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Decision-making approaches in the antagonistic digital communication of the online communities users

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Abstract
The information space is an effective hybrid warfare tool on the web. This study investigated the decision-making process in the antagonistic digital communication of internet services users. Implementation of the proposed methods in this study minimized the negative impact of the spread of destructive content and actions of unfair competitors in the ecosystem of social internet services. The innovativeness of the suggested methods is the ability to make real-time decisions in a situation of antagonistic behavior of online users. The authors presented a model to secure user data, contributing to sustainable communicative interaction for its managers and users. This article presented approaches to decision-making by online community administrators under conditions of antagonistic behavior of the online services, which ensures the increase of efficiency of online communication. Timely and effective decision-making eliminated the negative impact of conflicts between communities and the spread of threats to users' information security. The algorithm of decision-making by users of stable internet services is suggested. This article contains examples of using the examined Wald and Savage criteria for making optimal decisions, confirmed by many experiments. The developed methods are tested on the online community on the social network Facebook.

Keywords Online community · Antagonistic communication · Digital · Social internet services · Decision-making · Web · Antagonistic behavior · Internet · Online community user

1 Introduction

As a consequence of the development of the information sector, social internet services have become one of the leading channels of digital communication among users in the information environment, giving it a new form, content, and mechanisms. Social internet services have become the main generator of macro-initiatives for the development of the information society, a platform for the establishment and transformation of economic entities and non-governmental organizations representing the will and interests of citizens, contribute to the structuring of communicative space (Zafar et al. 2021; Obermayer et al. 2021), social media analytics for business decision-making system (Srebalova et al. 2020; Zhang et al. 2022), the creation of online communities (Reinikainen et al. 2021), etc. However, this has led to social internet services as an effective tool for competing with social systems or entire countries in the information sphere (Molodetska et al. 2020; Korobiichuk et al. 2019). The fight against information in social internet services involves a complex destructive information impact on users (Bizzi and Labban 2019; Hysa and Spalek 2019) while protecting their own controlled information space with similar adversary influence. The ultimate goal of the information struggle is to win and maintain information supremacy over the opposing party.

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As a result of the progressive development of information technologies, the deepening of their introduction into all public activity areas, and the creation of new knowledge, information has become a significant factor in influencing economic activity (Fraccastoro et al. 2021). At the same time, as the positive advantages of modern information technologies, new threats to the economic relations associated with information activities have emerged (Ye et al. 2022). Thus far, information and cybernetic influences (Wu et al. 2021) have become an effective tool for achieving the objectives of the opposing party and have opened up opportunities for the management of individual actors' spheres of public activity and entire societies and states. Of particular importance is the use of embedded power technologies in social internet services that influence the mental sphere of users and aim to reduce criticality in the perception and implementation of embedded content (Fedushko and Davidekova 2019). Social internet service is a service on the Internet for creating user profiles, connecting them with other users and online communities, and providing digital communication tools, creating and distributing content of various types. Implementing compelling technologies is critical for economic agents that use social internet services to communicate with target audiences, manage corporate image, conduct investor relations, and promote goods and services. The main risks for the economic actors are when the users of social internet services and their communities are exposed to the negative image of the target audience, discredit in the eyes of the partners, hidden influence on users in the direction necessary for the manipulator, call of given reactions, etc.

Today, the advantage in the information space of social internet services is achieved due to the high rate of dissemination of destructive content by users and their communities and the decentralized nature of the links between them. Therefore, online communities in social internet services play a significant role as centers of common interest for interpersonal and group digital communication in the information space. The online community is a form of community that arises and operates in social internet services to help solve their professional and meet their interests. Users of social internet services are united in these online groups with joint interests to work to improve the network further. Users of the online community are the actors of the online community, users who have profiles created by social internet services. They use these profiles in social internet services not only for digital communication but also for self-organization.

Online communities in social internet services in their activities are changing society. Such changes are possible by producing and sharing content that is part of the information space. However, such content may be unreliable, incomplete, or biased and create preconditions for manipulating the individual or public consciousness. Various studies have shown that implementing threats to information security in social internet services (Kim and Hawkins 2019) makes user interaction disorderly and uncontrollable, leading to chaotic dynamics of communication processes (Harris and Mak 2021). The solution to this problem is to reduce the level of information entropy in the information space of social internet services to stabilize the public opinion of users (Marchand et al. 2021), increase their critical perception of destructive content (Timm 2015), and regularize the relationships between community users (Can and Balatas 2019) and their decisions.

The study aims to increase the efficiency of social communication in the internet services of subjects of economic activity in conditions of antagonistic behavior in an information environment to improve the strategic decision-making process in online communities.

The antagonistic behavior of online community users is a person's behavior with noticeable signs of forms of conflict and rivalry. The antagonistic behavior in the relationship is characterized by the tension between the dominant majority and smaller user groups in the online community. Antagonistic behavior arises based on conflict of ideological, political, social, economic, and religious interests. This behavior is manifested in the relationship between dominant and subordinate groups in online communities and the level of subordinate groups. The struggle between users with antagonistically opposite behavior occurs in acute forms and mostly ends with the destruction (exit from the community) of one of these users. The goals of the users with antagonistically opposite behavior are completely opposite. The complete resolution of antagonism in the online community is achieved only by eliminating the basis that gave rise to it.

1.1 Innovations of study

This article proposes for the first time to take into account the information situation in the decision-making process for the management of online communities of social Internet services. This innovative approach provides information security for business entities. The proposed approach increases the efficiency and validity of decisions by administrators of online communities. As a result, the preconditions for the sustainable development of online communities in social Internet services are being created in the conditions of spreading and implementing threats to the information security of users and their associations. This allows the online community of economic entities to achieve the goal of functioning and minimize the negative impact associated with the spread of destructive content and actions of unfair competitors in the environment of social Internet services.

