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INFORMATION OPERATIONS RECOGNITION:
FROM NONLINEAR ANALYSIS TO DECISION-MAKING

Kiev – 2017

NATIONAL ACADEMY OF SCIENCES OF UKRAINE
INSTITUTE FOR INFORMATION RECORDING

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The book is dedicated to the issues of information operations recognition based on analysis of information space, particularly, web-resources, social networks, and blogs. In this context, open source intelligence technology (OSINT) solves the problem of initial analysis of modern-time information flows. The book provides a detailed description of mathematical principles of information operations recognition, based on mathematical statistics, nonlinear dynamics, complex networks theory, information and mathematical modeling, sociology. A separate chapter covers the applications of approaches from expert estimation theory and decision-making support to information operation recognition.

The book is addressed to a broad circle of specialists from information technology and security domains.

The book is recommended for publication by the academic council of the Institute for Information Recording of the National Academy of Sciences of Ukraine (protocol # 5 of December 12, 2017)

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1. Information operations

In recent years, thanks to numerous documents and publications of US Department of Defense, the term "information operation" has gained popularity, first and foremost, because information technologies are playing an increasingly important role in military operations. At the same time, information operations are defined as actions, targeted at enemy's information and information systems, as well as protection of one's own information and systems [Roadmap, 2003]. Information operations are considered a combination of key capacities of radio-electronic warfare, computer network operations, psychological operations, military action, and operations for ensuring security, intended to influence, destroy, and distort the information, that the enemy needs for decision-making, as well as to protect one's own information.

Information operations cover a whole complex of processes in the most diverse spheres. At the same time it should be noted that they are an important and traditional component of military operations. While the formal definition in the documents of US Department of Defense is focused on military aspects, it is quite applicable to almost every sphere of life.

Below we are going to consider information operations, implemented in the form of information impacts on human conscience.

Information reflects the meanings it contains. That is why today information turned from an abstract term into the object, the purpose, and the means of information operations, became a critical concept within the problematic scope of security. On March 18, 1999, William Cohen, US Secretary of Defense at the time, stated that the ability of an army to use information to dominate in future combats would give the US a new key to victory for many years (if not for several generations) to come [Hill, 2000].

While modeling and performing information operations, we should consider the value of information for decision makers (DM). The value of information includes its

relevance, accuracy and “analytic property”. In practical terms, the value of information can also be defined as its significance or usability (availability for usage). By usability of information we understand ensuring the access of a DM to information that is ready for usage. ISO 9241 standard defines usability as the effectiveness, efficiency and satisfaction with which specified users achieve specified goals in particular environments. In practice, DM gets most of useful information from information and analysis systems, providing guidance for a given situation (situational awareness), as well as decision-making support. According to the field manual (FM 100-6) of the US Department of the Army “Information Operations”, situational awareness is a combination of clear understanding of the disposition of one’s own and enemy forces, and assessment of the situation and intentions of the commanders.

Information operations are performed in a specific social environment. In order to ensure their success, it is necessary to adapt to this environment, overcome a certain barrier of insufficient attention to information impact. This barrier emerges as a result of the so-called, environmental immunity system that can block information impacts if it is powerful enough and/or if it has already learned to protect itself from such impacts. Preparatory actions before launching an information operation can include creation of “immune deficiency” in the social environment by influencing the information space, for example, using materials in the media. Very often information impacts use “virus marketing” mechanisms, for example, in the form of rumors, when disinformation presented as sensation spreads with tremendous speed. The immunity system fights back information operations just like this one. Quite often immunity system of the society is associated with the government that has to ensure security of this society, i.e. under strong government apparatus, the chances of success of anti-social information operations significantly decrease. The reader knows well, how counteraction to such informational processes was organized in totalitarian states. In democratic societies totalitarian methods are,

naturally, inapplicable. In this case immunity is achieved through “learning”, i.e. a democratic society must go through many information attacks, impacts, influences of stereotypes, in order to work out the necessary immunity.

Today, the level of readiness for performing information operations is considered a key success factor of any social procedure or campaign.

Targets of information operations include information and analysis systems of the impact subject. By influencing such systems, one can force decision-makers from enemy camp draw inadequate conclusions, so that the targeted social process changes its trajectory and follows the direction, required by the impacting party [Горбулін, 2009] (fig. 1.1).

In this case immediate information impacts can include placing documents, that compromising the opponents, in the information space, advertisement (including hidden ads) of one’s advantages, distortion of data about external environment, distortion of information concerning one’s intentions etc.

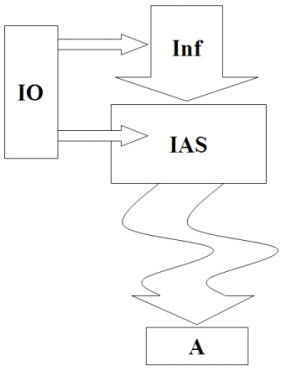


Fig. 1 – Impacting the enemy’s information and analysis system: Inf – information space; IAS – information and analysis system; A — system user (DM); IO — information impacts

As a rule, social procedures and processes are difficult to evaluate and model, because their results are psychological and sociological, rather than physical. This fact also makes it problematic to predict the results of information operation modeling. Beside that, experimentation with information impacts in the framework of information operations is more complex and dangerous, than modeling of physical processes.

In order to ensure efficient influence upon enemy's decision-making processes it is, sometimes, necessary to keep taking certain actions for a long time before they start producing effect.

1.1. Information influence

One of the key information operation components is the social impact, including the whole spectrum of impact processes. Considerable changes in public opinions or attitudes towards a certain problem or event are expected to entail changes in behavior, related to this problem.

In 1948 Harold D. Laswell [Lasswell, 1948] developed a model of communication transmission, including five components:

- source – a person that influences or convinces other persons;
- message – the means, with which the source tries to convince the target;
- target – a person that the source tries to influence;
- channel – a method of message communication;
- impact – reaction of the target to the message.

Although Laswell was interested, primarily, in mass communication, his model of information transmission can be applied to interpersonal communication, belonging to the type of circular models of Shannon–Weaver and Osgood–Schramm, who include feedback loops in communication process, stating that communication is a

circular rather than linear process [Schramm, 1974], [Osgood, 1954].

Modeling of objective factors of social impacts calls for interdisciplinary approaches, related to informatics, marketing, political science, social psychology. The most renown models of public opinion formation and social impact are based on Latane's dynamic social impact theory [Latane, 1981], [Latane, 1997], elaborated by many other authors, particularly by [Nowak,1990], [Lewenstein, 1993], [Kacperski,2000], [Sobkowicz,2003].

Trying to validate the mechanism of social impact of messages, [Latane, 1981] stressed the importance of the three indicators of the source's relation to the target:

- strength – social force, probability or level of impact upon individuals;
- immediacy – physical or psychological distance between individuals;
- number of sources – number of sources, aimed at the target.

Present-day situation with information operations modeling is characterized by a set of open problems, primarily, those concerning understanding of information impact and influence concepts.

Universal characteristics of an object are its state and ability to influence other objects. Implementation of influence potential requires certain conditions that are called impact. An object capable of imposing its will is called a subject, while control is denoted as influencing the impact object with some specific purpose.

When an individual is the impact object of one or several sources, dynamic social impact theory states that the level of social impact upon the individual can be expressed by an equation, providing the basis for the so called individual-oriented model:

$$I_i = -S_i\beta - \sum_{j=1, j\neq i}^{N} \frac{S_j O_j O_i}{d_{i,j}^{\alpha}},$$

where I_i is the intensity (amount) of the social pressure upon the individual i ($-\infty < I_i < \infty$). O_i is the individual's opinion (±1) about the topical question, where +1 and -1 represent support of or objection to the given question, respectively. S_i is the strength of individual i or impact $(S_i > 0)$, β is the individual's resistance to change $(\beta > 0)$, $d_{i,j}^{\alpha}$ is the distance between individuals i and j ($d_{i,j}^{\alpha} \geq 1$), α is the indicator of distance reduction $(\alpha \geq 2)$, N is the total number of agents (individuals that constitute the population). The value of β, the tendency towards maintaining one's opinion or resistance to change, defines, whether higher or lower social pressure is required to change the opinions of individuals within the model. Larger values of α represent the effect of increase of distance between the source and the target; as a result, the level of social pressure on the target also changes.

Based on the suggested terms, the concept of "information field of the object" is introduced by [Кононов, 2003], and its characteristics are described. This provides an opportunity to define information impact as impact upon the object's information field. By researching information fields of objects, we can define information impacts and control actions. In this process information can be considered the object and the means of influence. In order to use information as impact means, in the process of control we should prepare the data, produce the respective information, and only then – implement it in the form of influence (impact).

One of the key information operation implementation methods is information influence, exerted for the purpose of information control. In this case by information control we mean the control mechanism, where control action bears implicit character, and control object is presented a certain information picture. Based on this picture, the object forms its behavior pattern. Thus, information control is the means of impact, creating an incentive for the public

to behave in an organized manner, i.e. to perform required actions.

According to [Кононов, 2003], [Кульба, 2004], it is appropriate to decompose the process of information influence of one object upon others into the following phases:

- the source generates influence of data, information elements, and information sets;
- the influence source transmits information;
- the recipient gets the information;
- data set, information components, and new sets of the influence object are generated;
- the influence object takes action.

Information impacts upon system components can be classified according to such criteria as sources of origin, impact duration, nature of origin, etc.

In order to select specific ways of information control implementation, we should specify the problems, solved through information impact, analyze the process of information operation formation, and come up with criteria for their evaluation. Information control is considered as a process, embracing three interconnected directions:

- control over data exchange between the real world and virtual world of the influence subject;
- control over virtual world of influence subjects and decision-making mechanisms;
- control over the process of turning decisions into real-world actions by the influence subject.

Information impact may belong to one of the two basic types:

1. Desirable change of data, used by the information and analysis system of the impact object during decision-making.

2. Immediate influence upon decision-making process of the impact object, for example, upon decision-making procedures or specific decision-makers.

Factors of particular importance for implementation of information operations include environment, condition of information impact objects, their mutual influence. Particularly, if the information operation object is some electoral field, then it is important to consider all electoral populations, belonging to this field, and representing supporters (or opponents) of these or that political forces. While further on we will consider some models, where the homogeneity of the environment is explicitly postulated, in the general case, the environment can consist of several spheres, related to information operations:

- dominant perception;
- increased sensitivity;
- indifference to respective information impacts.

If mass media system is used, external impact is implemented through a set of information impacts, i.e. manipulations with information (dissemination, withholding/concealment, change).

Characteristic features of modern-time information operations:

- provide an opportunity to conceal the fact of their implementation, while still produce the desired effect;
- signify targeted activity of a broader character;
- ensure considerably lower cost of goal achievement in comparison to traditional means.

