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Suggestions for Informational Influence on a Virtual Community

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ABSTRACT

The growing popularity of social networks made them a perfect platform for informational warfare. They are widely utilized in influencing miscellaneous processes of human interaction, namely opinion formation, decision making, imposing goals and spreading information. Such interference in people's behavior poses a threat to the personality and the society as a whole. An open problem is to reduce the informational hazard in virtual communities to the threshold value. Our contribution to the solution of the problem is the algorithm of choosing discussions of a virtual community that are suitable for the influence on the internal informational space. The algorithm in action is demonstrated on the virtual community model. In this paper we dwell on one stage of the algorithm, particularly making suggestions. On this stage, the list of discussions unsuitable for informational influence (prohibited discussions) is composed. The experiments results have proved the significance of this stage and the advantages of influencing a virtual community with the list of prohibited discussions in getting accurate outcome.

Keywords

Informational influence, Informational hazard index, Prohibited discussion, Virtual community, Group value, Information space, Reachability matrix.

1. INTRODUCTION

The Social networks development and increase in the number of users, which ensued from continuous improvement of the tools, made social networks an ideal base for creating virtual communities.

Owing to the content diversity of virtual communities` discussions, the users have an opportunity to join a related to their fields of interest conversations. As a result discussions could be used for conducting social researches, finding out people`s attitudes to various fields of consideration (politics, culture, etc.). Besides, as time goes by they are more and more used in information wars, namely electoral competitions, marketing products or services in the competitive space, or affecting collective conscience. The last could be carried out with the aim to change people`s behavior, impose goals, that either don`t correspond to their interests or contain information risks to an individual, society or state.

Thus, there exist not only beneficial to society virtual communities aiming at enhancing society`s well-being as a whole, or separate social groups and individuals life, however social networks are more and more used for creating destructive virtual communities. Destructive communities do not exclude illegal methods from their strategies. They direct their aggression at opposing social networks or generally at society.

One of the methods used in information wars and preventing information hazards is informational influence, which is employed for informational management. In this case informational management means providing the objects of influence with the information that will make them alter the course of their behavior.

Informational influence success to the great extent depends on the right choice of the object for informational influence. To put it differently information advantage is essential. This necessity is a result of the complicated discussion structure of virtual communities. Due to the immense network of interconnected with hyperlinks discussions and numerous registered users, the informational influence on all virtual community`s constituents at once is impossible.

2. RELATED WORKS

The rules, following which a state could combat informational influence of virtual communities, are presented in [1, 2]. They are:

- Applying force - shutting down servers;
- Legal – prosecuting virtual community members;
- Monitoring and exercising of informational influence methods with the aim to fight the informational influence of virtual communities.

Monitoring and exercise of informational influence methods to fight virtual informational influence of communities is proved to be in the long run the most efficient of three enlisted previously methods. These methods give opportunity not only to cease or slow down virtual communities activities but change their ideology.

In the research [3] the model of virtual community informational space, which consist of exterior and internal informational space, was created.

Taking into account the model of informational space presented in [4, 5] was worked out informational hazard index. It is utilized to measure the informational hazard level. The following constituents of informational space are considered:

- The number of virtual community members;
- The amount of operating assets;
- The amount of virtual community content;
- Discussion relations structure of a virtual community.

In order to resist and fight informational hazards in virtual communities it was researched how to choose the appropriate strategy of informational influence on internal virtual community space.

The strategies of influence on the internal space of the virtual community were worked out according to the rules of counteraction to informational hazards in virtual communities.

Strategy 1. Discussions banning, that means decrease in discussions and members number.

Strategy 2. Destroying discussions` relations, doesn`t involve without diminishing discussions and members number.

Strategy 3. Destroying discussions` relations, with the aim of forming groups of discussions, doesn`t involve without diminishing discussions and members number.

Conducted researches [6] showed that the most efficient in influencing the structure of virtual community`s informational space are mixed strategies. Before making this deduction the following influence types were studied:

- Discussions' relations destroying by means of discussions banning;
- Informational influence on discussion content in order to reduce the degree of messages relevance to the discussion`s topic, which would result in transferring the discussion to rival virtual community.