The following tasks should be pursued in this study:

- Identifying the features of the decision-making process in stable online communities;
- Analysis of up-to-date information situations with taking into account the uncertainty of the steel only stable online communities choice of its development strategy;
- Creating an algorithm of decision-making by users of stable network networks;
- Formalizing strategic decision-making process in online communities to implement their operation strategy.

In the era of using social networks and information space as a tool for hybrid warfare, influencing various spheres of community activity, digital community functioning strategies are critical to ensure the sustainable development of groups of actors (online users) and the interests of economic entities they represent. Therefore, the use of the proposed approaches allows the manager of the online service to make operational decisions in the conditions of prostitution. The innovativeness of the proposed methods is the ability to make real-time decisions in a situation of antagonistic behavior of web users.

Strategic decision-making in the functioning of the online community is a process of understanding the interaction of decisions and their impact on the online community and its users to gain an advantage. Wrong decisions about the organization and functioning of online communities made at the wrong time can lead to catastrophic consequences in the management of the online community or its closure.

The increasing efficiency of digital communication in internet services is not a quantitative indicator. The efficiency of the implemented methods is evidenced by the number of correct strategic management decisions in the functioning of the online community.

The remainder of this study is organized as follows. The related work in Sect. 2 is discussed, while Sect. 3 introduces the materials and methods of decision-making by stable online community administrators to implement a sustainable functioning strategy and criteria for decision-making by users of stable online networks. Section 4 presents the research results. Section 5 discusses the obtained results, especially the efficiency of the suggested solution, which confirms the Wald criterion and minimizes the risks according to the criterion of the Savage. Finally, the authors conclude this work in Sect. 6. The authors present a model to secure user data in online social services, contributing to stable communicative administration and interaction by managers and users of these services.

2 Related Work

To analyze related works to our study, we use PRISMA (Preferred Reporting Items for Systematic Reviews). PRISMA analysis was carried out in the two most significant academic research databases: Scopus and Web of Science. The analysis results are represented with the Preferred Reporting Items for Systematic Reviews (PRISMA) flow diagram for systematic reviews. Queries were created to select a set of records in Scopus and Web of Science databases: TITLE-ABS-KEY (decision-making AND techniques), TITLE-ABS-KEY (online AND community), TITLE-ABS-KEY (antagonistic AND behavior AND online), and TITLE-ABS-KEY (innovation).

The search results of Scopus and Web of Science databases are filtered with the following parameters: Document Types: Articles; Publication Years: 2018- 2022; Languages: English; Access: Open Access. The authors applied additional filtering to research areas.

The PRISMA flow diagram of systematics reviews results of this study is shown in Fig. 1.

The following problems have been studied in 23 selected research papers by PRISMA methods. A thorough analysis of each scientific paper in this sample is provided below.

The antagonistic behavior is often observed in users of social internet services. This type of behavior (Perchtold-Stefan et al. 2021)—antagonistic behavior—keeps dominant online users from attacking. With the onset of global quarantine caused by the COVID-19 pandemic, many scientists have become interested in studying the antagonistic behavior of online users. Such an unplanned global event as quarantine and the forced transition to a remote form of communication requires the involvement of new technologies and innovations. The authors analyzed current research on using innovation-driven methods to solve information and computer science problems, web technology, management, and others. The following is an overview of selected significant case studies in these areas.

The positive and negative influences among online community users were investigated by Leverso and Hsiao (2021). The relationship of these influences is investigated based on the analysis of information traces formed on public Facebook about the content of Chicago Latino gangs using negative binomial regression models. The scientists analyzed the sentiment analysis of online customers' feedback, suggestions, and recommendations for Amazon and Flipkart products using Random Forest and K-Nearest Neighbor techniques (Dadhich and Thankachan 2021). The study shows the maximum usage of feature extraction and positive–negative sentiment for a large set of reviews. Also, scientists (Salehin et al. 2021) used the sentiment analysis

