MATHEMATICAL MODELS OF WEIGHTED NETWORKS:
FORMALIZING THE DESCRIPTION OF NETWORK CONFLICTS

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Abstract.

The essence of the problem is that modern communications have a pronounced network character, that causes a dramatic increase in the risk of network conflicts. It has been shown that the traditional conflict with its conceptual and analytical framework in the description of conflicts in general and of information conflicts in particular is not focused on the network and the formalization of network conflicts needs to be developed. In this regard, it is expected to build on the evaluations of weighted networks, bearing in mind that the modern network is a graph with a disjoint set of vertices (users) and edges (links) on which the network filler is circulating. Its volumes and values form a statistical (accumulated) resource (filler) on the vertices of the network and a dynamic (traffic) resource (filler) passing through the edge in a unit of time. The maximum values of these resources indicate the capacity of network elements. Even the resources dynamics of conflicting networks are considered in the context of a bilateral conflict. And the changes are proposed to be evaluated by the relative sensitivity functions that provide an inseparable assessment of the parameters of interest. Evaluations of the fundamental conflict from this approach are proposed through the deflection of the conflicting resources at the appropriate
time sampling. As a result of the proposed approach, analytical expressions of the sensitivity factors that allowed for a weighted classification of network conflicts were obtained. Consideration was also given to the value and volume of fillers that make up the resources of network elements. The stages of the dynamics conflict have the same interpretation. Possible attacks by the parties in the course of their conflict interaction are also being considered. Then, the article deals with the practical value of the results obtained. In this regard, we consider the possible applications for the proposed methodology. Information networks are growing in popularity, that is why we analyze the application of the results in the context of the use of malicious software and destructive content in conflicts, where a step-by-step assessment of the dynamics of conflicting resources will make it possible to produce the necessary conflict analysis. At the interconnectivity level, a possible field of application of the article results can be a competing social network, as well as a intranet impact of antagonistic content within those networks.

Keywords: information network, network conflict, network potential, network resource, sensitivity

I. Introduction

The term conflict is derived from the Latin conflictus-clash-a clash of opposing interests, views and desires; serious disagreement, arduous debate leading to a struggle:

1) Conflict is a contest in which the parties shall endeavour to achieve incompatible results.

2) Conflict is not synonymous with confrontation, but it is a way to overcome contradictions and limitations, and a way of interacting complex systems.

The first is a definition of conflict in a narrow sense and the second is in a broad sense [XVII].

Any conflict, regardless of its nature, its specific content and type, necessarily comprises of contest and confrontation. Conflict is a bipolar phenomenon. Even if several groups are involved in the conflict, coalitions are formed between them, and the conflict is becoming a bipolar structure again.

In the philosophical sense, the conflict is seen as the main factor of progress. Conflict does not necessarily lead to destruction, but also contains potentially positive opportunities. The productivity of confrontation stems from the fact that the conflict leads to adaptation and the adaptation contributes to survival. Conflict is an incentive for change, a threat that requires creative reaction. Creating coercive situations, a conflict is becoming a source of innovation and progress.

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Denis G. Plotnikov et al
Conflict does not only divide, but also is capable of unifying the conflicting parties, forming new integrity — a meta-system that possesses independent properties that are not inherent in any system, but determines their behavior.

There is a wide variety of conflict: social, technical, environmental, etc., including network (in the present article). In social conflicts, the human factor has a leading role, but the deep penetration of technology in all areas of human interaction left its mark on them. So today, technosphere is dominated by complex ergatic systems that unite individuals, societies and techniques with a wide range of capabilities, capacity for self-organization, and considerable freedom of conduct.

Modern ergatic systems are of a highly network nature. These networks are necessarily weighted, i.e. each element has its own weight, and heterogeneous. The contradictions arising during the evolution of such systems generate states that can be called network conflicts.

The content of the network conflict is disclosed in different ways:
- the state of an open network fight or a network war;
- state of disharmony in the relations of the parties (networks);
- simultaneous operation in a common space of networks with mutually exclusive trends of development, i.e. confrontation and clash of opposites.

Obviously, this is a struggle for the main parameters of the network: nodes and their links, and the circulating filler flows. For information networks [III-IX] it is primarily the control of the information serving as a filler. That is why the development and the occurrence of conflicts in such structures is largely linked to this issue.

Despite the heterogeneity of complex systems, there is much in common in their behavior, especially when there is a security violation in critical (extreme) situations. In conflict, the parties interact and the specificity of their interactions is that each side continually forms a local environment (network) that is affected by the change itself. Adaptive systems are self-preserved through adaptation to the environment and the use of rare favorable developments for their benefit. This is especially true for ergatic systems.