Usage of online mass media within management cycle, among other things, provides the opportunity to communicate the decisions of the management to broad audience. Beside that, these media reflect public reaction to the decisions being made. According to a study by E. Noelle-Newman [Noelle, 1973], many people try to hide their views and opinions if they contradict opinions of the majority. According to this theory, mass media are an effective instrument for influencing public opinion. Many researchers of information combat in open systems stick to this view as well. For instance, S. Ball-Rokeach and M. DeFleur [Ball-Rokeach, 1984] underline the strong

connection between social system, media, and audience. Dependence of the audience on the media is defined by individual differences of the recipients, the scale of covered events, the amount and degree of centralization of information functions, fulfilled by the media. News messages often include not only information about some event, but also about authors' attitude to this information [Лозовский, 2000], [Лозовский, 2006], [Лозовский, 2003], [Лозовский, 2000], [Урсу, 2011], [Урсу, 2012]. For example, in the coverage of the events in eastern Ukraine, the editors' attitude can be defined by how the combating sides are called when mentioned: "militia/volunteers" – "guerillas", "punitive forces" – "antiterrorist operation forces" etc.

In order to implement efficient information impact upon conscience of the public, it is necessary to ensure that the message is read by as many people as possible [Brosius, 1992] [Wanta, 1994]. As, nowadays, more than 100, 000 news reports appear in online media just within Ukrainian Internet segment, even the latest news of a significant event can remain unnoticed.

A research by S. Ball-Rokeach, M. Rokeach, and J. Grube [Ball, 1976] indicate that people tend to revise their opinions and behavior models if they feature certain contradictions. Results of this research are used to perform permanent, gradual change of public attitude through a sequence of information impacts.

From information operations viewpoint, online media have a set of advantages in comparison to traditional ones [Манойло, 2007], such as:

- efficiency, accessibility, economy, information dissemination;
- potentially unlimited audience;
- complexity of information representation and perception;
- opportunity to create media, available to any organization or individual.

Presently, information operations are widely used [Почепцов, 2001]; in some countries special information operation units are created, and guidelines for their implementation in time of peace and war are developed, as well as instructions for cooperation of the respective units etc. Beside that, special non-governmental structures are created, that have an opportunity to effectively implement information operations.

1.2. Information operation phases

Let us now address the phases of information operations. Naturally, there is no unified “standard” plan for implementation of information operations, both offensive and defensive. We can only consider the approximate sequence of actions taken in the process of information operation implementation. These actions can be reconstructed based on generalized experience of some of the already implemented information operations.

In practice, information operation as a process of information impact upon public consciousness is, usually, implemented as follows. As a result of preliminary intelligence phase, the plan of the next phase – operational control – is developed, and respective operational intelligence measures are planned, which provide an approximate decision model. After that operational control is applied to the enemy. During operation intelligence phase, the level of deviation of the initial model from reality is defined. If the deviation is insignificant, then the initial plan is implemented. Otherwise, a new plan is developed for operational control and control of the enemy. Then the cycle is repeated until operational intelligence confirms the model. At the same time, the final decision is made with a certain degree of operational risk.

Information impact process includes the following key phases [Чхартишвили, 2004]:

- Preliminary intelligence;
- Detection of current situation, condition of the enemy;

- Control of the enemy (information impact upon the enemy, aimed to communicate the information, corresponding to the control subject's intention);
- Operational intelligence (verification of reflexive control results);
- Operational control – actions of the control subject, aimed at achievement of the required goal.

While planning and modeling social processes, particularly, information operations, we should always keep in mind, that general behavior of social systems cannot be defined based exclusively on refined mathematical models. The main reason for this phenomenon is that such behavioral processes are mostly guided by socio-psychological factors.

The two basic information operation types are offensive and defensive operations. However, in practice most information operations belong to a mixed type. Moreover, the majority of information operations are both offensive and defensive at the same time. Each of information operation types includes the above-mentioned phases, but also envisions certain specific features and clarifications.

A peculiar feature of offensive information operations (information attacks) is that impact objects of such operations are clearly defined, and planning process is based on rather specific information about these objects. An information attack, usually, requires the attacker to find or create and informational cause (for defensive information operations the cause may be the enemy information attack itself), promote this cause, i.e. organize its propaganda (as opposed to counter-propaganda used in defensive information operations), and take measures to suppress information counteraction.

Operational control of information operations using information and analysis systems can be illustrated by the diagram, displayed on fig. 1.2.

According to this diagram, from the real world (R) information gets into information space, particularly, to the media (I), or directly to the experts (E) (also through the

media). From the experts or directly from the information space, information gets into the information and analysis system (IAS), for example, with the help of content-monitoring tools. The information and analysis system communicates the data that defines the information impact measures, to decision-makers (P). Information impact measures are information operations (IO), targeted at information space and directly at real-world objects (people, environment, computer systems, etc).

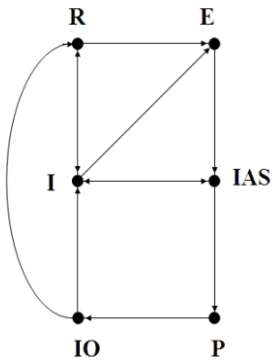


Fig. 1.2 Diagram of operational control using information and analysis systems

An approximate algorithm of information operation assessment was presented in the information operations center of US Department of Defense [Roadmap, 2003] in the form of eight consecutive steps including specific actions:

1 – characterization of information space;

2 – inclusion of information operation assessment into military operation plan;

3 – study of the needs for information, required for assessment of the information operation, and planning of data collection;

4 – compiling initial data for information operation assessment;

5 – implementation of activities for information operation and intelligence support;

6 – observation and collection of data for information operation assessment;

7 – analysis of obtained data; assessment of the information operation;

8 – reporting the obtained results to and providing recommendations for the commander.

While most information operations represent activities, in which only non-lethal weapons are used, they allow their initiators to achieve the results that are the same as in the case of traditional weapon implementation, and, at the same time, minimize or totally eliminate potential negative consequences.

According to US DD analyst Lara M. Dadkhah, who studied the war in Afghanistan, capacities of "Taliban" guerillas for launching information operations were, sometimes, "the most effective air defense means". After all, it doesn't really matter, how the enemy aircraft is neutralized, i.e. whether it is hit by a missile or landed as a result of enemy propaganda.

Developing this topic further, US Armed Forces command stated that the purpose of information operations force would be to establish more accurately the balance in implementation of lethal and non-lethal impacts in order to enhance the efficiency of information capacities of the troops, and, thus, to achieve the purpose of a military operation in shorter time. At the same time, the command recommended to consider the above-mentioned components in the next edition of the doctrine JP 3-13 "Information operations", as well as in other documents, featured in the series JP 3-13.XXX and immediately concerning information operations. From their side, US military specialists stressed the extreme need for preparation and release of a new document on information operation assessment.

1.3. Information operations modeling

Modeling can be considered one of the ways of solving real-world problems, particularly, those, emerging while planning and implementing information operations. Most often, modeling is used when experimentation with real objects is either impossible or too costly. Modeling includes bringing of the real problem into the world of abstraction, analysis, and optimization of the model, as well as bringing of the optimal solution back into the real world.

There are two alternative approaches to modeling – analytical and imitation (simulation) modeling. Ideal analytic models allow us to get strict analytical solutions or, at least, problem statement, for instance, in the form of differential equation systems. However, analytic solutions are not always possible to find. That is why, especially nowadays, and particularly while solving problems from social dynamics domain, imitational modeling (*Simulation Modeling*) methods are used more and more often. Simulation modeling is a powerful and virtually irreplaceable means of social procedure analysis. A simulation model can be considered as a set of rules, defining the future system state based on its present state. Modeling process is observation of the system's evolution (according to the given rules), and, respectively, (if possible) assessment of the model's adequacy.

The most promising direction of information operations modeling is mathematical description of information dissemination and perception environment self-organization, based on current situation. Self-organizing domains, in which there is no centralized control mechanism, but evolution goes on as a result of multiple local interactions, are studied by the theory of complex systems. This theory covers such knowledge fields as nonlinear physics, thermodynamics of non-equilibrium processes, dynamic systems theory. Mutual impacts of separate elements of complex systems define the emergence of complex behavior under absence of centralized control. Research of such behavior calls for usage of the most contemporary methods, covered by the

interdisciplinary basis of present-day methodology – the concept of complexity. At present, theoretical and technological basics of this concept include the theories of dynamic chaos and complex networks, synergetic studies, fractal and wavelet analysis, multi-agent modeling, self-organized criticality theory (studying dynamic development up to critical state, characterized by strong temporal and space fluctuations, without external control [Bak, 1996]), percolation theory etc.

Modeling of social procedures (undoubtedly, including information operations) calls for numeric experiments, as, most often, substantial limitations are witnessed, making it problematic to conduct "natural" experiments in the field.

When modeling information operations, a numeric experiment allows us to reduce the number of operations on limitation clarification, initial data selection, as well as selection of model component functioning rules etc. In such a case we get an opportunity to consider cases, which are problematic to implement in practice, using real data only to identify parameters of the mathematical model. At the same time, mathematical modeling has its limitations, and real world turns out to be too complex to be modeled with a sufficient degree of detail, precision, etc., i.e. more or less credible mathematical models are so complex and multi-parametric that they are problematic to analyze and evaluate using exact methods.

In order to detect information influence in social networks, we can use different models. Let us consider several of these models [Wasserman, 1994].

- Models with thresholds, including linear thresholds, where an agent can be in active and passive states, while transition is possible only from passive to active state (inverse transition is not allowed);
- Models of independent cascades, belonging to the so-called "interacting particle systems";
- Models of infiltration and contamination;
- Ising models;
- Models based on cell automata;

- Markov chain-based models.

Particularly, according to dominant nature of information impacts, information operations in the web can be nominally classified as:

- “propaganda”, when information impacts bear mostly promotional character, for instance, when elections are held and prepared, or in the process of political struggle;
- “des-information”, when the primary goal is to disorient the enemy; these information operations are used in both political and economic spheres, as well as during military conflicts;
- “manipulative”, when the key task is to put the competitor’s behavior under control using various information impact techniques (persuasion, manipulation, attitude modification);
- defensive (“counter-operations”), when the purpose is to neutralize the enemy’s information impact (say, through counter-propaganda), to protect oneself from such influence, to respond to information impact of the competitor [Манойло, 2003].

If information impact depends only on awareness and interconnections between the agents, then a classical model from game theory can be used. The award, received by an agent depends on the activities of its “friends”. Game theory-based information impact models include the following ones [Губанов, 2009]:

- mutual awareness;
- coordinated collective actions;
- communications and minimum sufficient network search problem;
- network stability;
- information influence and control;
- information combat.