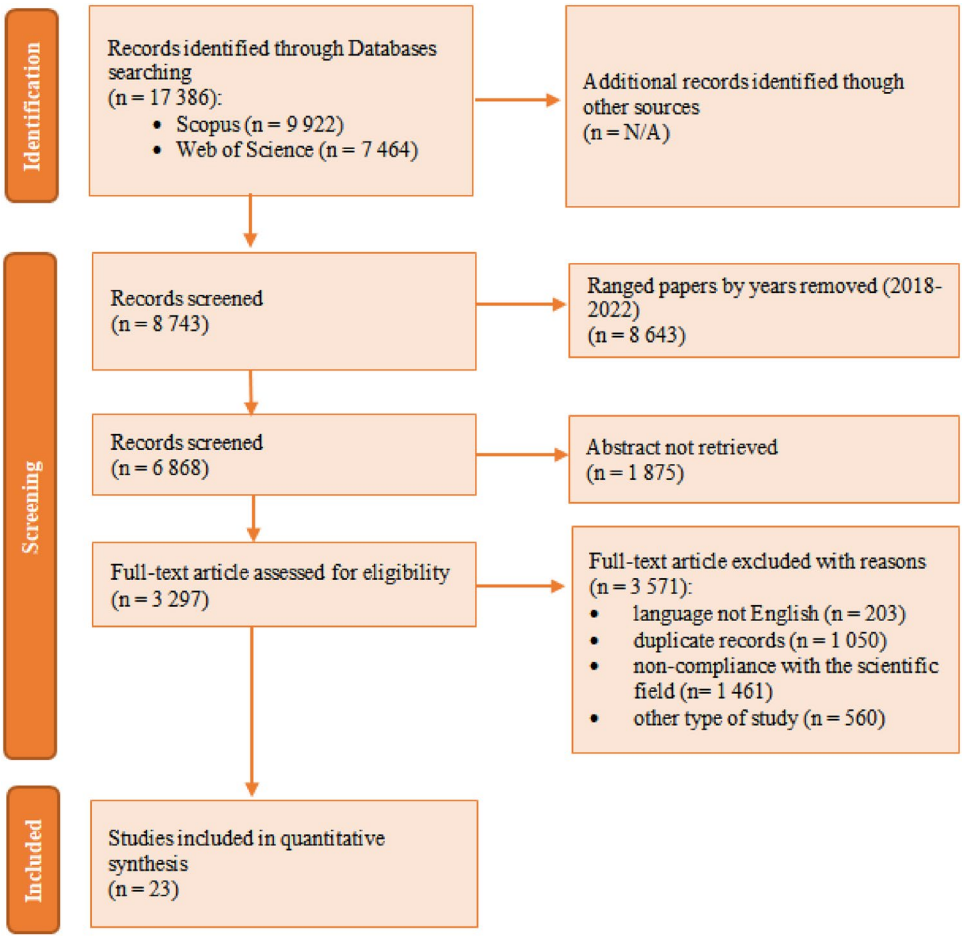

Fig. 1 The PRISMA flow diagram for systematic reviews of this study

technique to detect online users' mental conditions and human mental behavior on the web.

Perchtold-Stefan et al. (2021), a study measuring malevolent creativity in 105 students through multiple regression analysis, found positive correlations with the maladaptive personality trait antagonism. Studies of aggressive behaviors in an anonymous virtual social ecology (Ye et al. 2021) use a moderated mediation model. The suggested model observes the mechanisms of relation principal between fear of COVID-19 and relational aggressive online behavior among students.

Alguliyev and Alakbarova (2021) identified the impact of the social credit system on the behavior of citizens and assessed the trust, reputation, and behavior of citizens based on personal data using modern information technologies in many countries, government agencies, and individual companies.

The scientist also researches political conflicts in online communities and the influence of antagonistic behavior on online community users. Skoog (2021) studied the political conflicts between different actors of the political system depend on the degree of horizontal specialization in this system. Moreover, he studies the antagonistic behavior that refers to the political climate and political influence.

In particular, it is worth paying attention to existing research innovations in web technologies. Hong et al. (2011) presented an information service system that allows users to comfortably monitor critical players, networks, and technology trends. Philipp et al. (2021) studied the advance of modern information system that reveals the positive impact of artificial intelligence progressive web apps on sustainability, especially in economic, environmental, and social benefits.

In work (Hossain et al. 2021) represented tests of the web performance analysis of e-commerce sites.

Payán-Sánchez et al. (2021) analyzed innovative new concepts applied to productive sectors that reality presents in the open innovation that revolutionized innovation management. Huang et al. (2021) used a design science research methodology, a text mining technique, and social network analysis to analyze development trends and justify the emerging cross-disciplinary trend. Gómez-Galán et al. (2021) investigated involving the Latin American university students in complex processes of open innovation through analysis of greatest interest to interacting ICTs, especially through

smartphones and the use of apps and social networks.Hrastinski et al. (2010) explored technologies for supporting open innovation and identified four types of open innovation systems.

Pawade (2021) analyzes the impact of modern search engine optimization techniques on students' depth of concept assimilation.Yang et al. (2021) identified a network of behavioral characteristics of high-expertise users in interactive innovation and provided a new perspective for finding high-value users in enterprise interaction innovation practice.

Davide (2021) considered an approach for social innovation powered by digital technology in the social service sector.Pynnönen et al. (2021) conducted a web-based survey of e-service portals as a service innovation.

Qi et al. (2021) demonstrated a social network based on users' online interactive relations in an online innovation platform and provided practical suggestions. The paper's authors conducted a critical analysis of research in innovation in information technology (Kechagias et al. 2022) and web technologies. This analysis helped to find out that the segment of internet services management remains undeveloped in terms of determining the optimal management decision by administrators to implement a strategy for sustainable operation of stable online communities in the antagonistic confrontation information environment.

The lack of generally accepted scientific tools to overcome the effects of antagonistic information on users of internet services determines the priority of the chosen area of research.

In contrast to existing research on the functioning of online platforms for user interaction, the proposed method ensures the validity of decision-making procedures to prevent and combat external and internal threats to the functioning of the online community. In these issues are the innovations of the presented study.

The filled research gaps. The common direction of the study of the considered scientific works is the study of the peculiarities of economic activities in social internet services and the increase in its efficiency and the behavior of users of online communities. The occurrence and counteraction of different types of conflicts in different spheres—political and educational processes—are also considered. However, the issues of making rational and effective decisions in the economic activity of actors of social internet services and their associations remain unresolved. The peculiarities of online communities' functioning of economic entities are considered to fill gaps in this research field. These features help formulate hypotheses and goals to improve the efficiency of decision-making procedures by users of online communities and their administrators in various information situations.

3 Methods

3.1 Decision-making by stable online community administrators to implement a sustainable functioning strategy

A study of social internet services concludes that services are a complex dynamic system structurally formed by a plurality of users and their associations in online communities based on common interests using the systems approach principles. The environment in which users operate in social internet services is the information space formed based on the influence of the mass media and the agents of threats to information security. The information environment is also affected by the forces of information operations and cyber units that use information weapons in their activities.