The actions of the opposing parties are aimed at achieving their objectives in the conflict. The goal is a conscious image of the anticipated result that the action is intended to achieve. A combination of actions for the next few steps in the development of a conflict is called a behavioral strategy. Each of the parties of conflict must develop and constantly adjust its tactics to changing conditions of the conflict. In order to develop strategies and tactics, it is appropriate to refer to the structural components of the conflict [XVII]:
- parties (participants) to the conflict;
- conditions of conflict;
A study of the conflict dynamics involves description of how a conflict arises from a certain set of external conditions, how the conflict interaction occurs itself, and how the conflict is resolved (or how it ends). In this context, it is appropriate to use the concept of homeostasis, implying a consistent steady state. The homeostasis mechanism in a conflict is a choice of each party's behavioral strategy depending on the behavior of the other party and the evolving situation in order to resolve the conflict in its favor. We use the concepts such as: conflict resolution - partial or temporary resolution; the end of a conflict - any its termination; resolution - agreement [XVII].

Of particular interest is the information conflict, which is described in the military sphere below [XVII].

The information processes in the networks, despite their applied and structural differences, have a fundamental commonality; therefore, in the conflict resolution it is appropriate to consider them with one voice.

The concepts of information conflict (IC) and the information struggle (IS) reflect the information interaction of complex systems. The analysis of contemporary views makes the IC an essential part of the information and psychological confrontation focused on information superiority, which refers to a combination of factors that include the possibility of changing adversary perception of reality, predicting and influencing subsequent events in resistance. IS can be seen as a process of antagonistic rivalry between the two sides, each of which takes action to proactive achievement of information supremacy. The outcome of this rivalry will largely be determined by the ability of a party to proactive obtaining information about the adversary, to mislead it against its own intentions, to predict reliably the situation, to adapt its actions to the evolving situation under actual or deliberately reinforced uncertainty.

Consequently, IC can be defined as a process of confrontation, comprising a set of reciprocal actions by parties for providing proactive information on its efforts and resources and their adaptation to the current situation. The target of IC hence the composition of participants - the means (systems) of the obtaining and transmission of information on the opponent and the means of counteraction and counter-counteraction.

IC not only excludes the possibility of active interference in the process of obtaining information, but it involves physical struggle for information by impeding the normal operation of the opponent's assets. The purpose of the parties in IC is to inflict some information damage on the opponent and to minimize loss of its own information assets, i.e., the IC implements both attacking and defensive strategies.
In civil industries, information is commercially valuable and, therefore, is a commodity that is possible to produce, store, sell, steal, copy and resell without the permission of the legitimate owner, causing economic damage to it. All of this can happen in the course of a network confrontation grew out of the information conflicts. Therefore, it is essential to further develop the conflict resolution in terms of formalizing the description of the processes in the network conflict, using the characteristics and parameters of heterogeneous weighted networks.

II. The methodology for formalizing the description of the network conflict

Let the network confrontation involve two networks \( \text{Net}_1 \) and \( \text{Net}_2 \). We can describe these networks as intersystem conflict. Conflicting networks \( \text{Net}_1 \) and \( \text{Net}_2 \) are in some supernet \( \text{Net} \) at the same level of hierarchy and interact according to their objectives \( W_1 \) and \( W_2 \).

The superset can be represented by a statement (1) that takes into account the topology (graph) of the \( G \) network and the filler \( F_{I\text{I}} \) that is circulating and recycled in network \( \text{Net} \).

\[
\text{Net} = \text{Net}(G,F_{I\text{I}}).
\] (1)

A graph of a network \( G = G(X,A) \) is set by multiple vertices (hubs) \( X \) and disjoint \( X \cap A = \emptyset \) multiple edges (transports) \( A \).

Then, the conflicting networks are as follows:

\[
\text{Net}_1(X_1,A_1,F_{I\text{I}_1}) \in \text{Net};
\]

\[
\text{Net}_2(X_2,A_2,F_{I\text{I}_2}) \in \text{Net}.
\]

Conflicting interaction \([X]\) of systems is characterized by the fact that efficiency functions are in operation for each of the parties to the conflict. However, in the case of a network conflict, determining the effectiveness of the network is a difficult analytical task. Therefore, the study of a network conflict requires the use of another broad indicator as an efficiency.

The main reason for a network conflict is often the resource constraints. The struggle is based on the interests of the parties to the conflict and the resources available to them (structure and filler). The network structure, as well as the flow of the network fillers, are the most important indicators [XII-XVI]. In so doing, the conflict is reflected in the actions of one party, resulting in a reduction or impediment to the growth of stock and filler flow or structural capacity of the other party.

Therefore, network resources can be used as evaluation indicators in a network conflict

\[
R_{es}(X) = \sum_{i=1}^{||X||} \delta(x_i) \quad \text{and} \quad R_{es}(A) = \sum_{\substack{j,k \in X \backslash \{k\}}} \delta(a_{jk}),
\] (2)
defining stock at vertices and the flows in the edges of filler that are circulating on the specified network.