3. STATING THE PROBLEM

In this paper the following model of internal informational space [3] is employed:

$$InfSpace(VirtualCommunity_i) = \langle Thread(VirtualCommunity_i), LinkInternal(Tread), \\ Member(VirtualCommunity_i), Shadow(VirtualCommunity_i) \rangle$$

where $Thread(VirtualCommunity_i)$ means the totality of the *i-th* virtual community discussions;

where $Thread(VirtualCommunity_i)$ means the totality of the i-th virtual community discussions;

$LinkInternal(Thread)$ means discussions relations matrix of the i-th virtual community;

$Member(VirtualCommunity_i)$ means the set of registered in social networks i-th virtual community participants (members);

$$Member(VirtualCommunity_i) = \bigcup_{j=1}^{N_i} Member(Thread_j),$$

where $Member(Thread_j)$ represents the set of registered in social networks j-th discussion participants;

N_i represents the number of i-th virtual community discussions;

$Shadow(VirtualCommunity_i)$ represents the set of registered in social networks users interested in the discussed in the i-th virtual topics;

$$Shadow(VirtualCommunity_i) = \bigcup_{j=1}^{N_i} Shadow(Thread_j),$$

where $Shadow(Thread_j)$ stands for the set of registered in social networks users, who despite being interested in a discussion do not participate in it;

N_i stands for the number of i-th virtual community discussions.

Provided:

$$Member(VirtualCommunity_i) \neq Shadow(VirtualCommunity_i).$$

A virtual community is presented by means of matrix method [7, 8] as a disconnected, undirected graph.

$$G = (V, A)$$

where V denotes the set of vertices that represents the totality of the i-th virtual community discussions $Thread(VirtualCommunity_i)$;

A denotes the graph`s G adjacency matrix that represents the elements of virtual community discussions relations matrix;

$$A = LinkInternal(Thread)$$

According to [3] the matrix of relations between the discussions of the i-th virtual community has the following look:

$$LinkInternal(Thread) = \|link_{ij}\|_{n*n},$$

where $link_{ij}$ indicates the existence of hyperlinks between the i-th and the j-th discussions of the virtual community;

n denotes the number of discussions in the virtual community;

The presence of a hyperlink between the i-th and the j-th discussions in the virtual community is determined in the following way:

$$link_{ij} = \begin{cases} 1, if\ there\ is\ a\ hyperlink\ between\ the\ i-\text{th}\ and\ the\ j-th\ discussions \\ 0, = if\ the\ hyperlink\ is\ absent. \end{cases}$$

Or:

$$link_{ij} = \begin{cases} 1, if\ ThreadMembers_i \cap ThreadMembers_j \\ 0. \end{cases}$$

where $ThreadMembers_i$ denotes the set of the i-th discussions members.

Vertices weights could be calculated on the grounds of discussions` characteristics $Sim(Thread_i)$ and the following discussion model [3]:

$$Thread_i = \langle ThreadTitle_i, ThreadDescription_i, ThreadMembers_i, Post(Thread_i), Link(Thread_i) \rangle$$

where $ThreadTitle_i$ represents the i-th discussion title;

$ThreadDescription_i$ represents the i-th discussion description;

$ThreadMembers_i$ represents the set of the the i-th discussion members;

$Post(Thread_i) = \{Post_{ij}\}_{j=1}^{N^{(PT_i)}}$ represents the set of the messages, that constitute the i-th discussion;

$N^{(PT_i)}$ represents the number of messages in the the i-th discussion;

$Link(Thread_i)$ represents the set of hyperlinks, that are in the i-th discussion informational content.

Thus vertices weights are denoted as

$$V = \left\| Sim(Thread_i), card(ThreadMembers_i) \right\|_{i=\overline{1,n}}$$

where $Sim(Thread_i)$ stands for the degree of relevance of the i-th discussion posts to its topic;

$card(ThreadMembers_i)$ stands for the number of discussion members.