The study (Hryshchuk et al. 2020) found that synthesizing stable online communities promises to ensure information security in social internet services. Such user associations are able to react and recover from the impact of threats to information security, adapt to changes in the information space, and realize their purpose of functioning. Publications (Hryshchuk and Molodetska 2016; Trukhaev 1981) suggest synergistic management by influencing users to initiate managed self-organization processes into stable online communities. However, such influence does not consider the state of the information space of social internet services. An established, stable online community should evolve according to a strategy that considers the state of the service itself. Therefore, the development of such strategies and strategic decision-making for their implementation is an urgent task in solving the problem of information security in social internet services.

Stable online communities have some characteristics that distinguish their behavior in the information space of social internet services. Such features are primarily related to the nature of their origin: the creation of stable online communities is an artificially controlled process triggered by managed information influence on social internet users, a service whose effect is synergistic. The synergistic effect enables the self-organization of users and the creation of new online network structures in which the links between individual users are constant. With the necessary number of active users, digital communities are capable of sustainable development. Coherent collective processes in the online community in the future prevent their reduction and ensure further self-development.

Suppose that in the process of a stable online community functioning in social internet service for the implementation of the strategy of old growth, it is necessary to take the solution from the set $R = \{R_1, R_2, \dots, R_i\}$, $i = \overline{1,n}$, which are mutually exclusive. In this case, the informational

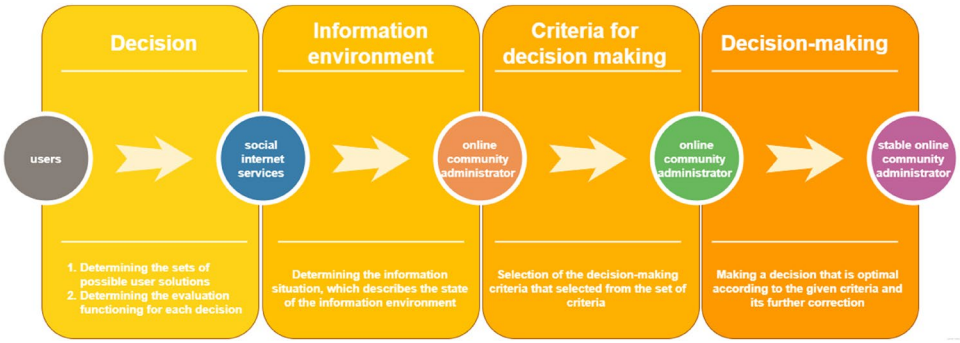

Fig. 2 Business processes of decision-making by an administrator of a stable online community

environment of the social internet service is in one of the states $E = \{E_1, E_2, \ldots, E_j\}$, $j = \overline{1, m}$. This is unknown at the moment of making a decision. A positive or negative result, which a stable online community achieves as a result of deciding by its users and/or administrators R_i under the condition that the social media environment is in the state E_j, is defined by F_{ji} function, where $F_{ji} = f(E_j, R_i)$.

The generalized scheme of making decisions by the owners of stable online communities to implement the steel development strategy is shown in Fig. 2.

In the first stage, the formalization of multiple possible decisions R, taken by the users of a stable online community in its functioning in social internet services, is carried out. It also establishes a multiplicity of E states of the information environment of the services, which are spreading threats to information security aimed at violating the economic security of economic entities. The fundamental indicators of efficiency, which are used for the formation of the estimated function F_{ji}, are defined.

The second stage involves the identification of the information situation in the E_j social internet services by the users and administrators of the digital community.

In the third stage, the decision-making criteria are selected from the set of criteria that can be used in the specific state of the social media environment of social internet services. The administrator of the online community is the manager with a crucial role in online community management and has the highest level of management rights. The administrator has complete control of the life cycle of the online community and assigns roles to other community users. The administrator of the online community is the decision-maker of the online community.

In the final stage, the administrator of the stable online community takes the optimal decision according to the chosen criteria. Additionally, its correction can be carried out.

3.2 Information situations in which users make decisions about static online communities

In general, based on the results of previous authors' research (Doubleday et al. 1983; Pirzadeh et al. 2020; Luo et al. 2021) and taking into account the peculiarities of decision-making by users in online communities, these informational situations of decision-making in social media (Trukhaev 1981) are shown in the following issues:

- Distribution of the acceptable probabilities of the diversity of the information environment of the services—decision-making in the risky environment—is set;
- Formalized the specified distribution of the permissibility of social internet service staying in different states of the information environment with unknown parameters;
- The system of linear order relations on the components of the approximate distribution of the information environment of the service is set;
- Distribution of permutations on the multiple stations of the social and informational environment of the social internet service is unknowable;
- Antagonistic interests of different online communities, which function in the informational environment of the social internet service, in the process of deciding on their functioning;
- Existence of a rooted multitude of conditions in the informational environment of social internet services when quality indicators formalize them.

Of particular importance for studying the processes of development of stable online communities in social internet services is an informational situation, in which antagonistic interests of the representatives of different groups of users are manifested in the informational space of the services (Arayankalam and Krishnan 2021; Arsenyan and Mirowska 2021; Ning and You 2018; Yokoyama et al. 2014; Taslimov et al. 2019; Moustakides and Verykios 2008). This situation is one of the variants of depicting informational confrontation processes in the services' informational space. Under

the conditions of antagonistic interaction in social internet services, there is strong opposition, mutual non-acceptance of the increase of conflicting online communities due to mutually exclusive interests, incompatible values, ideologies, differently minded attitudes and orientations, irreconcilable positions, aggressive behavior of users, and activity in the informational space of the services. The informational environment is combined with online communities, which have opposite goals of functioning, proactively oppose the decision-making goals of the users from the stable online communities, i.e., from all of its states, it selects the very ones in which the F_{ji} functional obtains the minimum values. Under the conditions of antagonistic interests of different groups of users, it is rational to choose the solution which ensures achieving the guaranteed values of the F_{ji} function.