The main objectives of the network confrontation are to preserve the integrity of the network as well as to ensure the conditions for its development in an effort to expand its resources.

Thus, the basic objective of national security doctrines has traditionally been to preserve the integrity and State sovereignty of any country that today constitutes a multiset structure \([\mathbb{I}]\). In addition, given the limited resources, the State should strive to concentrate on the various types of resources in its networks, as well as to initiate the growth of the network filler by encouraging investment flows, increasing energy production, improving the quality of information exchange, etc.

According to (1), the scale of the network depends on a number of primary parameters. This is primarily the capacity of multiple vertices \(|X|\) and edges \(|A|\), as well as the volume of fillers \(|F|\). Consider the possible objectives \(W\) of conflicting parties in dynamics of network conflict, based on the parameters listed.

One of the objectives of network development is to enhance the network structural capacities. This objective is characterized by the desire to increase the number of network hubs \(X\) and transporters \(A\). The goal in this case is measured by the power of the respective sets \(|X|\) and \(|A|\).

As the conflicting parties are intended to build the structural capacities of the network, it is appropriate to take advantage of the static and dynamic potential of a weighted network as an indicator of efficiency

\[
P_{\text{st}}(X) = \sum_{i=1}^{|X|} \max [\delta(x_i)] \text{ and } P_{\text{st}}(A) = \sum_{j,k \in X, j \neq k} \delta(a_{jk}).
\]  

(3)

In some cases for (3) the statements are true:

\[
\begin{align*}
&\text{if } \frac{\partial \ln |X_1|}{\partial t} > \frac{\partial \ln |X_2|}{\partial t}, \text{ then } \frac{\partial \ln P_{\text{st}}(X_1)}{\partial t} > \frac{\partial \ln P_{\text{st}}(X_2)}{\partial t}; \\
&\text{if } \frac{\partial \ln |A_1|}{\partial t} > \frac{\partial \ln |A_2|}{\partial t}, \text{ then } \frac{\partial \ln P_{\text{st}}(A_1)}{\partial t} > \frac{\partial \ln P_{\text{st}}(A_2)}{\partial t}.
\end{align*}
\]  

(4)

Inequality (4) is appropriate for unweighted networks, if the network \(\text{Net}_1\) has achieved better results in achieving the goal of increasing its capacity over the network \(\text{Net}_2\), the dynamics of the structural potential of network \(\text{Net}_1\) are more relevant to the network \(\text{Net}_2\).

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The statements (4) needed further clarification. First, it should be noted that they relate to a particular point in time of interaction between the parties, as the derivatives have an instantaneous nature. In addition, the logarithmic function is present in statements (4) to give a relative (dimensionless) form of the deviations. It is justified that absolute deviations of parameters are not objective evaluates in comparison of the two indicators performance. Therefore, the following will be applied in future computations, where there is rationing

\[
\frac{\partial \ln P_{ot}}{\partial t} = \frac{1}{P_{ot}} \frac{\partial P_{ot}}{\partial t}
\]

This is the fundamental difference between the evaluations of conflict introduced in the article.

The goal \( W_2 \) can also be to accumulate fillers \( F_{il}(X) \) in hubs (vertices) without increasing the network structural capacities. At the same time, the accumulation of filler increases the network capabilities. That is why, for this purpose, we can use a static network resource \( R_{es}(X) \) as a performance indicator. For the conflict in question, the following statement can be applied:

\[
\text{if } \frac{\partial \ln |R_{es}(X_1)|}{\partial t} > \frac{\partial \ln |R_{es}(X_2)|}{\partial t}, \text{ then } W_2 > W_2 ',
\]

i.e., the first network is better than the second one for the purpose \( W_2 \) of resource building.

In addition, networks could aim \( W_2 \) at increasing the flow of filler \( F_{il}(A) \) through transporters (edges). The conflict then describes the statement (6) anchored in a dynamic resource, i.e., the first network is better than the second one for the purpose \( W_2 \) of building a dynamic resource:

\[
\text{if } \frac{\partial \ln |R_{es}(A_1)|}{\partial t} > \frac{\partial \ln |R_{es}(A_2)|}{\partial t}, \text{ then } W_3 > W_2 ',
\]

In addition to building own capacities, the purpose of attacking network, is to create conditions for preventing the development of the opponent's network. At the same time, the aim of attacking network \( Net_1 \) may be to completely destroy the affected network \( Net_2 \), i.e., to achieve \( Net_2 = 0 \). Such a network conflict is antagonistic and similar to terrorist and extremist networks. More often, the aim is not to destroy, but to subjugate. For example, the initiator of a network confrontation can fight for the possession of filler resources. Natural (e.g., hydrocarbons), economic (industrial and financial sector), information (computer

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Denis G. Plotnikov et al
networks and other communication systems) resources can be used as such objects. In this case, the more important the resource and the more the potential volume, the more violent the network conflict and the operations of network confrontation [XX].