Thus, the aim is, by means of the graph theory algorithm, to solve the problem of finding the shortest list of the virtual community discussions, which deletion would reduce the information hazard index of the virtual community to the threshold level.

4. THE ALGORITHM OF CHOOSING DISCUSSIONS

The algorithm outcome is the minimal amount of the virtual community discussions sufficient for performing informational influence on the internal space aiming at reducing informational hazard to the threshold level.

Running the algorithm the following complementary goals are reached:

- Discussions groups forming;
- When applying the algorithm repeatedly, the feedback of informational influence on the virtual community should be taken into account.

The overall algorithm is depicted on Figure 1.

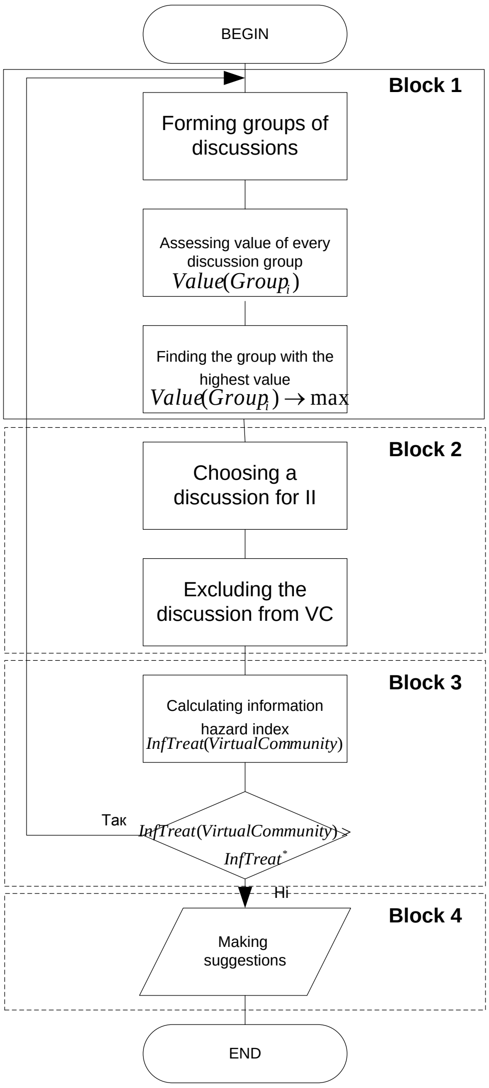

Figure.1: The flow chart of the algorithm of choosing virtual community discussions suitable for the influence on the internal informational space.

4.1 Block 1

Discussion groups have to be formed according to the following rules [4,5]:

- The group can`t be empty, it should consist at least of one discussion.
- A virtual community can contain from 1 to n groups (n means a number of discussions in a virtual community), therefore the group can contain from 1 to n discussions.
- All discussions are interconnected with internal and exterior hyperlinks or have common members. Discussions, not connected with any discussion of the group, found another group.
- All discussions of the group have no internal or external hyperlinks and no common members with the discussion from the other groups. Otherwise, the groups have to be referred as to one.

Next step is to assess the value of the formed groups. The formula for calculating virtual community group value is presented further:

$$Value(Group_i) = \sum_{j=1}^{M^{(Group_i)}} \left(Sim(Thread_j) \cdot card(ThreadMembers_j)\right) \cdot \ln\left(\sum_{j=1}^{M^{(Group_i)}} \left(Sim(Thread_j) \cdot card(ThreadMembers_j)\right)\right) - \sum_{j=1}^{M^{(Group_i)}} \left(Sim(Thread_j) \cdot card(ThreadMembers_j)\right)$$

where $ThreadMembers_j$ represents the set of the j-th discussion participants;

$Sim(Thread_j)$ stands for the degree of the j-th discussion`s topic relevance;

$M^{(Group_i)}$ stands for the number of discussions in the j-th group.