3.3 Algorithm of decision-making by users of stable network networks

It is necessary to formalize the decision-making procedure of administrators of online communities to ensure the improvement of digital communication in the internet services of economic entities.

Stage 1. Identification of the information situation in which the online community functions and decision-making occurs. According to paragraph 2.2, decisions can be made in six different situations. The peculiarities of the antagonistic situation are the sharp confrontation between the users of online communities and the rejection of other narratives. The proposed algorithm is used for this class of tasks that the administrator of social internet services solves.

According to the methods of the theory of decision-making, the guaranteed values of functionality can be achieved by using the criteria of Savage and Wald (Taslimov et al. 2019; Moustakides and Verykios 2008; Giocoli and vs. 2004). The criteria of Wald and Savage are the selection criteria for making a decision based on information with antagonistic nature. The decisions can be obtained by these two criteria coincide. In the informational situation (digital communication), with the antagonistic interests of nature, the Wald or Savage criterion is used for the best solution.

The transition to step 2.1 or step 2.2 of the algorithm is carried out depending on the expected decision-making results.

Stage 2.1. Decision-making occurs when the functional reaches the maximum value.

When it is necessary to evaluate the positive effect of the implementation of decisions on the strategy of development of a stable online community, it is reasonable to use the Wald criterion (the principle of the maximum). Let us consider the case of making decisions on managing the strategy for developing a stable online community under the conditions of antagonistic behavior of the social internet services environment, taking into account the requirement that the function achieves the maximum value. Then the authors consider it reasonable for the administrators to choose a stable online community solution $R_i, i = \overline{1,n}$, for which the following condition is satisfied (Taslimov et al. 2019)

$$F_{i0} = \max_{R_i \in R} \min_{E_j \subset E} F_{ji}^{+}, \tag{1}$$

Such a decision of the administrators allows for achieving the maximum victory in a situation of increasing antagonistic opposition in the social media environment of social internet services. However, the Wald criterion is valid in an environment where the enemy in information warfare uses sophisticated technologies of destructive information influence on the users of social internet services. Considering that due to effective strategic communication in the information environment of the services (Giocoli and vs. 2004), the influence of destructive content on the users is decreasing; the Wald criterion, by its conservatism, can significantly limit the level of winnings of a stable online community, a result of the decision made. That is why it is advisable to use the criterion of Savage in certain situations.

Stage 2.2. Decision-making occurs when the functional reaches the minimum value.

Go to step 2.2 if you need to determine the losses from the decisions made by online community administrators according to Savage's criterion.

The optimal solution $R_i, i = \overline{1,n}$, is considered

$$F_{i0} = \min_{R_i \in R} \max_{E_j \subset E} F_{ji}^{-}, \tag{2}$$

An analysis of the instances of using this criterion shows the following disadvantage. If the decision was taken by the administrators of a stable online community in conditions of antagonistic opposition in the informational environment of social internet services, the solution $R_{i0} \in R$ is optimal according to Savage's criterion, and the non-optimal solution $R_i \neq R_{i0}$ is excluded from the solution multiplier R, then on the new diversity R^* the solution R_{i0} may not be optimal.

4 Results

Let us consider the application of the suggested approaches to decision-making to implement the sustainable functioning of stable online communities in the conditions of antagonistic opposition in the information environment of the services.

A decision must be made to change the number of online community users. These variants of decisions are allowed:

- R_1 is to keep the number of users unchanged;

- R_2 is to increase the number of users by adopting users of online communities with opposite purposes of functioning (taking advantage of the existing resource);
- R_3 is to increase the number of users by recruiting new service users (increasing the resource);
- R_4 is to reduce the number of users in the online community.

In this case, in the informational environment of the social internet service, there can be such kinds of antagonistic opposition:

- E_1 is the following are some of the reasons why the users of the system are not interested in this;
- E_2 is the contradiction between the oppositely directed group motives of the online communities of the users of social internet services, who are the consumers of a particular product or service;
- E_3 are conflicts occur in the information environment, which is based on the economic interests of certain entities of economic activity;
- E_4 is conflict, in which the volume of influence decreases vertically from top to bottom: boss/affiliate, higher organization/enterprise, boss/small company.

Based on many years of professional experience of online community administrators involved in the study, it is empirically established that the benefits of decisions $R_1 - R_4$ in terms of situations of antagonistic confrontation $E_1 - E_4$ community users can be formalized as an integrated economic indicator of gains. The situation of decision-making by the administrator of the stable online community in social networking services is described by a matrix of benefits in the expression of such an indicator

$$\begin{array}{cccccc} & R_1 & R_2 & R_3 & R_4 \\ E_1 & 3 & 10 & 6 & 0 \\ E_2 & 2 & 8 & 7 & 0 \\ E_3 & 2 & 12 & 5 & 1 \\ E_4 & 1 & 5 & 4 & 2 \end{array} \tag{3}$$

To find the optimal solution, the authors use the Wald criterion

$$F_1 = \min_{E_j \subset E} F_{ji}^{+} = \min\{3;2;2;1\} = 1 \tag{4}$$

$$F_2 = \min_{E_j \subset E} F_{ji}^{+} = \min\{10;8;12;5\} = 5 \tag{5}$$

$$F_3 = \min_{E_j \subset E} F_{ji}^{+} = \min\{6;7;5;4\} = 4 \tag{6}$$

$$F_4 = \min_{E_j \subset E} F_{ji}^{+} = \min\{0;0;1;2\} = 1 \tag{7}$$

$$\max_{R_i \in R} \min_{E_j \subset E} F_{ji}^{+} = \{1;5;4;1\} = 5, \tag{8}$$

The results of the calculations showed that the optimal solution for this situation is R_2.