Most models focus, primarily, on the agent interaction rules, but when it comes to the influence network itself and its properties, analysis of respective models yields very modest results. That is why in [Əliquliyev, 2010] it is suggested to define the so-called “information archetype” of social network users and agents’ states. Just like in many other models, an agent’s state can be active and passive, while an active agent’s ability to spread information through the network depends on multiple factors.

Different approaches to classification of information impact models, mentioned above, indicate that currently available models adequately reflect many properties and effects, witnessed in social networks. At the same time, all models of information influence and struggle should be formulated according to the specificity of an applied problem being solved, the possibility of modeled problem identification, parameters of agent environment, potential actions of agents, their advantages and awareness.

On the whole, we can conclude that modeling of influence in a social network is, currently, becoming an independent study subject, and respective models will soon form a separate branch of research.

During planning of information operations, mathematical models can be refined only in the process of modeling of specific procedures, when they are constantly compared to reality.

The purpose of the information operation assessment methodology is to ensure timely and accurate analysis of potential discrepancies between the planned operation and the actual impact. When substantial differences (that influence the probability of the operation success) are detected, analysis system must inform decision-makers about them, in order to correct current plans and decisions accordingly. At the same time, while planning information operations we cannot rely on trial-and-error method. That is why, it is necessary to develop methods that would allow us to aggregate retrospective data and verify model adequacy on their basis.

Synergic approaches provide the basis for viable information operation models. Indeed, a society is a complex system, where each component is characterized by a multitude of features, and has many degrees of freedom. An important property of this system is self-organization, resulting from interaction of such components as randomness, recurrence, positive and negative feedbacks.

Relative simplicity of interpretation of obtained results can be considered the specific feature of information operations modeling. Such concepts as “electorate number”, “political weight” etc are perceived intuitively, even without knowledge of exact definitions (if applicable). This allows us to make detailed analysis the subject of broad discussion.

As some decisions are unstable in respect to their parameters, values of these parameters have to be defined with high precision. This requires a complex of methodologies based on processing of large statistical data as well as on versatile sociological research.

Presently, the most realistic problem statement is based on mathematical model usage for predicting the dynamics of social processes at qualitative level. In this formulation dynamics modeling occupies a kind of intermediary level between what we are going to set forth here and accurate forecasting. However, we will need to select parameter values that (to some reasonable approximation extent) correspond to the situation under consideration. Moreover, usage of relative values seems to be the most productive approach in most cases. Although it is impossible to get credible data on future turns of events based on this approach, most probably, it might allow us to reconstruct a more or less clear picture of what can happen and how. And that is already something.

In order to succeed, we need to consider separate information impacts as parts of a unified information operation (similarly, artillery shelling or aviation strikes can be considered coordinated parts of a military operation).

Information operations have the following basic features:

- information operations represent an inter-disciplinary set of methods and technologies from such spheres as informatics, sociology, psychology, international relations, communications, defense;
- even now there are still no standards for information operation implementation;
- not just defense departments, but also numerous governmental and commercial structures are interested in development of information operation technologies;
- the problem of developing a scientific approach to information operations is topical and relevant.

While implementing information operations, it is important to detect the content (knowledge), input into information, concerning various aspects – social, political, religious, historical, economic, psychological, mentality-related, cultural – specific to different social strata. That is why, now it makes sense to consider information operations in a broader sense, as knowledge-based operations (Knowledge Operations) [Burke, 2001].

Nowadays, an ordinary information operation in web environment is performed as follows: as a rule, a special web-site is created (let us call it the "source of origin"), that functions during certain time, and publishes rather specific information. At the moment of time X a special document appears on the web-page. Usually, it contains some compromising evidence (credible or falsified) against the attack object. Then the so-called "information laundering" is performed. The document is re-published online by sources of two types: either those interested in the attack or those in need of any information to fill their information field with. In case of complaints, these re-publishers just refer claimants to the "source of origin", and, in the worst case, remove the material from their web-sites on request from the attack object. The source of origin, if necessary, also removes the information, or even gets eliminated (afterwards it often turns out that the source is registered under the name of some nonexistent person). However, the

information has already spread, and the original source's task is completed: the attack is launched.

Contemporary information space presents a unique opportunity to get any information on some given inquiry (providing the respective tools are available), allowing us to analyze interconnection between possible events or events already happening and information activity of a certain group of information sources. On the other hand, during retrospective analysis of any process or phenomenon, some characteristics of its development represent particular interest:

- quantitative dynamics, inherent to the process or phenomenon, such as the number of events within a unit of time, or the number of events, related to it;
- definition of critical, threshold points, reflecting quantitative dynamics of the phenomenon;
- definition of occurrences in critical points, such as detection of key subjects in media publications, concerning the chosen process or event;
- once the key manifestations of the phenomenon in critical points are detected, these manifestations are ranked, and dynamics of development of certain manifestations before and after critical points is studied;
- statistical, correlative, and fractal analysis of the general dynamics and dynamics of separate manifestations is performed. Based on this analysis, attempts to predict future development of the phenomenon or its specific manifestations are made.

In order to study the interconnection between actual events and publications about them in the Internet, the authors have used InfoStream system, ensuring integration and monitoring of online information resources.

The daily number of web-publications on some topic, and, especially, change (dynamics) of this value sometimes allow even average-level specialists in the subject domain to draw more or less accurate conclusions.

We can obtain the data on such dynamics, for example, through daily visits to web-sites of news integrators (news.yandex.ru, webground.su, uaport.net). Of course, users of professional monitoring systems, such as Integrum or InfoStream, are in better position. It is InfoStream that allowed us to obtain amazing statistics on the number of web-publications on influenza epidemics in different time periods.

During modeling and implementation of information operations, we should keep in mind the importance of the value of information for decision-makers. The value of information includes its relevance, accuracy, and “analytic property”. From practical viewpoint, the value of information can also be defined as its significance or usability (availability for usage). By usability of information we understand ensuring the access of a DM to information that is ready for usage.

The first step in creation of a network multi-agent information dissemination model is formation of a realistic virtual information space, populated by virtual agents, with which separate information messages in social networks are associated. Beside other information, these messages encapsulate links to information resources from the Internet.

Below we suggest a model of thematic information flow (TIF) formation based on network multi-agent model [Додонов, 2015a], within which separate documents, presenting information subject, are associated with agents, while agent lifecycle is associated with document lifecycle in the information space. It is assumed that the population of agents evolves with time.

In this book we consider a multi-agent information dissemination model, where the key element is a message. Every message can provoke different reaction types, such as positive/negative comments, expressions of approval or disapproval (like/dislike), while the message text can be copied and reposted; beside that, one message can contain links to other messages. That is why we are going to consider a message as an agent in the model, while an

agent's evolution will be associated with events, happening to it. Let us denote the basic characteristic feature of an agent as "energy" (E) that reflects the message relevance and the degree of interest it provokes. Naturally, obsolescence of information or negative response decreases the energy of a message, while positive reaction or new references to the message increase its energy.

Rules of evolution of an agent in the model

An agent emerges with initial energy E_0 and with every discrete time unit its energy decreases by 1. We will consider events, typical for social networks: like, dislike, repost, link (when one agent makes a reference to another agent). These events influence the agent's energy level as follows: a "like" increases the energy by 1, a "dislike" decreases it by 1, a repost increases it by 2, a link increases it by 1. On the other hand, the probability of occurrence of any of these events depends on the relevance of the message and on the level of interest to the information it contains; these factors are also expressed in energy terms within the model. So, let us denote the probabilities of events that can happen to a message with energy E.

$$p_{like}^{(E)} = p_{l_0}\varphi(E); \quad p_{dislike}^{(E)} = p_{d_0}\varphi(E); \quad p_{repost}^{(E)} = p_{r_0}\varphi(E),$$

where p_{l_0}, p_{d_0}, p_{r_0} are model parameters while φ is some monotonously non-decreasing function of current energy of the agent, assuming values within [0, 1] range. Once the energy reaches 0, the agent "dies" and is no longer taken into consideration.

Fig. 1.3 displays an example of potential dynamics of a multi-agent system: processes of production of new agents by existing ones are marked by continuous lines, while processes of making references to agents are marked by punctured lines; living agents are black circles, while "dead" agents (as of the moment $t = 5$) are empty circles.

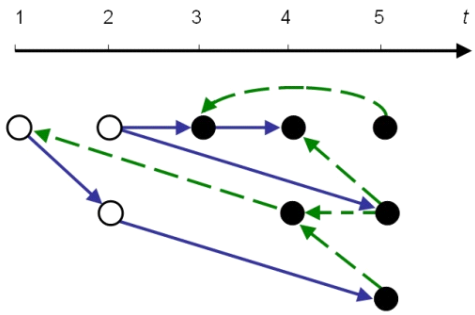


Fig. 1.3 – Multi-agent space fragment

Modeling of information flow dynamics

Fig. 1.4 displays the results of numeric modeling of agent number (ordinate axis on the graph) in the multi-agent system under consideration as function of model cycles (abscissa axis on the graph).

The considered model of agent space evolution under different values of controlling parameters is consistent with dynamics of real topical information flows, defined using InfoStream system.

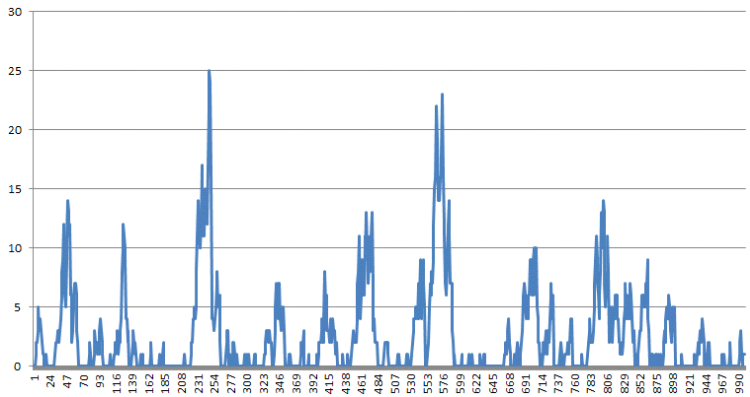


Fig. 1.4 – Dynamics of change of agent number in the model

Modeling of dynamics of the whole information flow starts with a single agent. A new agent can emerge in one of the two ways. First, an existing agent can be copied using repost operation. Beside that, “self-generation” of an agent is also possible (it represents publication of a new message). Thus, with each new moment of time, any of the listed events can occur to every agent with a certain probability. Also, at any moment of time a new agent can emerge as a result of self-generation with a probability p_s.