The degree of relevance is calculated by the equations described below [3]:

$$Sim(Thread_i) = \frac{\sum_{j=1}^{N^{(Thread_i)}} card\left(Post_j^{+}(Thread_i)\right)}{N^{(Thread_i)} - \sum_{j=1}^{N^{(Thread_i)}} card\left(Post_j^{(flood)}(Thread_i)\right)}$$

where $Post_j^{+}(Thread_i)$ the set of the i-th discussion’s positive messages;

$Post_j^{(flood)}(Thread_i)$ means the set of the i-th discussions messages that in light of the virtual community subject matter convey no useful information;

$N^{(Thread_i)}$ means the number of the i-th discussions messages.

And

$$Sim(Thread_i) = \frac{\sum_{j=1}^{N^{(Thread_i)}} Weight\left(Post_j^+(Thread_i)\right)}{\sum_{j=1}^{N^{(Thread_i)}} Weight\left(Post_j(Thread_i)\right)}$$

where $Weight\left(Post_j^+(Thread_i)\right)$ denotes the weight of the i-th discussion`s positive messages;

$N^{(Thread_i)}$ denotes the number of the i-th discussions messages.

$$Weight\left(Post_j(Thread_i)\right) = \frac{\sum_{w^*_{Centroid(Thread_i)} \in Post_{ij}} w^*_{Centroid(Thread_i)}}{M_{Centroid(Thread_i)}},$$

where $w^*_{Centroid(Thread_i)}$ represents the weight of the keyword from the i-th discussion centroid, which is in the j-th post of the i-th discussion;

$M_{Centroid(Thread_i)}$ represents the number of the keywords from the i-th discussion centroid, which are in the j-th post of the i-th discussion;

The group that has the highest value of all other groups and contains more than two elements is to be selected.

4.2 Block 2

Before applying informational influence, it is necessary to decide on a discussion or several suitable for informational influence discussions.

Further step is excluding the discussion from the virtual community, this can be achieved either by applying power (shutting down a discussion) or by informational influence (reducing the degree of the discussion topic relevance and discussion transfer to the rival virtual community).

4.3 Block 3

Calculating the information hazard index for the virtual community that has undergone enlisted above changes [4,5]:

$$InfTreat(VirtualCommunity) = \begin{cases} \dfrac{Value(VirtualCommunity)}{Value(VirtualCommunity)^*}, \\ 1, \text{якщо } \dfrac{Value(VirtualCommunity)}{Value(VirtualCommunity)^*} > 1 \end{cases}$$

where $Value(VirtualCommunity)$ means virtual community value;

$Value(VirtualCommunity)^*$ means the extreme virtual community value, when the information hazard realises. The content quality and links structure of the virtual community are disregarded.

Virtual community value:

$$Value(VirtualCommunity) = \sum_{i=1}^{N}\left(\sum_{j=1}^{M^{(Group_i)}}\left(Sim(Thread_j)\cdot card(ThreadMembers_j)\right)\cdot \cdot \ln\left(\sum_{j=1}^{M^{(Group_j)}}\left(Sim(Thread_j)\cdot card(ThreadMembers_j)\right)\right) - - \sum_{j=1}^{M^{(Group_j)}}\left(Sim(Thread_j)\cdot card(ThreadMembers_j)\right)\right)$$

where N – the number of groups in the virtual community;

$M^{(Group_i)}$ represents the number of discussions in the i-th group.

Extreme virtual community value:

$$Value(VirtualCommunity)^* = Members(InfTreat_i)\cdot \ln\left(Members(InfTreat_i)\right) - - Members(InfTreat_i)$$

where $Members(InfTreat_i)$ denotes determined by experts extreme number of a virtual community members, when the information hazard realises. The content quality and links structure of the virtual community are disregarded.

If the information hazard index excesses the threshold level go to Block 1.

4.4 Block 4

At this stage suggestions about the list of suitable for information influence on the internal information space discussions are made and expected structure of the internal informational space of the virtual community is composed.

5. DISCUSSION GROUPS FORMING

Due to the fact that the virtual community is presented by means of the matrix method, the algorithm of the graph partition into as dense as possible graphs is used.