The network Net₁ may be forced to fight the network Net₂ if the network performance Net₂ is reduced the overall effectiveness of network Net₁ in terms of achieving the goal W. In this case, we can [XI] mark that the network Net₁ is in conflict with the network Net₂ in terms of achieving the goal W

\[
\left( \text{Net}_1, \frac{W}{\text{conf Net}_2} \right),
\]

if \( R_{\text{es}}(\text{Net}_1)\mid\text{Net}_2 \in \text{Net} < R_{\text{es}}(\text{Net}_1)\mid\text{Net}_2, \)

Where \( R_{\text{es}}(\text{Net}_1)\mid\text{Net}_2 \in \text{Net} \) is the network resource Net₁ based on the presence of a network Net₂ in supernet Net₁; \( R_{\text{es}}(\text{Net}_1)\mid\text{Net}_2 \) - network Net₁ taking into account the absence of a network Net₂ in supernet Net (second network excluded Net₂).

Therefore, the presence of the network Net₂ has a negative impact on the first network, indicating a conflict between them.

There may be other relations between Net₁ and Net₂ ensuring compliance with conditions:

\[
R_{\text{es}}(\text{Net}_1)\mid\text{Net}_2 \in \text{Net} > R_{\text{es}}(\text{Net}_1)\mid\text{Net}_2;
\]

\[
R_{\text{es}}(\text{Net}_1)\mid\text{Net}_2 \in \text{Net} = R_{\text{es}}(\text{Net}_1)\mid\text{Net}_2. \tag{9}
\]

In the first case (8), networks Net₁ and Net₂ can be interconnected, as the presence of networkNet₂ increases the potential of networkNet₁. The second case (9) describes the situation where the networks Net₁ and Net₂ are independent.

The last (7) - (9) assessments of the conflict rely on an abstract exclusion from the consideration of an alternative network. However, if it already exists, it is very difficult to formalize such inferences on parameters. Moreover, the ultimate goal of a modern confrontation extremely rare provides for such a fatal outcome. Therefore, statements (7) - (9) could not be expected to have a broad practical application.

A conflict assessment based on the relative sensitivity function is much more prospective [XVIII]. Let us consider them in more detail. For example, we can write a statement for a bilateral conflict

\[
\frac{\partial \ln R_{\text{es}}(\text{Net}_1)}{\partial \ln R_{\text{es}}(\text{Net}_2)} = \frac{R_{\text{es}}(\text{Net}_1)}{R_{\text{es}}(\text{Net}_2)} \frac{\partial R_{\text{es}}(\text{Net}_1)}{\partial R_{\text{es}}(\text{Net}_2)}. \tag{10}
\]

It differs from usual assessment of conflict resolution in the normalization parameters. In addition, the statement (10) is nothing other than a function of the
relative sensitivity of changing one parameter $R_{es}(Net_1)$ to changing the second parameter $R_{es}(Net_2)$, i.e., [XVIII]

$$\frac{\Delta \ln R_{es}(Net_1)}{\Delta \ln R_{es}(Net_2)} = \frac{\frac{\partial R_{es}(Net_1)}{\partial t}}{\frac{\partial R_{es}(Net_2)}{\partial t}}. \quad (11)$$

The negativity (11) demonstrates the disharmony between the parties at a given point in time, since it is possible to write

$$\frac{\partial \ln R_{es}(Net_1)}{\partial \ln R_{es}(Net_2)} = \frac{\frac{\partial \ln R_{es}(Net_1)}{\partial \ln t} \frac{\partial \ln t}{\partial \ln R_{es}(Net_2)}}{S_{\partial \ln t}}.$$  

and move the review to the temporary area through the ratio of relative sensitivities of both parameters to the time change. Furthermore, we can use the first approximation to define the deviation of the matched parameters,

$$\frac{\Delta \ln R_{es}(Net_1)}{\Delta \ln R_{es}(Net_2)} = \frac{\frac{\partial \ln R_{es}(Net_1)}{\partial \ln t} \frac{\Delta t}{\partial \ln R_{es}(Net_2)}}{S_{\partial \ln t}}\frac{\Delta R_{es}(Net_1)}{R_{es}(Net_1)} = \frac{\Delta R_{es}(Net_2)}{R_{es}(Net_2)}.$$  

relation of which, found in the interval $(t_0 \pm \Delta t)$, gives us a sensitivity and describes the dynamics of the interval in question. It is also pertinent to note that the conflict has an interval characteristic. The conflict cannot continue indefinitely.