Let us now consider the life cycle of a single agent [Ландэ, 2016a]. An agent emerges with initial energy level E_0, then its energy changes, depending on events that happen to it. Let us assume that two events are possible: a “like” and a “repost”. Within one time unit three options are possible: both events can happen, one of the two events, or none of them.

Let us record the agent’s energy level ε_t at the moment t. Then, the energy of the agent at the next moment can be expressed as follows.

$$\varepsilon_{t+1} = \varepsilon_t + \delta_t,$$

where δ_t is a random value from the set {–1, 0, 1, 2}. According to energy change rules, introduced above, energy increase by 2 represents the situation when both “like” and “repost” take place; increase by 1 – to repost-only; the energy doesn’t change if a “like” takes place, and decreases by 1, if none of the events occurred. Consequently, we can denote the conditional distribution under known energy level:

$$P\left(\delta_t = 2 \mid \varepsilon_t = E\right) = p_{like}^{(E)} p_{repost}^{(E)};$$

$$P\left(\delta_t = 1 \mid \varepsilon_t = E\right) = \left(1 - p_{like}^{(E)}\right) p_{repost}^{(E)};$$

$$P\left(\delta_t = 0 \mid \varepsilon_t = E\right) = p_{like}^{(E)} \left(1 - p_{repost}^{(E)}\right);$$

$$P\left(\delta_t = -1 \mid \varepsilon_t = E\right) = \left(1 - p_{like}^{(E)}\right)\left(1 - p_{repost}^{(E)}\right).$$

These formulas apply when *E>0*. Further on we are going to use the denotation: $P_{\Delta}^{(E)} = P\left(\delta = \Delta \mid \varepsilon = E\right)$.

The process of agent's energy change can be considered as whole-number random walk with transition probabilities

$$p_{ij} = \begin{cases} P_{j-i}^{(i)}, & (j-i) \in \{-1,0,0,1,2\}, \quad i > 0; \\ 1, & i = j = 0; \\ 0, & else. \end{cases}$$

As energy value at the next moment of time depends only on energy level at current moment of time, the stochastic sequence $\left(\varepsilon_0, \varepsilon_1, ..., \varepsilon_t, ...\right)$ is a Markov chain with transition probabilities p_{ij}. The graph, representing such Markov chain, is shown on fig. 1.5.

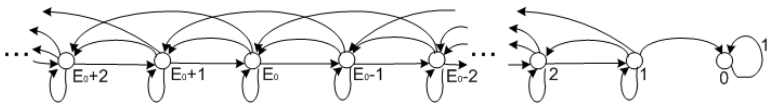


Fig. 1.5 – A graph, representing a random walk of agent's energy

Probability distribution of the sequence can be explicitly shown using transition probabilities:

$$P\left(\left(\varepsilon_0, \varepsilon_1, ..., \varepsilon_t, ...\right) = \left(E_0, E_1, ..., E_t, ...\right)\right) = \prod_{i=1}^{\infty} p_{E_{i-1}E_i}.$$

Or a similar distribution for $\left(\delta_0, \delta_1, ..., \delta_t, ...\right)$:

$$P\left(\left(\delta_1, \delta_2, ..., \delta_t, ...\right) = \left(\Delta_1, \Delta_2, ..., \Delta_t, ...\right)\right) = \prod_{i=1}^{\infty} P_{\Delta_j}^{\left(E_0 + \sum_{j=1}^{i-1} \Delta_j\right)},$$

providing $\Delta_i \in \{-1,0,1,2\}$ and for some $k : \sum_{i=1}^{k} \Delta_i = -E_0$ (the agent's energy fell to 0 on step *k*), then

$\Delta_l = 0, \ \forall l > k$. For series $(\Delta_0, \Delta_1, ..., \Delta_t, ...)$, that do not satisfy these conditions, the probability equals 0. Further on we are going to consider only series that satisfy the listed conditions.

Theoretically, there are series $(\Delta_0, \Delta_1, ..., \Delta_t, ...)$, that occur with positive probability, while $k : \sum_{i=1}^{k} \Delta_i = -E_0$ can rise to any values without limitation. We should note that k corresponds to agent lifespan duration and denotes the time period, during which the information message remains relevant. Consequently, agent's lifespan should be finite with large probability.

Let us denote the agent lifespan duration with initial energy amount E_0 as τ_{E_0}; thus, we denote the time during which from E_0 we get to 0. In the realistic model it would be good to have an estimate $P\left(\tau_{E_0} > T_{\max}\right) < \varepsilon$ for not very large values of ε; this would allow us to consider finite series $(\Delta_0, \Delta_1, ..., \Delta_t, ...)$ instead of infinite ones.

Let us consider function $\rho_T(E) = P(\tau_E > T)$. The following recurrent relation is relevant.

$$\rho_T(E) = P_2^{(E)} \rho_{T-1}(E+2) + P_1^{(E)} \rho_{T-1}(E+1) + P_0^{(E)} \rho_{T-1}(E) + P_{-1}^{(E)} \rho_{T-1}(E-1).$$

Such a system of recurrent relations can be solved using initial conditions:

$$\rho_0(E) = \begin{cases} 0, & E = 0, \\ 1, & E \neq 0. \end{cases}$$

Under initial parameters $p_{l_0} = 0.4, \ p_{r_0} = 0.1$, the following estimate can be obtained from the recurrent equation solution: $P\left(\tau_{E_0} > 1.5E_0\right) < 10^{-3}$. That is, agent's lifespan duration is limited by $1.5E_0$ and, consequently, in

order to get $(\delta_0, \delta_1, ..., \delta_t, ...)$ distribution estimates, that are accurate enough, we can consider vectors with finite length $T_{\max} = 1.5E_0$.

The number of events, which occur to agents, is also an issue, deserving attention. Let us consider the distribution of "like" numbers. We should note, that if at the moment t a "like" occurred, then $\delta_t \in \{0, 2\}$; otherwise $\delta_t \in \{-1, 1\}$. Let $(\Delta'_1, \dots, \Delta'_{T_{max}})$ be the vector, that satisfies the condition that $\Delta'_t \in \{0, 2\}$, if $t = t_1, ..., t_n$ and $\Delta'_t \in \{-1, 1\}$ otherwise, where $0 < t_1 < \dots < t_n < T_{max}$. So, for an agent that received a "like" the following formula applies:

$$P\{like\} = \sum_{t_1 < \dots < t_n} \sum_{(\Delta_1, \dots, \Delta_{T_{\max}})} \prod_{i=1}^{T_{\max}} P_{\Delta'_i}^{\left(E_0 + \sum_{j=1}^{i-1} \Delta_j\right)}.$$

Numeric results

Fig. 1.6 illustrates the obtained distribution density under initial parameters $p_{l_0} = 0.4$, $p_{r_0} = 0.1$. The points, connected by straight lines, denote the obtained values P {agent received n "likes"}.

The smooth curve corresponds to Weibull distribution density:

$$f(x) = \begin{cases} \frac{k}{\lambda}\left(\frac{x}{\lambda}\right)^{k-1} e^{-\left(\frac{x}{\lambda}\right)^k}, & x \geq 0 \\ 0, & x < 0 \end{cases}$$

Weibull distribution parameters k and λ were obtained with maximum likelihood estimation method. Under the aforementioned initial parameters, the obtained values are $k = 1.9$, $\lambda = 3.8$.

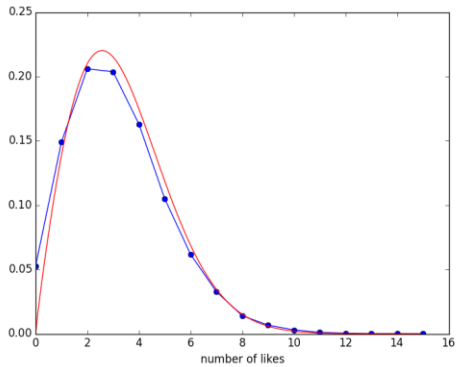


Fig. 1.6 – Distribution density of the number of “likes”, received by the agent under initial parameters

$$p_{l_0} = 0.4, \quad p_{r_0} = 0.1$$

Fig. 1.7 displays a similar result under initial parameters $p_{l_0} = 0.3, \quad p_{r_0} = 0.1$. In this case the obtained distribution parameters are $k = 1.9, \quad \lambda = 3.0$.

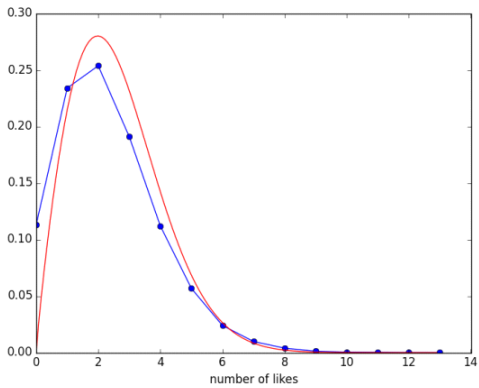


Fig. 1.7 – Distribution of the number of “likes” received by the agent under initial parameters $p_{l_0} = 0.3, \quad p_{r_0} = 0.1$

Study of actual information flows

Obtained modeling results were compared to the results of the authors' research of news message lifecycles in the microblog network Twitter, where the characteristics of reposts (retweets) of selected messages were analyzed [Li, 2012]. Distribution of "likes" and "retweets" in this case (just like in the model) matches the standard Weibull distribution, while parameter k coincides with the model value with high accuracy (fig. 1.8).

Software tools, developed using *R* programming language, included three components:

- Tools for scanning and collection of data on growth of retweet numbers for messages of a specific network user (for messages from New-York Times paper, the cycle of 15 sec was selected).
- Processing of collected information through approximation of data on growth of retweet number with Weibull function; calculation of respective scale and form coefficients (nonlinear approximation using least squares method), as well as calculation of the derivative for estimation of retweet number growth speed and building of the necessary graphs.
- Accumulation of obtained results for further analysis. For this purpose, data, obtained using software tools, developed on R, are imported into external databases.

Thus, the records were gathered, which included the text of each message, the time it was published online, values of scale and form coefficients, graphs of growth of the number of retweets and "likes", graphs of approximation of data on retweet number growth by Weibull function, graph of retweet number growth speed etc.

As a result of described research, a model of news lifecycle in information networks has been built.

As a result of modeling, statistical patterns have been detected, relating to the number of "likes" and "reposts" of specific messages. Modeling results indicate that their distribution matches Weibull distribution function.