To perform this, the adjacency matrix A is exploited. All the diagonal elements of the adjacency matrix A are equal 1, as long as, each vertex is reachable for itself.

Following the parallel algorithm of constructing reachability matrix on the basis of the graph [9], build the reachability matrix R.

The constructing reachability matrix algorithm consists of the following steps:

1. Create a reachability matrix .
2. Using the general formula, create a reachability matrix for the k subsequent iterations.
3. Repeat the step 2 until the condition is satisfied:

The matrix where the entry of 1 in row i, column j indicates a path from i to j with just one edge $r_{ij} = 1$, is the result of parallel algorithm of constructing reachability matrix.

Having grouped the matrix R by shifting the columns and rows that have similar ordinal numbers, you will build a block diagonal matrix , where the each group of elements denotes a group of virtual community discussions.

If all matrix elements equals 1, a virtual community is represented only by one group.

If from all elements representing a vertex, only a diagonal element equals 1, the discussion is isolated.

6. DETERMINING THE SUITABLE DISCUSSION

Matrix product of n copies of adjacency matrix properties [7, 8] are employed to choose a discussion. Only the existence of the trace between the vertices is of interest, therefore in the matrix exponentiation algorithm arithmetic operations are substituted with logical operations (Addition with disjunction and Multiplication with conjunction).

The algorithm consists of the following steps:

1. Create a reachability matrix .

2. Using the general formula, create a reachability matrix for the k subsequent iterations.

3. Repeat the step 2 until the sum of all row elements of the matrix equals the number of discussions in the group.

The outcome of the algorithm are one or several discussions that have the shortest route to all the other discussion groups of a virtual communities.

7. CHOOSING THE DISCUSSION FOR INFORMATIONAL INFLUENCE

When choosing a discussion, the list of unsuitable for informational influence discussions (prohibited discussions) has to be considered. The list is a result of revised monitoring and influence strategy decision process. Using the prohibited discussions in carrying out informational influence is impossible because:

- The discussion is strongly moderated (administrators and moderators constantly delete undesirable content);
- Informational influence had negative results.

Therefore, prohibited discussions must be excluded from the list of determined for the informational influence discussions. After that following rules are to be adhered to:

- If the discussion list is empty, run the algorithm for k+1 iteration to obtain additional discussions list.
- If the list contains only one, choose it for an informational influence object.
- If several discussions are available, choose the discussion, which deletion leads to the most dramatic informational hazard rate reduction. If the previous filtering gave more than one results, choose the discussion with the most undefined subject matter.

8. MAKING RECOMMENDATIONS FOR INFLUENCE ON INTERNAL INFORMATION SPACE

Recommendations are made after the completion of the full list of discussions, which when deleted, would cause information hazard rate fall to its threshold level.

Besides a discussion list, the prospective structure of the internal and external information space of the virtual community after informational influence is sketched.

For the further virtual community monitoring is determined the observation window. It gives opportunity to see the results of the informational influence.

During the revised social network monitoring are taken all measures to form the virtual community with the determined subject matter.

The list of prohibited discussions is made before the revised monitoring.

9. EXPERIMENTAL PART

The calculations were made for the virtual community model with the following features showed in Table 1.

Table 1. Characteristic features of the virtual community's models graph

№	Graph metrics	Meaning
1.	Vertices (discussions)	500
2.	Edges	737
3.	Connected components	1
4.	Maximal number of the vertices in the connected component	500
5.	Maximal diameter of the graph	500
6.	Average diameter of the graph	12
7.	Graph`s density	5,72

Presented characteristic features of graph of the virtual community model correspond to the previous investigations of social networks structure [10, 11].

Additional features of the community`s discussions are presented in Table 2.

Table 2. Characteristics of the virtual community`s discussions

№	Discussions` characteristics	Meaning
1.	Minimal number of members	100
2.	Maximal number of members	1000
3.	The lowest degree of posts relevance to the topic of the discussion	0,5

4.	The highest degree of posts relevance to the topic of the discussion	1

Calculations were carried out for the two virtual community types:

Type 1.