Analogously, the authors use the Savage criterion to find the optimal solution. In this case, the losses due to decision-making by administrators of online communities are formalized based on an empirical approach, in which an integrated economic indicator of losses formalizes them. The risk matrix looks as follows

$$\begin{array}{cccccc} & R_1 & R_2 & R_3 & R_4 \\ E_1 & 9 & 3 & 7 & 15 \\ E_2 & 10 & 4 & 9 & 13 \\ E_3 & 8 & 1 & 4 & 9 \\ E_4 & 12 & 3 & 5 & 7 \end{array} \tag{9}$$

Authors carry out calculations according to the minimax criterion

$$F_1 = \max_{E_j \subset E} F_{ji}^{+} = \max\{9;10;8;12\} = 12, \tag{10}$$

$$F_2 = \max_{E_j \subset E} F_{ji}^{+} = \max\{3;4;1;3\} = 4, \tag{11}$$

$$F_3 = \max_{E_j \subset E} F_{ji}^{+} = \max\{7;9;4;5\} = 9 \tag{12}$$

$$F_4 = \max_{E_j \subset E} F_{ji}^{+} = \max\{15;13;9;7\} = 15, \tag{13}$$

$$\min_{R_i \in R} \max_{E_j \subset E} F_{ji}^{+} = \{12;4;9;15\} = 4, \tag{14}$$

According to the Savage criterion, the optimal solution is R_2.

In order to confirm the work of the considered approaches for decision-making, an experiment was conducted in which the users and administrators of the online community who function in the antagonistic environment of the social internet service Facebook took part (Facebook page of Lviv Polytechnic National University 2022). By its nature, the Facebook group is an economic object.

The administrators of the community implemented the optimal solution R_2 to increase the number of users through the commitment of online communities' users with opposite functional goals. Changes in activity and efficiency of the studied community are shown in Fig. 2. It was found that the number of users in the first month of implementation of the strategy of sustainable development of the stable community

increased by 1.17% compared to the data for October 23, 2021 (Fig. 3).

The dynamics of the users' activity in terms of the number of publications, comments, and reactions to messages are shown in Fig. 4.

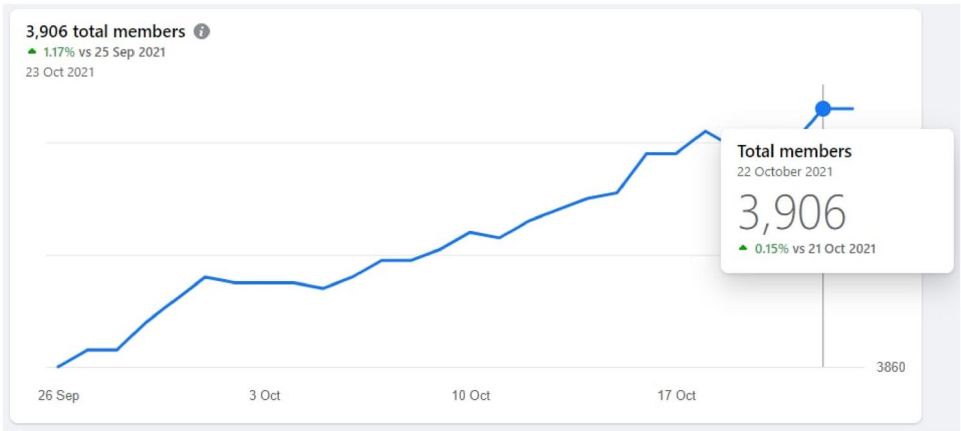

Fig. 3 Dynamics of the number of stable online community

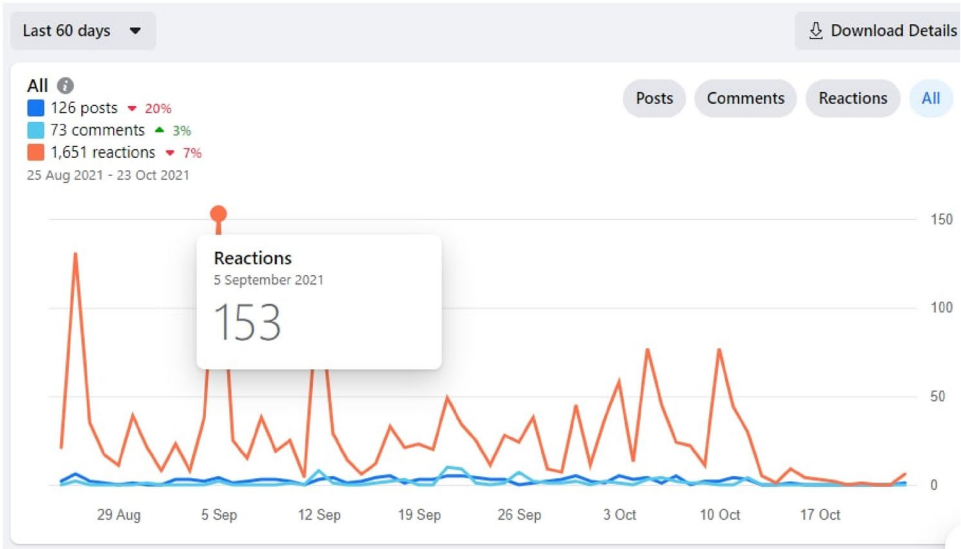

Fig. 4 The activity of stable virtuosity consumers

Fig. 5 Integral indicator of the activity of users of a stable online community

Among the users' activity indicators in the information environment, the number of comments to publications increased by 3%, while the number of publications and reactions decreased. This result is explained by the need for transition processes in the online community, which leads to structural changes and strong ties between new users and existing users.