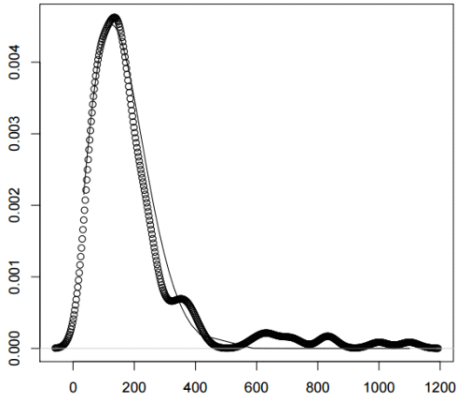


Fig. 1.8 – Distribution density of retweet numbers, obtained from the real network (approximation with Weibull distribution under k=1.9, λ=180)

Modeling data was verified by research of the real microblog network Twitter. Matching between modeling results and real network parameters allows us to speak of a pattern, specific to real networks, and of high model accuracy.

Naturally, orientation towards a single type of sources and mathematical models may lead to deficit of information, necessary for decision-making, inaccuracies, and, sometimes – to disinformation. Only usage of complex systems, based on utilization of multiple sources, data bases, mathematical models, along with above-mentioned capabilities of content-monitoring systems, may guarantee effective information support during information operation counteraction.

1.4. Information operation recognition problem

For operational analysis of information situation in the process of information operation detection specialized information space monitoring (content-monitoring) systems are used. First, such systems ensure efficiency that cannot be provided by traditional search systems (network content indexing time in even the best of them ranges from several

days to several weeks). Second, they ensure completeness (in terms of both sources and representation of materials of these sources), that is not always provided by ordinary news aggregators. Third, they provide the necessary analytical tools, allowing the user to compile analytical reports, based on publications on given topics for the required time period.

In the context of information operation prevention we should carefully monitor the dynamics of publications on target campaign, and, if possible, take tonality of these publications into account, as well as use available analytical tools, such as wavelet analysis. At the same time we should use existing information attack models as basis. For instance, if a model includes such phases as “background publications” – “calm” – “preparatory shelling” – “calm” – “attack” (Fig. 1.9), then even the first three components allow us to predict further events with high probability.

The abovementioned plan is, obviously, an optimal one, based exclusively on web-resource content-monitoring data.

Of course, users of professional content-monitoring systems are in better position. Many contemporary information and analysis systems incorporate tools for displaying statistics of inclusions of concepts, corresponding to users’ inquiries, into databases. Particularly, the authors used the statistics sub-system of web-space content-monitoring system InfoStream, in which the respective functionality was implemented.

When information operation trends are analyzed as time series, it is the series of thematic publication numbers during fixed time period (usually, during one day), associated with a particular operation, that are considered. That is why, for elicitation of trends, we are studying information streams, associated with information operation topics – thematic information streams.

Numerous academic studies are dedicated to research of information operations; in [Corso, 2005], [Kleinberg, 2006], [Ландэ, 2006], [Rakesh, 2014] it is shown that in typical

situations the dynamics of news (information precedent) dissemination bears the wavelike character with distinctive periods of impact increase and gradual decline.

As a result of analysis of numerous behavior diagrams of thematic information streams (TIF), the most typical basic behavior profiles were detected [Ландэ, 2012]. Some scenarios develop as follows: after a quick preparatory information surge there is a gradual recession (for instance, in case of reports on natural catastrophes), while others, on the opposite, start with gradual informational preparation, followed by sharp downfall (for example, in case of publications on events planned in advance). Some thematic flows are characterized by a symmetrical dynamics curve that can be narrow (short-time) or broad (long-time).

In case of information streams, associated with specific thematic streams, we should describe dynamics of each of these streams separately, keeping in mind that increase of one of them might automatically lead to decrease of others and vice versa. That is why limitations on information streams across all topics apply to the whole set of information subjects. In case of research of the general information stream we are witnessing the “re-streaming” of publication volumes from subjects whose relevance is decreasing, into other subjects.

Message trends, set forth in [Горбулін, 2009], and representing information operation stages, are shown on Fig. 1.9. In the listed cases analysts should focus on such models, for example, when monitoring allows them to detect the key phases (“background” – “calm” – “preparatory bombardment” – “calm” – “attack”), so that even the first three components allow them to predict future events with high probability.

We should note that such dynamics of topical message numbers during information operation implementation is well described by a famous equation of electromagnetic wave propagation:

$$y = A + Bx\sin(x),$$

where x is time, A and B are empirically defined constants.

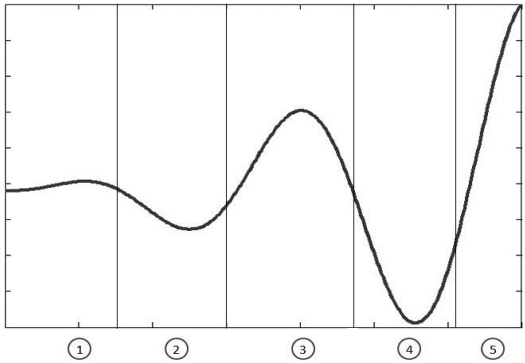


Fig. 1.9 – Dynamics of thematic message numbers during information operation implementation: 1 – background; 2 – calm; 3 – “preparatory shelling”; 4 – calm; 5 – attack/increase trigger

As we know, present-day innovative activity is also implicitly measured by the number of innovation-related publications; there are a few innovation process models, among which we can mention the innovation diffusion model [Bhargava, 1993]. At the same time, innovation implementation can also be considered an information operation. So, let us look at the respective research results. Fig. 1.10 displays a diagram, substantiated in [Хорошевский, 2012], and showing the number of publications, related to innovative activity.

By uniting the graphs, illustrating information operation start (Fig. 1.9) and information activity trend (Fig. 1.10), we can get a complete graph, displaying the representation of information operations in the information space (Fig. 1.11).

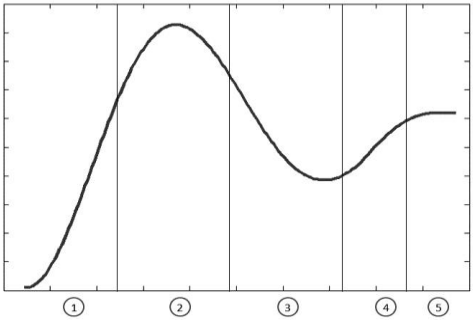


Fig. 1.10 – Diagram of the number of publications, corresponding to innovative activity trend: 1 – attack/growth trigger; 2 – overestimated expectation peak; 3 – loss of illusions; 4 – public realization; 5 – productivity/background

It is assumed that systematic violation of typical dynamics of certain information subjects in the open information space might indicate both information operations [Горбулін, 2009] and existence of an information reservation. During research of information operations much attention is given to information subject analysis [Додонов, 2013].

Suggested models fully correspond to real data, extracted by content-monitoring systems [Додонов, 2009], [Ландэ, 2007]. That is why the listed patterns can be used as templates for information operation detection, both through analysis of retrospective fund of online publications and through online real-time monitoring of some of their indicators. As we know, for information operation detection we should carefully monitor the dynamics of publications on the target topic, and, if possible, use the available analytical tools, as well as digital data processing and image recognition tools, such as wavelet analysis or Kuntchenko's polynomials [Чертов, 2009].

We should note that the suggested model allows us to differentiate information streams, whose behavior is determined by natural patterns of the information space, from streams, induced by influence of external factors.

Particularly, in case of information reservations, the following indicators can be used: deviation of dynamic trends of certain information subjects from characteristic distribution patterns, emergence of periodic value instability zones, or (the opposite) untypical local stability of these values.

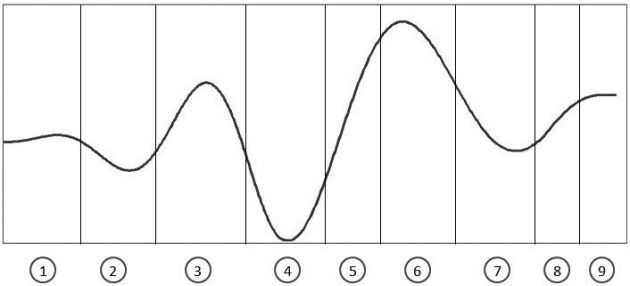


Fig. 1.11 – Generalized diagram, illustrating all the stages of information operation lifecycle: 1 – background; 2 – calm; 3 – "preparatory shelling"; 4 – calm; 5 – attack/growth trigger; 6 – overestimated expectations peak; 7 – loss of illusions; 8 – public realization; 9 – productivity/background

As an example, Fig. 1.12 shows the dynamics of publications in RUNet (thematic information streams) on such inquiries as "Cyprus banks", "Offshore", "Virgin Islands" for March and April 2013, the well-known crisis period. The data was obtained using InfoStream system. As we can see from Fig 1.12, publications concerning Cyprus bank crisis peaked on March 17-18, 2013, while most publications on Virgin Islands appeared on April 4-5, when events, similar to Cyprus situation, only in much smaller scale, started there. We should note the weak correlation of dynamics of information streams related to Cyprus and Virgin Islands. Mutual correlation coefficient of the respective time series amounted only to 0.3. However, we can stress the high mutual correlation level of time series, associated with such topics as "Offshore" and "Cyprus banks" (0.73), as well as "Offshore" and "Virgin islands" (0.77).

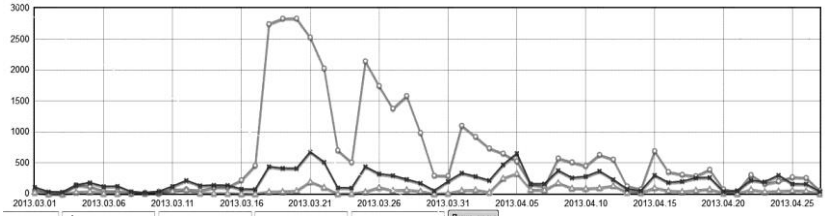


Fig. 1.12 – Diagram of topical information streams related to queries: o – “Cyprus banks”; Δ – “Virgin Islands”; x – “Offshore”

Obviously, manifestations of information operations related to offshore banks, in this case, can be better witnessed during analysis of the more general topic – “Offshore”. On the diagram of the respective time series two local extreme zones are clearly visible; they represent crisis situations on Cyprus and Virgin Islands; beside that we can see phases, representing “calms” and “preparatory bombardments”.

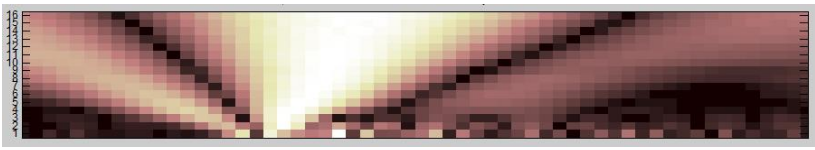
We can presume that if at a certain point dynamics of a specific information stream starts to deviate significantly from dynamics of the stream, representing the more general subject (in the listed case these are “Cyprus banks” and “offshore”), then it is, possibly, an indication of a newly-launched information operation, related to the narrower topical scope.