Next, we consider the conflict depth metrics. In particular, the following metric may be proposed:

$$\rho = [\frac{\partial \ln R_{es}(Net_1)}{\partial R_{es}(X)} - \frac{\partial \ln R_{es}(Net_2)}{\partial R_{es}(X)}] \frac{\Delta t}{\partial \ln R_{es}(Net_2)}]. \quad (12)$$

The statement (12) can serve as an estimate for measuring the depth $\rho$ of a network conflict. Thus, $\rho > 0$ highlights a conflict $W_{Net_1 \text{conf} Net_2}$, and the greater the value $\rho$, the greater the degree (depth) of the network conflict between the opposing networks $Net_1$ and $Net_2$.

Let us look at the network rivalry, which has a goal $W_2$ to change the content resource of conflicting networks $R_{es}(Net)$. Then, for conflicting interaction $W_{Net_1 \text{conf} Net_2}$, we can enter the following analytical assessments to measure the depth $\rho$ of the network conflict:

$$\rho = \left| \frac{\partial \ln R_{es}(X_1)}{\partial t} - \frac{\partial \ln R_{es}(X_2)}{\partial t} \right|.$$  

(13)

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Denis G. Plotnikov et al
\[
\rho[R_{es}(A)] = \frac{\partial \ln R_{es}(A_1)}{\partial t} - \frac{\partial \ln R_{es}(A_2)}{\partial t},
\]

(14)

through resources of vertices (13) and arcs (14) respectively.

The statements (13) and (14) reflect the relative dynamics of networks rivalry \( \text{Net}_1 \) and \( \text{Net}_2 \) in the context of expansion (narrowing) of the actual capabilities of hubs (13) and fillers transporters (14).

Extreme assessments can be imposed in the context of conflict aimed at changing the potential of the parties involved \( P_{\omega}(\text{Net}) \). For a set of vertices, we have:

\[
\rho[P_{\omega}(X)] = \frac{\partial \ln P_{\omega}(X_1)}{\partial t} - \frac{\partial \ln P_{\omega}(X_2)}{\partial t},
\]

(15)

and for a set of arcs:

\[
\rho[P_{\omega}(A)] = \frac{\partial \ln P_{\omega}(A_1)}{\partial t} - \frac{\partial \ln P_{\omega}(A_2)}{\partial t}.
\]

(16)

In addition, we can introduce other depth estimation of a conflict. For example, the above-mentioned statements can be interpreted through deviation of resources:

static:

\[
\rho\left[\text{Res}(X), t_0 \pm \frac{\Delta t}{2}\right] = \frac{\Delta \text{Res}(X_1)}{\text{Res}(X_1)} - \frac{\Delta \text{Res}(X_2)}{\text{Res}(X_2)};
\]

(17)

and dynamic:

\[
\rho\left[\text{Res}(A), t_0 \pm \frac{\Delta t}{2}\right] = \frac{\Delta \text{Res}(A_1)}{\text{Res}(A_1)} - \frac{\Delta \text{Res}(A_2)}{\text{Res}(A_2)},
\]

(18)

where the count is taken for the observed discrete period of

\[
\left[ t_0 - \frac{\Delta t}{2}, t_0 + \frac{\Delta t}{2}\right]
\]

conflict development.

Accordingly, it is possible to evaluate the root-mean-square deviation for a number of diskret periods \([t_i, t_i + k(\Delta t)]\):

\[
\overline{\rho}[\text{Res}(X), k(\Delta t)] = \sqrt{\sum_{i=1}^{k} \rho^2[\text{Res}(X), t_i + i(\Delta t)]};
\]

(19)

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Denis G. Plotnikov et al
The proposed depth estimates (17) - (20) can be useful for ongoing analysis of conflict situations in network.

### III. Results of the proposed methodology for describing network conflicts

As a network confrontation is aimed at changing the potential and resource capacities of the conflicting parties, you can enter a certain classification of network conflicts.

To do this, consider the dynamics of conflicting network resources $R_{es[Net_1]}$ and $R_{es[Net_2]}$. Under the influence of interaction the resources of each network are changed. The intensity of this interaction based on differential sensitivity is determined by the following functional derivatives [X]:

$$\frac{\partial R_{es[Net_1]}}{\partial R_{es[Net_2]}} \cdot \frac{\partial R_{es[Net_2]}}{\partial R_{es[Net_1]}}.$$

values of which describe the intensity of the resource impact on one network to another, and the characters are the direction of the impact.

The above assessment of the network conflict $[Net_1][Net_2]$ is not entirely objective. The use of relative sensitivity to changing the parameters of conflicting networks [XVIII] is more appropriate in this respect.