On the other hand, the increase in the level of comments shows the increase in the level of interest of the active digital community users in the shared content. Upon completion of the transition processes in the stable online community, the level of activity of the users grows, as shown in Fig. 5. This confirmed that the activity level of the stable online community users is increased and confirms the positive effect of the strategy of the old community development implemented by the administrators.

Figure 5 shows the results of the analysis of the activity of a large number of data users of a stable online community (Facebook page of Lviv Polytechnic National University 2022) on a new dataset group on the social network Facebook of the educational institution with a number of users–3 929 people.

The set of data from the Facebook group of the educational institution is operated by authors using data mining and visualization software Orange. This approach will provide a high degree of clarity of data display and allow the user to evaluate the effectiveness of the proposed approach to decision-making by users and administrators of online communities of social Internet services. Figure 5 shows how the number of active community users in the social internet service has changed since the implementation of the strategy according to the example in Sect. 4 (decision R_2). In antagonistic conflict, the number of users was involved by adopting users of online communities with opposite purposes of functioning. This indicates that due to the conflict situation in the information space of services, the average number of active users has not decreased.

Figure 6 provides detailed data on users' activity in the online community of the service. The diagram shows that users carried out the most important types of interaction with the service: publications, comments, and other types of active activities. This further indicates a high degree of user involvement in the online community's functioning and hence the online community's goal.

The data in Fig. 6 demonstrate that the Reactions indicator in the users of the stable online community is proportional to the growth of the indicators of Posts, Comments, and Active users.

Figure 7 shows the result of the analysis of the following components of user activity: posts, comments, active members, total members, pending members, approved member requests, and declined member requests by the Reactions indicator. The implementation of the optimal solution R_2 in the online community of the educational institution improved the process of strategic decision-making in online community administration. The analysis of the activity of the users of the stable online community by the total users' indicator (Fig. 7) shows a continuous growth of active users due to the implementation of the optimal solution R_2 to increase the number of users.

An online community is a commercial informational project that targets many users. Nowadays, the advantage of online communities is the wide choice of platforms for creating online communities and generating an information

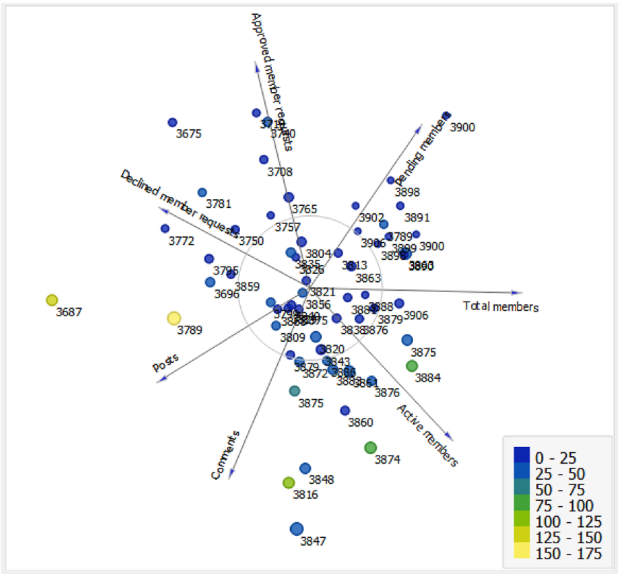

Fig. 6 Statistics of activity of the users of a stable online community by the reactions indicator

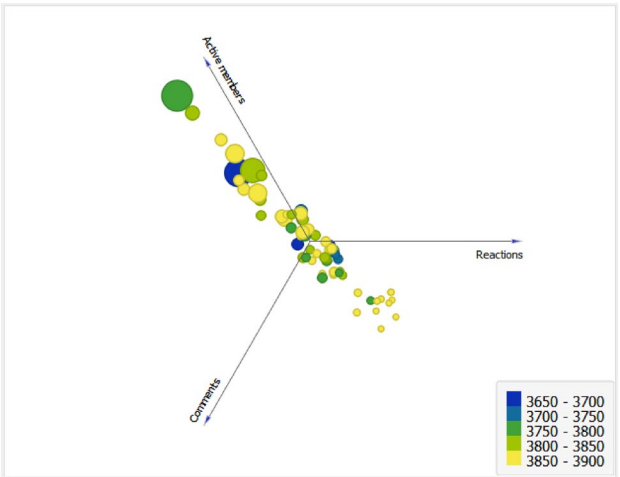

Fig. 7 Statistics of activity of the users of a stable online community by the total users' indicator

image of the project on several platforms in online social environments.

The success of creating and managing an online community is influenced by many factors, including ideas and goals, team selection, project documentation, platform selection, marketing, analytics, project life cycle stages, risks, etc.

One of the most critical issues in online community management is project risk management and the development of crisis response measures in online community management. Prompt decision-making is an integral part of the crisis management of online communities. Often, crises are caused by recklessness in antagonistic behavior of individual online community users.