During wavelet-analysis [Астафьева , 1996], [Buckheit, 1995] (Fig. 1.13) it was decided to use a “Mexican Sombrero” type wavelet, as its shape was very close to the diagram, shown on Fig. 1.11.

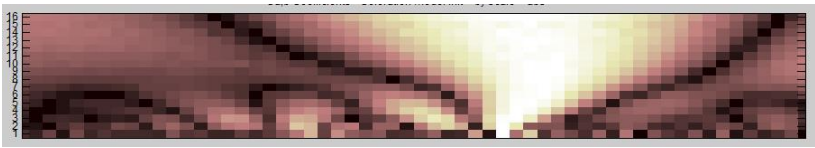
The processes under consideration are clearly visible on both wavelet-spectrograms and their respective skeletons (graphs of extreme lines).

The listed models and methods are applicable for description of general dynamic trends of information processes; however, the forecasting problem remains open. Evidently, more realistic models can be built if an additional set of factors (most of which are not reproduced in time) is taken into account. All the same, the structure of rules, providing the functioning basis for most of

available models, allows us to introduce respective corrections, for instance – to artificially model random deviations.



a)



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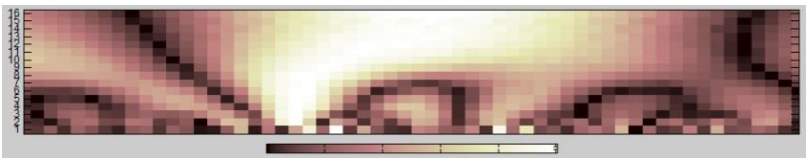

c)

Fig. 1.13 – Wavelet-scalograms, corresponding to dynamics of information streams on queries: a – “Cyprus banks”; b – “Virgin Islands”; c – “Offshore”

Let us now consider another example: the results of express analysis of the thematic information stream, associated with such object as the National academy of sciences of Ukraine, considering the risks, faced by the Academy in the second half of 2015. As a result of analysis, content-monitoring system InfoStream allowed us to formulate a query for the period between 01.07.2015 and 31.12.2015. As a result of the query processing a topical information stream of 1932 documents from Ukrainian web segment was compiled. For detection of information operations, publication dynamics on target subject was analyzed using the available analytical tools (Fig. 1.14).

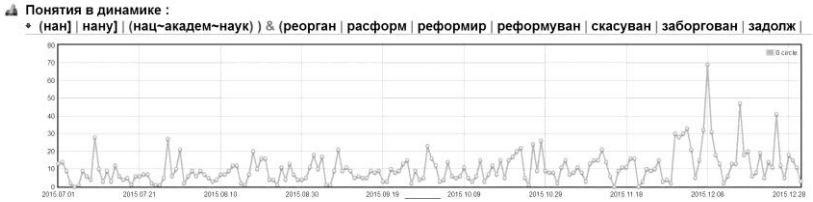

Fig. 1.14 – Topical information stream dynamics

To define the degree of "proximity" of the analyzed time series to information operation diagram in different scales it is suggested to use "wavelet-analysis" that is, nowadays, widely used in both natural sciences and sociology.

Wavelet-coefficients indicate how close the actual process behavior is to the wavelet in the given scale. On wavelet-scalogram (Fig. 1.15) we can see all characteristic features of the initial series: scale and intensity of periodic changes, trend directions and values, location and duration of local phenomena.

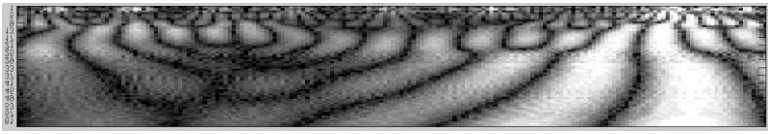

Fig. 1.15 – Wavelet-scalogram (Morlet wavelet) of the analyzed information stream

Once critical points are defined, the content-monitoring system builds basic scenario chains of messages related to the query for selected dates. Thus, the key events for selected dates are detected: *They want to let the National academy of sciences go with the wind… (Vector News) 2015.12.03*

- *Young scientists rally under Rada (Left bank) 2015.12.08*
- *Ukrainian government destroys Ukrainian science (2000.ua) 2015.12.08*
- *"The hands of academia are tied": employees of the NAS of Ukraine rally under Presidential Administration (UNIAN) 2015.12.16*

Conducted analysis, particularly, indicates that a targeted information operation is launched against the NAS of Ukraine, and counteraction to this operation is widely covered in the national information space.

As part of conducted research, a set of information operation templates of different scales was developed for information operations modeling. It corresponds to phases 1-6 of the shape, presented on Fig. 1.11. Examples of templates of different length are shown on Fig. 1.16.

Comparison of the developed template system with the time series associated with the actual topical information stream (Fig. 1.17) in the newly-built model is performed using correlation analysis.

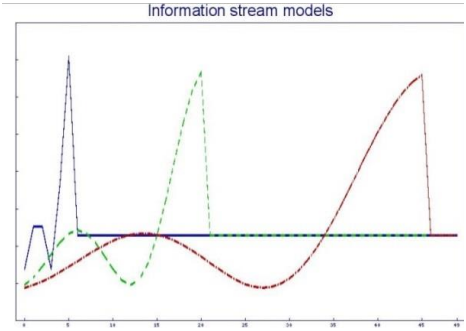

Fig. 1.16 – Template examples with length 5, 20, and 45

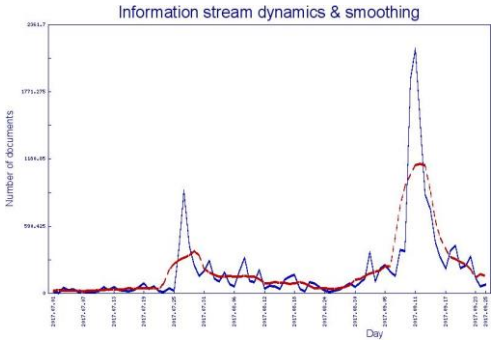

Fig. 1.17 – Time series, associated with the real thematic information stream, and the smoothing curve

The respective correlation diagram, where the horizontal axes represents the time and vertical axes – the scale (template length), while coloring represents correlation coefficients, is shown on Fig. 1.18. The diagram allows us to clearly visualize the phases of information operation implementation, corresponding to certain templates under different observation scales.

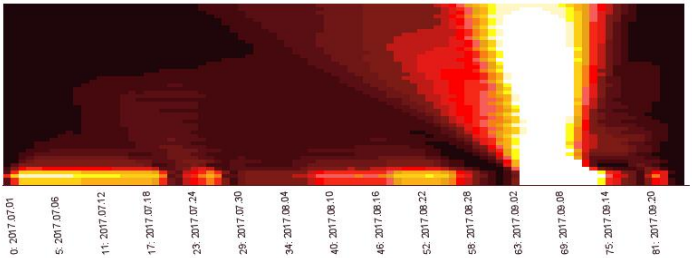

Fig. 1.18 – Correlation diagram, representing the correlation between thematic information stream and the abovementioned template system

We should note that reproduction of the results in time presents a serious problem during information process modeling, and provides the basis for a scientific methodology. Presently, retrospective analysis of the already implemented information operations remains the only relatively credible way of their verification.

A linear combination of linearly independent transforms $f_1(e), f_2(e), ..., f_n(e)$ of the respective generating element e can be built as approximation polynomial P_n of order n for the part of output signal $f_s(e)$:

$$P_n = \sum_{\substack{k=0,\\ k\neq s}}^{n} c_k f_k(e),$$

where coefficients c_k are defined based on condition of minimum distance between the polynomial being built and the signal. Element c_0 is defined from the expression:

$$c_0 = \frac{\langle f_s(e), f_0(e) \rangle - \sum_{k=1,\ k \neq s}^{n} c_k \langle f_k(e), f_0(e) \rangle}{\langle f_0(e), f_0(e) \rangle},$$

while other coefficients c_k – are calculated as a solution of the linear equation system:

$$\sum_{k=1,\ k \neq s}^{n} c_k F_{i,k} = F_{i,s},\ i = 1, \ldots, n,\ \ i \neq s,$$

where centered correlants $F_{i,k}$ are also calculated through respective transforms:

$$F_{i,k} = \langle f_i(e), f_k(e) \rangle - \frac{\langle f_i(e), f_0(e) \rangle \cdot \langle f_k(e), f_0(e) \rangle}{\langle f_0(e), f_0(e) \rangle}.$$

Efficiency indicator d_n can be used as a numeric characteristic of a quality criterion during comparison of the signal to a selected template (i.e. as approximation measure for Kuntchenko's polynomial P_n approximating the signal $f_s(e)$):

$$d_n = \frac{\sum_{k=1,\ k \neq s}^{n} c_k \langle f_k(e), f_s(e) \rangle}{\langle f_s(e), f_s(e) \rangle}.$$

The described method of recognition of certain patterns through construction of a space with a generating element and search for coefficients of the respective Kuntchenko's polynomial can be used in any problem domain, where characteristic templates can be distinguished within a time series a priori.

Thus, having built typical models for topical publication intensity series behavior during information operation implementation, and having compared templates obtained on their basis, we can use Kuntchenko polynomial method for detection (and prevention) of potential information attacks.

Thematic information stream dynamics is determined by a complex of both internal and external nonlinear mechanisms that should be considered (possibly, implicitly) during modeling. Often, a satisfactory option is to stick to a simplified understanding of a thematic information stream as some time-dependant value, behavior of which is analytically described by nonlinear equations. Today, mostly analytic nonlinear models are used for information stream modeling. The most commonly utilized approaches include nonlinear dynamics, cell automata theory, percolation, self-organized criticality etc [Ландэ, 2009], [Додонов, 2011].

According to [Расторгуев, 2014], it is appropriate to start detection of information threats (and any other threats as well) with analysis of approaches and methods of targeted reprogramming of information systems, such as technical systems, social structures, or individuals. Outlining of a series of information operation-specific events and their further detection within the general “life noise” is a classical way of solving such problems. The approach includes the following steps.

1. A series of events, presenting a threat, is always associated with some goal. Achievement of this goal calls for reprogramming of information combat subjects. In order to understand the extent of goal achievement, it is desirable to be able to evaluate the results of reprogramming and your own capabilities, i.e. – the degree of potential damage that information weapon can bring to this or that system. Destruction and reprogramming of some objects is easy, while in case of other objects the task may be impossible to complete within required resource and time limitations.

2. Estimation and substantiation of event occurrence frequency, under which we can talk about launching of a reprogramming information operation.