Relative sensitivity $S$ is defined as the percentage change in network resources $Net_1$ to the percentage change of $Net_1$ [XVIII]:

$$S_{lnR_{es[Net_1]}/lnR_{es[Net_2]}} = \frac{\Delta R_{es[Net_1]}/R_{es[Net_1]}}{\Delta R_{es[Net_2]}/R_{es[Net_2]}}.$$

Where $\Delta R_{es[Net]}$ is the increment of the network resource in the considered time interval.

In the limit, this statement seeks to the following type:

$$S_{lnR_{es[Net_1]}/lnR_{es[Net_2]}} \rightarrow \frac{\partial R_{es[Net_1]}/R_{es[Net_1]}}{\partial R_{es[Net_2]}/R_{es[Net_2]}} = \frac{\partial lnR_{es[Net_1]}}{\partial lnR_{es[Net_2]}}.$$

The sensitivity for classifying a network conflict can be written as follows

$$S = \frac{\partial lnR_{es[Net_1]}(t)/dt}{\partial lnR_{es[Net_2]}(t)/dt}. \quad (21)$$

Based on the vertices $R_{es[X]}$ and arcs $R_{es[A]}$ resources, we can convert the statement (21) to:
These statements are appropriate provided that the confrontation is aimed at changing the resource potential of the conflicting parties.

If the confrontation is aimed at changing the networks capacities, it is appropriate to evaluate the network conflict by criteria

$$S[R_{es}(X)] = \frac{\partial \ln R_{es}(X_1)}{\partial \ln R_{es}(X_2)}; S[R_{es}(A)] = \frac{\partial \ln R_{es}(A_1)}{\partial \ln R_{es}(A_2)}.$$ 

The condition \(\frac{\partial \ln \text{Pot}(X_1)}{\partial \ln \text{Pot}(X_2)} < 0\) attests to the network \(X_2\) having a negative impact on the first network \(X_1\), while the condition \(\frac{\partial \ln \text{Pot}(X_1)}{\partial \ln \text{Pot}(X_2)} > 0\) refers to the positive impact of the second network on the first. Equation \(\frac{\partial \ln \text{Pot}(X_1)}{\partial \ln \text{Pot}(X_2)} = 0\) characterizes no impact of \(X_2\) on \(X_1\).

Based on the evaluations discussed above, we can classify conflicts by selecting the following classes:

1. **Opposition:**
   \[
   \left[ S_{ln R_{es}(X_1)} < 0 \right] \& \left[ S_{ln R_{es}(A_1)} > 0 \right] \& \left[ S_{ln R_{es}(A_2)} < 0 \right].
   \]  
   (22)

   Inequality data shows the negative impact of conflicting networks on each other's resource capacities.

2. **Assistance:**
   \[
   \left[ S_{ln R_{es}(X_1)} > 0 \right] \& \left[ S_{ln R_{es}(A_1)} < 0 \right] \& \left[ S_{ln R_{es}(A_2)} > 0 \right].
   \]  
   (23)

   The latter inequities shows the positive impact of interacting networks on each other's resources.

3. **Exploitation:**
   \[
   \left[ S_{ln R_{es}(Net_1)} < 0 \right] \& \left[ S_{ln R_{es}(Net_2)} > 0 \right] \\& \left[ S_{ln R_{es}(Net_3)} < 0 \right] \\& \left[ S_{ln R_{es}(Net_4)} > 0 \right].
   \]  
   (24)

   The conflicting state in this case is characterized by both the elements in countering and in promoting, i.e., the objectives of conflicting networks are contradictory, but the presence of each other is necessary to achieve their goals.

4. **Neutrality:**
   \[
   \left[ S_{ln R_{es}(X_1)} = 0 \right] \& \left[ S_{ln R_{es}(A_1)} = 0 \right] \& \left[ S_{ln R_{es}(A_2)} = 0 \right].
   \]  
   (25)

   In other words, neutrality is characterized by the lack of influence of the networks on each other's resources.

The analysis of the network confrontation requires consideration of the conflict in the context of an adversarial mode of interaction, which in turn is divided into three main classes: antagonism, strict rivalry and non-strict rivalry [X].
Antagonism is diametrically opposed to the objectives of the conflicting parties, i.e., the reduction of a resource on one network leads to an increase in another network:

\[
\frac{\partial \ln R_{es}(Net_1)}{\partial \ln \text{Pot}(Net_2)} / dt < 0 \quad \& \quad \frac{\partial \ln R_{es}(Net_2)}{\partial \ln \text{Pot}(Net_1)} / dt < 0
\]

& \[\max R_{es}(Net_1) \iff (R_{es}(Net_2) = 0), \max R_{es}(Net_2) \iff (R_{es}(Net_1) = 0)\].

In fact, antagonism is characterized by a high degree of counteraction in a network conflict.