Virtual communities with no list of prohibited discussions, which usage in carrying out informational influence is impossible.

Type 2.

Virtual communities with provided list of prohibited discussions, which usage in carrying out informational influence is impossible. The list is composed on the basis of calculations made for the Type 1.

For both types calculations are repeated until information hazard index drops to its threshold value – 0,5.

Graphs structures for type 1 and type 2 are depicted in the figures 1 and 2 correspondently.

◇ denotes objects (discussions) determined for informational influence (Type 1)

Figure 2. Virtual community structure (Type 1)

◇ objects (discussions), determined for informational influence (Type 1)
● prohibited discussions, that can`t be subjected to informational influence

Figure 3. Virtual community structure (Type 1)

Calculations results for the type 1 and type 2 are presented in the Table 1 and 2 correspondingly.

Table 3. Calculations results for the Type 1

Step	Object of the II	Groups count	Isolated discussions count	Informational hazard index of the VC	Reduction of an informational hazard index:		
					Total	By means of destroying VC structure	By means of excluding VC elements
0		1		0,723			
1	5	1	2	0,721	0,002	0,002	0,000
2	128	2	9	0,670	0,052	0,051	0,001
3	1	3	13	0,642	0,081	0,079	0,002
4	224	3	20	0,634	0,088	0,086	0,002
5	311	3	20	0,633	0,089	0,087	0,002
6	428	4	32	0,621	0,102	0,099	0,003
7	101	4	38	0,615	0,108	0,105	0,003
8	196	4	42	0,610	0,112	0,109	0,004
9	435	4	53	0,599	0,123	0,118	0,005
10	201	4	57	0,595	0,128	0,122	0,005
11	253	4	59	0,593	0,129	0,124	0,006
12	135	4	70	0,583	0,140	0,133	0,007
13	401	4	75	0,579	0,143	0,136	0,007
14	470	4	79	0,573	0,150	0,141	0,008
15	132	4	85	0,565	0,158	0,148	0,010

16	496	4	89	0,560	0,163	0,153	0,010
17	487	4	90	0,558	0,165	0,154	0,011
18	265	4	96	0,552	0,170	0,159	0,011
19	336	4	96	0,551	0,172	0,160	0,012
20	345	4	99	0,547	0,176	0,164	0,012
21	459	5	102	0,536	0,187	0,174	0,013
22	293	5	105	0,532	0,190	0,177	0,013
23	300	5	106	0,528	0,194	0,181	0,013
24	165	5	107	0,527	0,196	0,182	0,014
25	209	5	115	0,521	0,202	0,188	0,014
26	129	5	122	0,512	0,211	0,195	0,016
27	429	5	127	0,508	0,215	0,198	0,016
28	121	5	129	0,505	0,218	0,200	0,017
29	**398**	**5**	**136**	**0,498**	**0,224**	**0,206**	**0,018**

Table 4. Calculations results for the Type 2

Step	Object of the II	Groups count	Isolated discussions count	Informational hazard index of the VC	Reduction of an informational hazard index:		
					Total	by means of destroying VC structure	by means of excluding VC elements
0		1		0,723			
1	5	1	2	0,721	0,002	0,002	0,000
2	230	1	7	0,714	0,008	0,007	0,001
3	278	1	11	0,708	0,016	0,014	0,002
4	218	1	12	0,707	0,028	0,014	0,002
5	152	1	12	0,695	0,026	0,014	0,004
6	187	1	12	0,696	0,026	0,014	0,005
7	204	1	12	0,697	0,025	0,014	0,006
8	227	1	12	0,698	0,025	0,014	0,006
9	224	2	18	0,689	0,034	0,023	0,011
10	209	2	25	0,682	0,040	0,029	0,011
11	144	2	28	0,678	0,044	0,032	0,012
12	253	2	30	0,677	0,046	0,034	0,012
13	300	2	32	0,672	0,050	0,037	0,013
14	165	2	34	0,670	0,053	0,039	0,014
15	270	2	35	0,668	0,055	0,041	0,014
16	176	2	35	0,668	0,055	0,041	0,014
17	170	2	39	0,664	0,059	0,045	0,014
18	181	2	41	0,660	0,063	0,048	0,015
19	214	3	41	0,618	0,105	0,089	0,016
20	196	3	45	0,613	0,110	0,093	0,017
21	246	3	47	0,611	0,111	0,094	0,017
22	139	4	48	0,605	0,117	0,099	0,018
23	293	4	48	0,602	0,120	0,102	0,019