3. Providing the user with efficient and easy access to information in the case when dangerous trends are detected.

1.5. Information operation counteraction problem

The analyzed practical examples allowed us to work out a certain general methodology for defensive information operation implementation using a web-resource content-monitoring system. Let us assume, a company “ABC” is an object of an aggressive information operation. The 12 steps for counteraction are as follows:

1) Collection of information with publications in “alien” media (unrelated to “ABC”, non-affiliated) about the company.

2) Building a diagram of publication of messages on “ABC” company in online media.

3) Analyzing the dynamics with a retrospective period of 6-12 months using time series analysis methods. Publication content in threshold points is analyzed; points, duration and regularity of impacts are defined; impact points are “tied” to other events from the object’s area of interest.

4) Defining sources that publish most publications with negative tonality concerning “ABC”.

5) Detecting the “sources of origin” of publications in the media, i.e., sources that were the first to publish the negative information.

6) Defining potential “customers” – owners or stakeholders, who influence the publication policy of certain media.

7) Defining the spheres of common interest of “ABC” and potential “customers” that ordered the operation (through detection of common information characteristics – intersections of “information portraits” built by InfoStream system for the object and the “customer”), ranking of potential “customers” according to their interests.

8) Defining information impact criteria based on top-rating interests.

9) Modeling of information impacts. For this end the “customer’s” connections are detected (i.e. persons and

organizations that are most closely related to the "customer"), dynamics of "customer's" impact is analyzed and forecast of this dynamics is made; publication content in threshold points of dynamics curve is analyzed – critical impact points are defined.

10) Further impact steps are predicted through analysis of similar publication dynamics for other companies from retrospective database of InfoStream system.

11) With realities and publications from the retrospective database taken into account, potential operation consequences are evaluated.

12) Informational (and other) counteraction is organized. Examples of publications related to counteraction context are stored in the retrospective database.

1.6. Document analysis

US armed forces are currently among the leaders in the sphere of information combat theory and practice.

Information operation ideas were considered based on provisions of such documents as US National Security Strategy 2010, The National Military Strategy of The United States of America 2011, "Sustaining US Global Leadership: Priorities for 21st Century Defense".

The essence of global information operations is set forth in the concept of building and use of the US armed forces "Joint Force 2020". In its provisions the following issues are addressed: use of armed forces, disseminated across the globe, creation of unified formations, "tailored" to solve particular problems and capable of acting as one. According to the US military doctrine, presently there are 14 fields of activity in the sphere of information operations (Table 1). During the last few years the following documents were adopted by US Armed Forces:

- the new edition of JP 3-13 doctrine "Information operations" (January 2006);

- Doctrine for Joint Psychological Operations JP 3-53 (September 2003);
- Field Manual 3-05.30 “Psychological operations” (April 2005);
- Field Manual 3-05.301 “Psychological Operations Process Tactics, Techniques, and Procedures” (December 2003, already revised);
- Field Manual 3-05.302 "Tactical Psychological Operations Tactics, Techniques, and Procedures” (October 2005);
- Pocket guide to (handbook of) technical PsyOp means: types, tactical, and technical characteristics and capacities (April 2005);
- “Psychological Operations Leaders Planning Guide” (August 2005), containing excerpts from manuals FM 3-05.301 and FM 3-05.302. Both guides are intended for PsyOp units;
- A whole series of military training programs (ARTEP), including:
  - ARTEP 33-712-MTP, “MTP for Headquarters and Headquarters Company of the PSYOP Group and Headquarters and Support Company of the PSYOP Battalion”, (April 2006);
  - ARTEP 33-715-MTP “MTP for the Psychological Operations Dissemination Battalion” (September 2006);
  - ARTEP 33-737-30-MTP “MTP for the Tactical PSYOP Company” (2007);
  - ARTEP 33-727-MTP “ MTP for the Regional PSYOP Company” (2007);
- A series of documents, regulating the issues of military training of PSYOP personnel, including:
  - STP 33-37II-OFS “Officer Foundation Standards II Psychological Operations (37A) Officer’s Manual” (2006), intended for meddle-rank officers (captain to lieutenant-colonel) and including the key tasks, military training issues

and requirements to knowledge levels that should be met by PSYOP officers of the listed categories;

- Soldier's Manual and Trainer's Guide MOS 37F STP 33-37F14-SM-TG Psychological Operations Specialist Skill Levels 1 Through 4 (August 2008).

Active scientific research work in the interests of PSYOP is supervised by military training and academic research department of US armed forces.

Table 1 Fields of activity of US Armed Forces in the sphere of information operations. Source: Joint Publication 3-08. Interorganizational Coordination During Joint Operations. 24 June 2011. p. 324 (D-10, JP 3-08)

(1) Strategic Communication (SC)
(2) Joint Interagency Coordination Group
(3) Public Affairs
(4) Civil-Military Operations
(5) Cyberspace Operations
(6) Information Assurance
(7) Space Operations
(8) Military Information Support Operations
(9) Intelligence (information operations intelligence integration)
(10) Military Deception
(11) Operations Security
(12) Special Technical Operations (STO).
(13) Joint Electromagnetic Spectrum Operations
(14) Key Leader Engagement (KLE)

Serious materials, dedicated to different information and psychological operation related topics, are regularly published in leading military-scientific journals of US

Armed forces: Military Review, Parameters, Special Warfare, and others.

In 2010 it was decided to replace the previously used term “psychological operations” with the term “information operations of military support”. The primary reason for the change is that the new terminology reflects, mostly, the activities of Defense Department in the area of informing and influencing enemy, neutral, and friendly public opinion, aimed at achievement of strategic goals of US military management. The published memorandum states that the change of terminology will not significantly influence the currently implemented operations. Military units, supporting psychological operations will continue to build their capacity to “persuade-change-influence” during operations of any kind, at any location and time [Memorandum, 2017].

The term “information operations” is introduced by the specialists of US defense department in field manuals FM 100-23 “Peace operations” and FM 33-5 on psychological warfare.

In the listed instructive documents one of the conceptual approaches to definition of “information operation” concept is the opportunity to use methods and means of this information combat form in times of both military action and peace.

In the Air Force Doctrine Document 2-5 “Information operations” of 2005 information operations are defined as measures, taken to influence the enemy information or information systems and, simultaneously, protect one’s own information and information systems.

According to the Joint publication 3-13 “Information operations” of 2006, information operations are defined as integrated usage of the key capabilities of electromagnetic tools, computer networks, psychological operations, military skills, and security operations, accompanied by special support and respective capabilities, intended for influencing, destruction, and damage, seizing of decision-making process (by either humans or technical means), and, at the same time, for protection of one’s own facilities.

The same guidance from 2012 includes a more general definition. Information operations are defined as integrated usage (during military operations) of capabilities, related to information, together with other operation means, aimed at destruction, damaging, and seizing of enemy decision-making process, with simultaneous protection one's own. NATO Strategic Communications Policy (2009) defines "information operations" as military recommendations and coordination of NATO information military operations, meant to produce the desired impact upon intensions, understanding (perception), and capabilities of the enemy and other subjects (potential enemy, decision-makers, cultural leaders, international community representatives etc) and support operations, missions, and goals of the Alliance.

In 2010 the Joint Chiefs of Staff of the US Department of Defense published the doctrine of Military Information Support Operations, stating that these operations were a critical element of the US foreign policy. In military conflicts such operations serve as force multiplier, providing an opportunity to decrease the efficiency of enemy's armed forces, limit the intrusion of civilians, reduce the related damage, and increase support of the operation currently in progress by local population [Military, 2011].

On January 14, 2014 the Defense Minister of the Russian Federation signed an order on formation of cyber-headquarters, whose primary task would be to prevent unsanctioned meddling with Russian digital management systems within the General headquarters of the Russian armed forces. On February 22, 2017, during his speech in Gosduma (the State council), he confirmed that information operation units were formed within Russian armed forces.

In Ukraine information operations are still not defined by official doctrines and concepts, however, their potential implementation is based on a series of fundamental documents:

The Law of Ukraine "On Intelligence Agencies of Ukraine" of March 22, 2001 no.2331-III lists the following key tasks of intelligence agencies: “implementation of special activities, intended for support of national interests and state policy of Ukraine in economical, political, military, military-technical, environmental, and ***information spheres***…”.

In addition, Article 3 of the Law of Ukraine “On Foreign Intelligence Service of Ukraine” of 01.12.2005 no. 3160-IV specifically provides the tasks of the Foreign Intelligence Service of Ukraine, including those concerning “implementation of special impact measures for support of national interests and state policy of Ukraine in economical, political, military-technical, environmental, and ***information spheres***…”.

Laws of Ukraine “On Security Service of Ukraine” of 25.03.1992 no. 2229-XII and “On the Fight Against Terrorism” of 20.03.2003 no. 638-IV place a whole set of tasks upon the Security Service of Ukraine, concerning ***information security of the state***, particularly, during antiterrorist operation implementation.

In the Law of Ukraine “About Armed Forces of Ukraine” (as a result of adoption of the Law of Ukraine "On amendments to some laws of Ukraine concerning the Special Operations Forces of the Armed Forces of Ukraine" of 07.06.2016 no 1437-VIII) parts four and five of Article 1 are edited as follows: “troops, units, and divisions of Armed Forces of Ukraine, can be involved in implementation of measures of legal regimes of martial law and emergency, organization and support of resistance movement, implementation of ***information-psychological operations***, as provided by Law…”.

2. OSINT – open source intelligence

2.1. OSINT as intelligence domain

Open source intelligence (OSINT) represents one of the key instruments of information operation implementation. OSINT is one of the intelligence domains, including search, selection, and collection of intelligence information, available from publicly available sources, as well as analysis of this information.

OSINT concept is based on two key terms:

- Open source is an information source that provides it without requirement of confidentiality, i.e. provides information that is not protected from public disclosure. Open sources are associated with publicly available information environment, and access of physical persons to them is not restricted in any way;
- Publicly available information is information that is published or posted for wide usage, i.e. available to public.

According to the CIA analyst Sherman Kent (1947), politicians get up to 80 per cent of information, needed for decision-making in times of peace, from open sources. Later lieutenant-general Samuel Wilson, head of Intelligence department of US Department of defense in 1976—1977, noted that 90 per cent of intelligence data came from open sources, and only 10 – from agents.

OSINT is, usually, performed through monitoring, analysis, and research of information coming from the Internet. Materials, compiled based on information from open sources, support all intelligence methods and activities through accumulation of intelligence knowledge, its analysis and dissemination.

According to [ATP, 2012], OSINT is also one of the ways of intelligence that significantly contributes to planning of military actions, and provides all the necessary information for these actions. It is also noted that:

1) OSINT is one of the methods of intelligence through gathering of information from open sources, its analysis,

preparation, and timely submission of the final product to higher management for solution of certain intelligence problems.