With strict rivalry, the greatest resource capacities of one network are achieved with the lowest resource value of another

\[
\left[ \frac{\ln R_{es}(Net_1)}{\ln R_{es}(Net_2)} < 0 \right] \& \left[ \frac{\ln R_{es}(Net_2)}{\ln R_{es}(Net_1)} < 0 \right] \& \[\max R_{es}(Net_1) \iff \min R_{es}(Net_2), \max R_{es}(Net_2) \iff \min R_{es}(Net_1)\].
\]

For strict rivalry, unlike antagonism, there is a possibility for compromise in resolving the conflict.

The non-strict rivalry is also characterized by the negative impact of networks on each other, but the two conflicting networks can increase their resource potential through compromise, although perhaps not fully:

\[
\left[ \frac{\ln R_{es}(Net_1)}{\ln R_{es}(Net_2)} < 0 \right] \& \left[ \frac{\ln R_{es}(Net_2)}{\ln R_{es}(Net_1)} < 0 \right] \& \[\max R_{es}(Net_1) \iff \min R_{es}(Net_2), \max R_{es}(Net_2) \iff \min R_{es}(Net_1)\].
\]

In non-strict rivalry, maximizing the resource of network $Net_1$ does not minimize the resource of network $Net_2$.

However, an assessment that takes into account the volume $V$ of the medium and its value $C$ has a practical interest. In this perspective, the sensitivity function will take the following form:

\[
\frac{\ln R_{es}(X_1)}{\ln R_{es}(X_2)} = \frac{\partial \ln (C(X_1)) V(X_1)}{\partial \ln (C(X_2)) V(X_2)}
\]

and

\[
\frac{\ln R_{es}(A_1)}{\ln R_{es}(A_2)} = \frac{\partial \ln (C(A_1)) V(A_1)}{\partial \ln (C(A_2)) V(A_2)}.
\]

For a case where the rivalry of the parties does not affect the specific value of the filler statement (3.29) and (3.30), we can rewrite as follows:

\[
\frac{\ln R_{es}(X_1)}{\ln R_{es}(X_2)} = \frac{\partial \ln V(X_1)}{\partial \ln V(X_2)} = \frac{V(X_2) \partial V(X_1)}{V(X_1) \partial V(X_2)},
\]

\[
\frac{\ln R_{es}(A_1)}{\ln R_{es}(A_2)} = \frac{\partial \ln V(A_1)}{\partial \ln V(A_2)} = \frac{V(A_2) \partial V(A_1)}{V(A_1) \partial V(A_2)}.
\]

In this (31) and (32) context, the classification characteristics of conflicts will take a slightly different view: Thus, counteraction appears in the case of inequities.
The statement (36) notes the null mutual influences of network settings. And in another network.


gives the logical

As can be seen (34), there is a positive mutual influence between the parties, both in the volume of the vertices filler and the bandwidth for both networks. There is an option for assistance that we call proportional. In this case, equation is performed:

\[
\frac{V(X_2)}{V(X_1)} \frac{\partial V(X_1)}{\partial V(X_2)} = 1 \quad \text{and} \quad \frac{\partial V(A_2)}{\partial V(A_1)} = 1.
\]

when the volumes and bandwidth in one network drive change inversely to the same settings in another network.

In turn, the options for assistance of parties can be recorded as inequalities

\[
\frac{\partial V(X_1)}{\partial V(X_2)} > 0 \quad \text{and} \quad \frac{\partial V(A_1)}{\partial V(A_2)} > 0.
\]

(34)

As can be seen (34), there is a positive mutual influence between the parties, both in the volume of the vertices filler and the bandwidth for both networks. There is an option for assistance that we call proportional. In this case, equation is performed:

\[
\frac{V(X_2)}{V(X_1)} \frac{\partial V(X_1)}{\partial V(X_2)} = 1 \quad \text{and} \quad \frac{\partial V(A_2)}{\partial V(A_1)} = 1
\]

when the volumes and bandwidth in one network drive change inversely to the same settings in another network.

**Exploitation**, as a kind of conflict, can be illustrated by the following logical statements:

\[
\left[ \frac{\partial V(X_1)}{\partial V(X_2)} > 0 \right] \land \left[ \frac{\partial V(X_2)}{\partial V(X_1)} < 0 \right] \lor \left[ \frac{\partial V(X_1)}{\partial V(X_2)} < 0 \right] \land \left[ \frac{\partial V(X_2)}{\partial V(X_1)} > 0 \right]
\]

\[
\left[ \frac{\partial V(A_1)}{\partial V(A_2)} > 0 \right] \land \left[ \frac{\partial V(A_2)}{\partial V(A_1)} < 0 \right] \lor \left[ \frac{\partial V(A_1)}{\partial V(A_2)} < 0 \right] \land \left[ \frac{\partial V(A_2)}{\partial V(A_1)} > 0 \right].
\]

(35)

Statements (35) symmetrically assert that when the volume and bandwidth in one network drive grows, the same parameters of other network are reduced.