24	173	4	51	0,600	0,122	0,103	0,019
25	265	4	58	0,594	0,128	0,109	0,019
26	435	4	68	0,576	0,147	0,126	0,021
27	249	5	70	0,571	0,152	0,131	0,021
28	110	6	70	0,553	0,170	0,148	0,022
29	401	6	75	0,550	0,173	0,151	0,022
30	496	6	80	0,544	0,178	0,156	0,023
31	470	6	83	0,538	0,185	0,162	0,023
32	487	6	84	0,534	0,189	0,166	0,023
33	336	6	84	0,534	0,188	0,164	0,024
34	345	6	87	0,530	0,192	0,168	0,024
35	459	7	90	0,519	0,204	0,179	0,025
36	82	8	95	0,510	0,212	0,187	0,025
37	429	8	101	0,507	0,216	0,190	0,026
38	311	8	102	0,506	0,217	0,191	0,026
39	428	8	114	0,494	0,228	0,202	0,026

Figure 4 presents changes of the information hazard index value for the Type 1and Type 2.

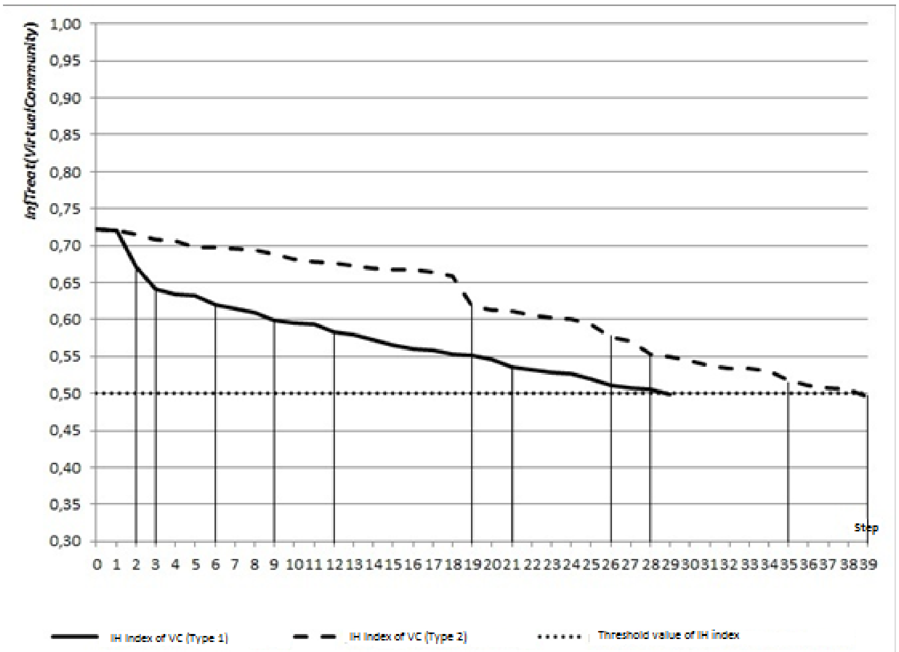

Figure 4. Changes of the information hazard index value for the Type 1and Type 2

Foreseen post-influence structures for the Type 1 and Type 2 virtual communities are presented in the Figures 4, 5 correspondingly.