2) OSINT is an intelligence method, developed based on collection and analysis of publicly available information, and not subject to direct supervision by US government. OSINT is a result of systematized collection, processing, and analysis of the necessary publicly available information.

American security researcher Marc M. Lowenthal defines open information as any information that can be obtained from open collections: all media types, governmental reports and other documents, academic research and reports, commercial information providers, Internet, etc. The key characteristic of open information is that its procurement does not require illegal collection methods, and that it can be obtained by means, which are fully compliant with copyright laws and commercial conditions of the providers.

International community is using more and more information from open sources to solve a wide spectrum of problems. Particularly, the role of OSINT during implementation of information operations is defined by a set of aspects, including efficiency of information flow, volume, clarity, ease of subsequent usage, cost of obtaining, etc. The following factors influence the process of planning and preparation of OSINT measures:

- Effective information support. Most of the necessary reference materials on information operation objects are gathered from open sources. This base is built through collection of information from the media. Accumulation of data from open sources is the key function of OSINT.
- Relevance. Availability, depth, and scale of publicly available information allow us to find the necessary information without engaging specialized human and technical intelligence means.
- Simplification of data collection processes. OSINT provides the necessary information eliminating the

need for engaging redundant technical and human intelligence methods.

- Depth of data analysis. Being a part of intelligence process, OSINT allows managers to perform in-depth analysis of publicly available information in order to make respective decisions.
- Efficiency. Sharp reduction of time of access to information in the Internet. Reduction of the number of man-hours, spent on search for information, people, and their interrelations based on open sources. Quick obtaining of valuable relevant information. Abrupt situation changes during crises are most thoroughly reflected by current news, so (as we know for sure), the downfall of the Berlin wall was witnessed in both Washington and the CIA headquarters in Langley, not through intelligence service reports, but through TV screens, broadcasting CNN reports right from the scene.
- Volume. Opportunity for mass monitoring of certain information sources, intended for search of the needed content, people, and events. Experience shows that proficiently collected information fragments from open sources, when taken as a whole, can prove equivalent to or even more significant than professional intelligence reports.
- Quality. In comparison with reports of special agents, information from open sources turns out to be more preferable, at least because it is unbiased and not mixed with lies.
- Clarity. So, while in the cases when OSINT is used, trustworthiness of open sources can be both clear and unclear, in the case of secretly obtained data, their credibility is always doubtful.
- Usability. Any secrets are supposed to be protected by barriers of “classifications”, clearances, restricted access etc. As for OSINT data, it can be easily communicated to any interested organizational bodies. There is an opportunity to conduct complex research based on data from the Internet.

- Cost. Cost of obtaining data through OSINT is minimum; it is defined only by the price of the service used.

Particularly, software and technological solutions offered for OSINT today, allow for:

- Data collection from social networks, such as Facebook, Twitter or Youtube, analysis of collected data;
- Getting to the core of events based on gathered content;
- Aggregation of information, obtained from the Internet;
- Information influence in the Web;
- Information credibility assessment;
- Monitoring and recognition of identity in the Web, particularly, based on geo-location;
- Working with information, obtained from the unseen web-space (dark web, hidden web, deep web).

2.1.1 OSINT application spheres

There are plenty of OSINT applications, including the following ones.

Intelligence

Open sources contain vast amounts of information, needed by intelligence bodies and compliant with their requirements, providing understanding of objective and subjective factors, related, for example, to information operation implementation. At the same time, there is no doubt, that in order to increase the efficiency of intelligence activities, the respective bodies use open information in combination with resources, received from agent networks.

The initiative of the United States Intelligence Community, known as the National Open Source Enterprise, is expressed in the Directive of the Intelligence Community no. 301, published by the Director of National Intelligence [DNI, 2006]. The Directive provides authority and responsibilities of the Deputy Director of National Intelligence for open sources (ADDNI / OS), the Open Sources Center of DNI and the National Open Sources Enterprise.

OSINT in armed forces

Units of US armed forces that participate in OSINT activities are listed below:

- Unified Combatant Command
- Defense Intelligence Agency
- National Geospatial-Intelligence Agency
- US Army Foreign Military Studies Office
- EUCOM JAC Molesworth
- Foreign Media Monitoring in Support of Information Operations, U.S. Strategic Command

National security

Department of Homeland Security includes an active intelligence unit for working with open sources. On February 14, 2007, «Domestic Open Source Enterprise» was established for support of OSINT department and working with state, local, and tribe partners.

Justice

Community of OSINT authorities uses open source intelligence to forecast, prevent, and investigate crimes, as well as to persecute suspects, including terrorists. Besides, fusion centers around the US are using OSINT more and more often to support their intelligence efforts and investigations.

Examples of successful OSINT authorities include Scotland Yard OSINT; Royal Canadian Mounted Police (RCMP) OSINT.

New-York Police Department (NYPD) includes the OSINT unit, as does Los-Angeles County Sheriff's Department: it is located within Emergency operations Bureau and connected to regional intelligence center of LA.

Within law enforcement activities OSINT can be used to prevent such violations as:

- Organized crime and gangs
- Pedophilia
- Personal data theft and extortion
- Money laundering

- Crimes related to violation of intellectual property rights
- Creation and development of extremist organizations

At the same time, OSINT is used to detect involvement and rising impact in the Web:

- Identification of key figures and activists
- Monitoring of enemy network in real time
- Restriction of information dissemination
- Public opinion formation
- Identification and monitoring of extremist organizations
- Risks for public transport
- Sanctions and legal requirements
- Analysis of enemy databases (HME, IED, TTPs)
- Target geo-location
- Support of military operations

Cybernetic security

As part of OSINT, cyber-security processes are supported. Particularly, based on OSINT information, answers to the following questions from telecommunication network protection domain can be obtained:

- Who is attacking your organization?
- What are their motives?
- How are they organized?
- Which instruments are they using?

Business

OSINT in business sphere includes commercial (business) intelligence, intellectual intelligence, and business analytics, and often represents the key activity domain of private intelligence agencies.

Enterprises can use the services of information brokers and private detectives for collection and analysis of the respective information for business purposes; these may include mass media, deep web, web-2.0, and business content.

2.1.2. International experience

Open source intelligence enhances the efficiency of the whole US intelligence community, from national to tactical levels. Below we list some organizations in the US, that collect, purchase, utilize, analyze, and disseminate information from open sources.

- Defense Open Source Council (DOSC);
- Intelligence and Security Command (INSCOM);
- Department of the Army Intelligence Information Service (DA IIS).
- Director of National Intelligence of Open Source Center (DNI OSC).
- Open Source Academy;
- Advanced Systems Department (ASD).
- FBI.
- Federal Research Department (FRD), Congress Library.

In addition to broad OSINT application in the USA, let us provide examples of the technology usage in other countries.

German external intelligence service, Federal intelligence service, also utilizes the advantages of Open Source Intelligence in the units of Abteilung Gesamtlage/FIZ and Unterstützende Fachdienste (GU).

In Australia the primary expert body for open sources is the Office of National Assessments that is one of intelligence structures. In the UK there is the BBC Monitoring information service, focusing on collection of open-access information with the efforts of journalists. The task of analysis of data, collected by the BBC, is placed upon the subscribers, including employees of British secret services.

2.2. Information space monitoring

Contemporary content-monitoring methods represent the adaption of Text Mining analysis concept and classical content-analysis methods to conditions of formation and development of dynamic information sets, such as

information streams in the Internet. A typical content-monitoring task is to build diagrams of dynamics of references to some terms (reflection of events) in real time. Let us take a look at how content-monitoring system InfoStream [Григорьев, 2007] keeps track of publications, related to spreading of computer virus Petya in the middle of 2017. A special query was formulated as ***«Virus&Petya»***, and input into the system's web-interface (Fig. 2.1).

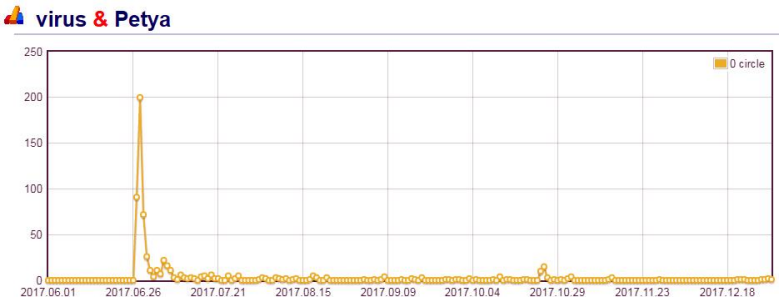

Fig. 2.1 – Diagram of concept dynamics in time

The diagram indicates that the crisis peak fell on June of 2017, while another surge, presumably, caused by the virus clone was witnessed in late October.

Let us consider the example of cyber-security issues to show, how to detect documents featuring maximum amounts of materials on computer viruses, within text information arrays from the Internet.

In order to get the list of key subjects, related to oil product market, we input the query **«Virus & Cyber»**, that was marked by a special indicator **lang.EN & country.US**, denoting search for Russian-language documents in the Ukrainian Web segment by InfoStream system (Fig. 2.2). After that, it was enough to switch to "lookup" mode and analyze the documents, references to which were returned by the system (Fig. 2.3).

Besides, we can switch to "Subjects" mode that envisions clustering of search results with weight coefficients taken into account, which allows the system to show only the most relevant document chains to the user.

That is why the system ensures sufficiently high level of correspondence between found documents and the search task, expressed by the query.

Fig. 2.2 – Basic subject chain according to the query

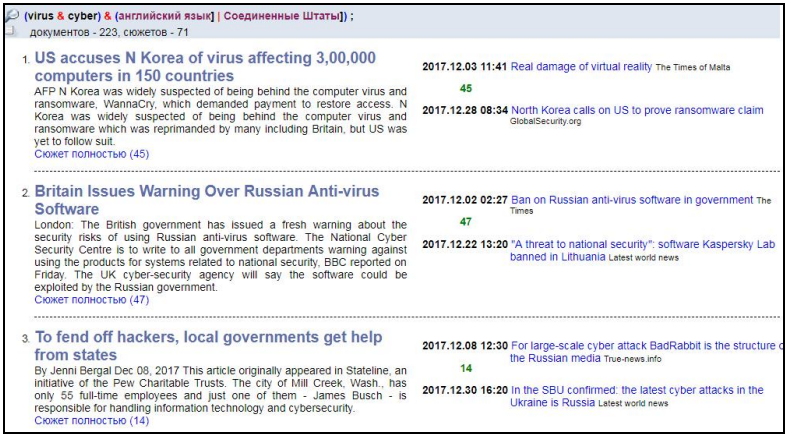

Fig. 2.3 – A fragment of basic subject chain

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