Anti-crisis management of online communities is risk management in a crisis. In crises, certain parameters of crisis indicators of online communities go beyond the predicted values, reducing the efficiency of the web project due to the destructive behavior of their users.

5 Discussion

A comparison of the results of the calculation for determining the optimal decision by administrators to implement the strategy of sustainable functioning of stable online communities under conditions of antagonistic opposition to the information environment for both criteria showed that the most effective is the solution R_2. Increasing the number of users of a stable community through the commitment of users in online communities with opposite goals of functioning ensures the maximum efficiency of the solution, which confirms the Wald criterion and minimizes the risks according to the Savage criterion.

The community development strategy in conditions of antagonistic opposition to the information environment is implemented following the approach to the redeployment of the available resource. It is more effective to involve active users of social internet services than to recruit new users who can quickly lose interest in the online community and promote its benefits.

The study of the peculiarities of information warfare in social media shows that in the case of online communities' administrators using the Wald criterion to make decisions, it is necessary to follow mixed strategies of the opposing side. Using online teams in an antagonistic environment with different strategies expands a multiplicity of possible solutions, resulting in the adoption of a rational decision and achievement of the set strategic goal of the team's functioning.

The proposed solution in this work increases the profitability of online communities, quickly and efficiently adapts to crises to their owners, quickly implements strategic decision-making in online communities by administrators, develops a crisis plan, and implements a strategy for the sustainable functioning of online communities under the antagonistic behavior of the social internet services users.

6 Conclusions

The present-day task of exploring the behavior of users of social internet services is investigated in this study. A promising area of ensuring users' information security in social internet services is the synthesis of stable online communities. This study presents approaches to decision-making by administrators of online communities under conditions of antagonistic behavior in the informational environment of the services, which enhance the efficiency of digital communication. The quality of strategies and decisions depends on the factors that users or administrators of stable online communities do not influence. The main emphasis is placed on studying the development of stable online communities in the environment of antagonistic behavior of the medium of online social services. Today, social internet services are actively used by economic entities as a generator of macro-trends for the development of high-tech society and a platform for their formation and transformation. With effective communication and communication advantages, spoilers and competitors can use social internet services to achieve an advantage in the informational space of services, supernaturalization, and the use of technologies of suggestive influence on the target audience. It was found that the synthesis of stable online communities is a promising way to ensure the information security of users in social internet services.

The authors implemented the following tasks of this study:

- Identified the features of the decision-making process in stable online communities;
- Analyzed up-to-date information situations by taking into account the uncertainty of the steel only commune communities' choice of development strategy;
- Created algorithm of decision-making by users of stable network networks;
- Formalized strategic decision-making process in online communities to implement their operation strategy.

This article presents approaches to decision-making by administrators of online communities under conditions of antagonistic behavior of the information environment of the services, which ensures the increase of efficiency of social communication. Achievement of advantage by a stable online community in the informational space of social internet services is possible based on the Wald criterion,

which predetermines attainment of the maximum value by the functionality, which determines the level of the winnings. Application by administrators of online communities for achieving strategic goals of functioning can be carried out based on the Savage criterion, which involves evaluation of losses of the users of the digital community in an antagonistic information environment of the services. This article contains examples of using the examined criteria for making optimal decisions. As a result, decision-making by users of stable online communities takes place in different information situations. In such an environment, users' development of online community strategies and decision-making is directly dependent on the state of the information environment of social internet services. The quality of strategies and decisions depends on the factors that users or administrators of stable online communities do not influence.

The authors present a model to secure user data in online social services, which contributes to sustainable communicative administration and interaction for managers and users of these services. The decision-making by users of stable online communities occurs in different information situations. An analysis of existing information situations is made, considering the lack of independence in selecting a unique online community's development strategy. Formalized method of selecting strategic decision-making for online communities' users is implemented in the development strategy of the online community. The peculiarities of decision-making by users in stable online communities are established.

The proposed method provides an opportunity to choose and implement an appropriate strategy for developing the online community in an antagonistic confrontation with the information environment. A case study based on the proposed approach demonstrated how the timely use of these models of decision-making by administrators of online communities would eliminate the negative consequences of unfair actions of competitors. Using the obtained results, scientists will be able to create innovative research projects to develop new approaches to managing the interaction processes between users of online communities and increase the level of information security of social internet services in general. Understanding the peculiarities of user interaction in social internet services provides new knowledge that is of great importance for the subject area of research. We then applied this approach to the field of digital communications in the environment of online social services for online community administrators. The results of our research, confirmed by numerous experiments, have shown that the use of decision-making models based on the information situation in social internet services is an effective tool for implementing a strategy for the sustainable functioning of the online community. Thus, timely and effective decision-making will eliminate the negative impact of conflicts between digital communities and the spread of threats to users' information security.

Limitations. In the research, the authors limit the cases when the parameters of threats to information security in social internet services do not change during a given time interval Δt, i.e., the model is static during this interval.

The *informational situation* of decision-making by the users in social internet services is defined as the level of gradation of unrecognizability in the informational environment of their states from a given diversity at the moment of making a decision by the users of a stable online community.

Future research goals striving to further focus of research are to identify practical approaches to making decisions on the steady development and functioning of stable online communities in other information situations in social internet services. Exploring the peculiarities of decision-making in all possible information situations that arise in social internet services will develop a decision support system for administrators of online communities. This model of the system, implemented in the form of a software application for managing digital communities of economic entities, will increase the efficiency of social communications in social internet services and the functioning of the user community as a whole.

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