of actors to  $W_{I_2}$  - dynamics of Internet community  $I_2 \rightarrow I_{12}$

Actors $I_2$	$W_{I_2,11}$	$W_{I_2,12}$	$W_{I_2,13}$	$W_{I_2,14}$	$W_{I_2,16}$	$\omega_{I_2,1}$
$W_{I_2,11}$	1	3	1/3	1/5	1/3	0.09
$W_{I_2,12}$	1/3	1	1/5	1/5	1/5	0.04
$W_{I_2,13}$	3	5	1	3	1	0.36
$W_{I_2,14}$	5	5	1/3	1	3	0.31
$W_{I_2,15}$	3	5	1	1/3	1	0.21



$$CR \approx 0,13 < 0,2$$

The remaining matrices of level  $I_2$  are formed according to the procedure given above.

## 6. Findings

The dynamics of integration and external disintegration factors counteraction matrices describe the actors influence (Tables 06, 07).

**Table 06.** Pairwise comparison matrix  $A_{I_2,1}$  and normalized geometric mean value of the vector of influence of actors to  $W_{I_1}$  - community itself  $I_2 \rightarrow I_{11}$

Actors $I_2$	$W_{I_2,1}$	$W_{I_2,2}$	$W_{I_2,3}$	$W_{I_2,4}$	$W_{I_2,1}$	$W_{I_2,2}$	$W_{I_2,3}$	$W_{I_2,4}$	$W_{I_2,1}$	$W_{I_2,2}$	$\omega_{I_{22}}$
$W_{I_2,1}$	1	1/5	1/5	3	1/3	1/3	1/5	3	5	1/5	0.05
$W_{I_2,2}$	5	1	3	5	3	7	5	7	7	1/3	0.23
$W_{I_2,3}$	5	1/3	1	5	3	3	1/3	3	3	1/3	0.11
$W_{I_2,4}$	1/3	1/5	1/5	1	1/3	3	1/3	3	3	1/5	0.04
$W_{I_2,1}$	3	1/3	1/3	3	1	5	1/3	3	3	1/3	0.08
$W_{I_2,2}$	3	1/7	1/3	1/3	1/5	1	1/7	1/3	3	1/7	0.04
$W_{I_2,3}$	5	1/5	3	3	3	7	1	3	5	1/3	0.14
$W_{I_2,4}$	1/3	1/7	1/3	1/3	1/3	3	1/3	1	3	1/5	0.04
$W_{I_2,1}$	1/5	1/7	1/3	1/3	1/3	1/3	1/5	1/3	1	1/5	0.02
$W_{I_2,2}$	5	3	3	5	3	7	3	5	5	1	0.25

$$CR \approx 0,135 < 0,2$$

**Table 07.** Pairwise comparison matrix  $A_{I_2,3}$  and normalized geometric mean value of the vector of influence of actors to  $W_{I_3}$  - external integration factors  $I_2 \rightarrow I_{13}$

Actors $I_2$	$W_{I_2,1}$	$W_{I_2,2}$	$W_{I_2,3}$	$W_{I_2,4}$	$\omega_{I_{23}}$
$W_{I_2,1}$	1	3	5	1/3	0.28
$W_{I_2,2}$	1/3	1	5	1/3	0.16
$W_{I_2,3}$	1/5	1/5	1	1/5	0.06
$W_{I_2,4}$	3	3	5	1	0.49

$$CR \approx 0,135 < 0,2$$

The remaining matrices of level  $I_2$  are formed according to the procedure given above.

### 6.1. Priority vectors for evaluation matrices

We write priority vectors  $\omega_{I_2i}, i = \overline{1, \dots, |I_1|}$  for evaluation matrix  $A_{I_2i}, i = \overline{1, \dots, |I_1|}$   $I_2$  level in a form of matrix  $W_{I_2} = \{\omega_{I_2i}\}, i = \overline{1, \dots, |I_1|}$ , where  $|I_1|$  is the cardinality of  $I_1$  (Table 08).

**Table 08.** Matrix  $W_{I_2} = \{\omega_{I_2i}\}, i = \overline{1, \dots, |I_1|}$  of system's actors influence to forces, influencing Internet community integration rate

Forces $I_1$	$W_{I_21}$ - «Community itself»	$W_{I_22}$ - «Community dynamics»	$W_{I_23}$ - «External factors»
Actors $I_2$	$\omega_{I_21}$	$\omega_{I_22}$	$\omega_{I_23}$
$W_{I_21}$ – group age,	0.03	-	-
$W_{I_22}$ – community volume dynamics,	0.11	-	-
$W_{I_23}$ – group's core quantitative composition,	0.10	-	-
$W_{I_24}$ – mobilization potential,	0.13	-	-
$W_{I_25}$ – modularity,	0.07	-	-
$W_{I_26}$ – external communications volume,	0.05	-	-
$W_{I_27}$ – internal communications volume,	0.13	-	-
$W_{I_28}$ – community volume,	0.05	-	-
$W_{I_29}$ – trust level,	0.09	-	-
$W_{I_210}$ – cohesion level,	0.23	-	-
$W_{I_211}$ – leadership features,	-	0.13	-
$W_{I_212}$ – participant features,	-	0.11	-
$W_{I_213}$ – publication's subject features,	-	0.20	-