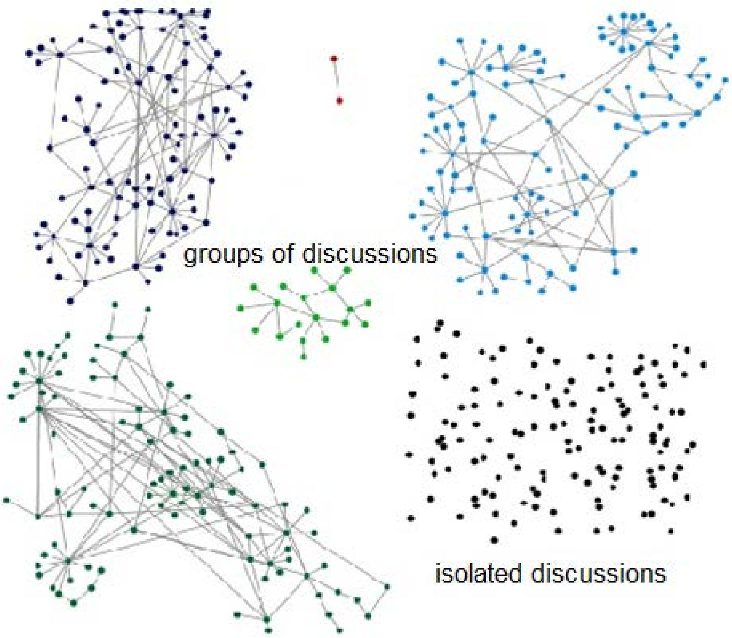

Figure 5. Foreseen post-influence structures for the Type 1 virtual community

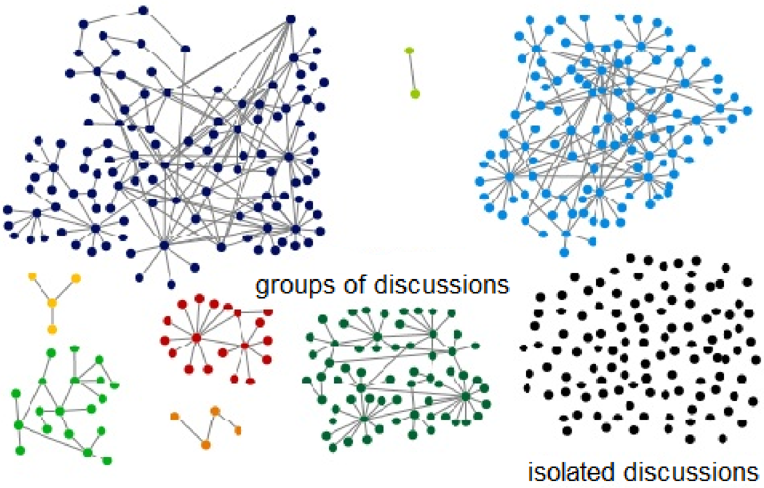

Figure 6. Foreseen post-influence structures for the Type 2 virtual community

The maximal information hazard reduction is reached when mixed informational influence strategies are applied in the process of groups forming (steps 2, 3, 6, 21 for the Type 1 and steps 19, 28, 35 for the Type 2) as well as due to the isolating of a large amount of discussions (steps 9, 12 for the Type 1 and steps 26, 39 for the Type 2).

The experiments results showed that reduction of the informational hazard level is achieved not by means of decreasing the quantity of discussions in the virtual community, but owing to destroying virtual community structure.

10. CONCLUSIONS

The set in the beginning of the research goals were reached. In other words the problem was formulated and applying graph-theoretic methods was developed an algorithm of making the minimal list of virtual community discussions suitable for the informational influence aiming at informational hazard reduction to its threshold. By repeated algorithm application, the feedback of informational influence on the internal space structure of a virtual community is taken into account. Moreover the list of unsuitable for informational influence discussions (prohibited discussions) is formed. The list contains strongly moderated discussions (administrators and moderators constantly delete undesirable content) and discussions, informational influence on which caused negative results on the participants of the discussion. Experiments results proved that the highest informational hazard index reduction ensued from destroying the structure of internal informational space. Causing a decrease in virtual community discussions count (members of virtual community count) appeared to be less efficient. The maximal informational hazard reduction occur, either by forming separate groups of discussions according to the Strategy 3 or by forming large quantity of isolated discussions corresponding to Strategy 2.

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