$W_{I_2,14}$ – group goals and values,	-	0.35	-
$W_{I_2,15}$ – online and offline activity features	-	0.20	-
$W_{I_2,16}$ – social network’s software and hardware platform features	-	-	0.18
$W_{I_2,17}$ – political and legal aspects,	-	-	0.16
$W_{I_2,18}$ – financial aspects,	-	-	0.12

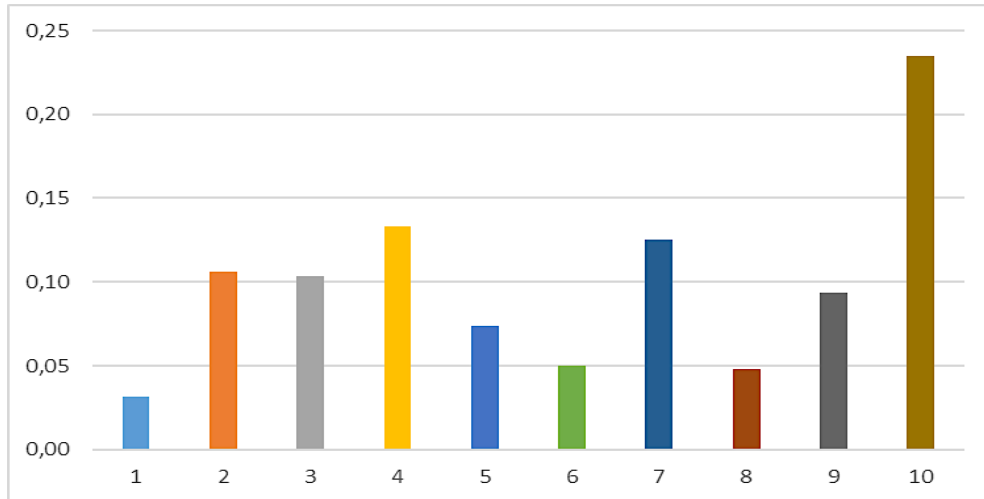
We now turn to the level of  $I_3$  (actors’ characteristics level). We consider its influence on the elements of the level  $I_2$ .

We form matrices of paired comparisons similarly to the previous level (the results obtained for the characteristics of the community are given in Table 09).

**Table 09.** Matrix of normalized value of vectors of influence of characteristics of actors  $X_i$  to  $W_{I_2,1}$  – community itself  $I_3 \rightarrow I_{21}$

Actors $I_3$	$X_1$	$X_2$	$X_3$	$X_4$	$X_5$	$X_6$	$X_7$	$X_8$
$W_{I_2,2}$ – community volume dynamics,	0.4	0.6						
$W_{I_2,4}$ – mobilization potential,	0.44	0.19	0.27	0.1				
$W_{I_2,6}$ – external communication volume,	0.17	0.33	0.23	0.27				
$W_{I_2,7}$ – internal communication volume,	0.23	0.18	0.58					
$W_{I_2,9}$ – trust level,	0.10	0.10	0.09	0.22	0.49			
$W_{I_2,10}$ – cohesion level,	0.06	0.06	0.10	0.24	0.10	0.22	0.08	0.14

A graphical representation of the results of calculations on the influence of actors on the integration process is shown in Figure 02 (Table 08 column “Community itself”). Also, according to Tables 08 and 09, similar histograms of the distribution of the influence of variables are constructed.



**Figure 02.** The influence of actors on integration processes in the Internet community

In figure 2 along the abscissa axis: 1 - the age of the group, 2 - the community dynamics volume, 3 - the group's core quantitative composition, 4 - potential of mobilization, 5 - modularity, 6 - the volume of external communications, 7 - the volume of internal communications, 8 - the community volume, 9 – trust level, 10 - cohesion level.

## 7. Conclusion

Summing up the research as a result of sociological observation and its processing according to the method of T. Saaty, we can indicate the following.

Achievement a fairly consistent assessment by experts of the degree of importance of the observed factors (Table 06, 07), is preliminary result of the research.

The active forces of integration of these communities as highlighted by experts: The community itself (it's internal processes), community dynamics and external factors, are equally important for community integration (Figure 01, Table 01).

According to Table 08, we can rank importance of the force's internal actors. Internal community actors (ascending): group age, community size, external communications volume, level of trust, modularity, group core qualitative composition, volume dynamics, internal communications volume, mobilization potential, cohesion level (Figure 02). Community dynamics actors: online and offline activities features, features of publications topics, leadership and participants' features, group goals and values. External factor's actors: financial aspects, legal and political aspects, the software and hardware platform features, sociocultural aspects.

The resulting model, being a working hypothesis, requires further verification, possibly expanding the parameters, refining the attributes and their quantification, as well as formalizing with mathematical means.

### 7.1. The nomination of a minimal hypothetical model

The results can be used to advance the minimum in composition (necessary), hypothetical model of "integration of mobilization in online communities." By using the Pareto principle, the minimum set of

Internet community's mobilization integration objective and reliable degree parameters (in decreasing order of importance): social and cultural aspects, values and goals of the group, the internal communications and volume of potential of mobilization.

## 7.2. Variables by which the listed parameters are fixed

Variables by which the listed parameters are fixed (Table 09):

- sociocultural aspects (ritualized practices);
- group goals and values;
- internal communication volume;
- mobilization potential.

## Acknowledgments

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