Apparelnantly, neutrality nullifies sensitivity

\[
\frac{\partial V(X_1)}{\partial V(X_2)} = \frac{\partial V(A_1)}{\partial V(A_2)} = 0.
\]

(36)

The statement (36) notes the null mutual influences of network settings.

On the contrary, antagonism in negative sensitivity:

\[
\left[ \frac{\partial V(X_1)}{\partial V(X_2)} < 0 \right] \land \left[ \frac{\partial V(X_2)}{\partial V(X_1)} < 0 \right] \lor \left[ \frac{\partial V(A_1)}{\partial V(A_2)} < 0 \right] \land \left[ \frac{\partial V(A_2)}{\partial V(A_1)} < 0 \right].
\]

shows the extreme imbalance:

\[
\text{[max}V(X_1) \iff V(X_2) \to 0] \lor [\text{max}V(A_1) \iff V(A_2) \to 0];
\]

\[
\text{[max}V(X_2) \iff V(X_1) \to 0] \lor [\text{max}V(A_2) \iff V(A_1) \to 0].
\]

(37)
For **strict rivalry**, sensitivity is also negative, but the additional conditions are different from the (37):

\[
\begin{align*}
\max V(X_1) &\iff \min V(X_2) \bigvee \max V(X_2) \iff \min V(X_1); \\
\max V'(A_1) &\iff \min V'(A_2) \bigvee \max V'(A_2) \iff \min V'(A_1).
\end{align*}
\]

In turn, the non-strict rivalry (also with negative sensitivity) provides the following additional inverse (38) conditions (39)

\[
\begin{align*}
\max V(X_1) &\iff \min V(X_2) \bigvee \max V(X_2) \iff \min V(X_1); \\
\max V'(A_1) &\iff \min V'(A_2) \bigvee \max V'(A_2) \iff \min V'(A_1).
\end{align*}
\]

It was further appropriate to consider the case where the conflict focused on manipulation of the specific value of drive. In information networks, this is a common practice when an opponent tries to lower the value of information as a drive on an opponent's network. In this situation, the conflict analysis will be based on the option (C) from (31) and (32) the first thing to consider is sensitivity, as follows:

\[
\begin{align*}
S_{\ln R_{\text{es}}(X_1)} &= \frac{\langle C(X_2) \rangle}{\langle C(X_1) \rangle}; \\
S_{\ln R_{\text{es}}(X_2)} &= \frac{\langle C(X_1) \rangle}{\langle C(X_2) \rangle}; \\
S_{\ln R_{\text{es}}(A_1)} &= \frac{\langle C(A_2) \rangle}{\langle C(A_1) \rangle}, \\
S_{\ln R_{\text{es}}(A_2)} &= \frac{\langle C(A_1) \rangle}{\langle C(A_2) \rangle}.
\end{align*}
\]

In theory \(\langle C(X_1) \rangle \neq \langle C(A_1) \rangle\) and \(\langle C(X_2) \rangle \neq \langle C(A_2) \rangle\). Information that's stored in information networks is more valuable than transmitted \(\langle C(X) \rangle > \langle C(A) \rangle\). However, such equality is observed in the gas networks. In the broadest sense, based on the statements (2.40) and (2.41), it is possible to obtain ratios similar (2.33) - (2.39) for the dynamics (C).

The process of conflict development can be divided into phases, where each phase is a fixed state of conflict and has its content and structure. Thus, there is escalating and de-escalating conflict processes in studies [1].

In the de-escalating development of network conflict, we distinguish the following phases [XVIV]:

1. Abandonment of actions by conflicting parties resulting in a reduction of stock or an impediment to the growth of the filler flow, including structural changes to the opponent's network.
2. Search of compromise between the parties that can be expressed in acceptable (for both networks) storage and distribution of filler flow and structural opportunities.
3. Partial or full achievement of the goals of conflicting parties. This solution for both networks may be to minimize the amount of stored and transferred drives compared to the same indicators before compromise (★)
\[
\left[ \frac{d \ln \text{Res}(X_1, A_1)}{dt} > \frac{d \ln \text{Res}^*(X_1, A_1)}{dt} \right] \& \\
\& \left[ \frac{d \ln \text{Res}(X_2, A_2)}{dt} > \frac{d \ln \text{Res}^*(X_2, A_2)}{dt} \right]
\]

up to the development of both networks in positive dynamics of the relevant derivatives

\[
\left[ \frac{d \ln \text{Res}(X_1, A_1)}{dt} \uparrow \right] \& \left[ \frac{d \ln \text{Res}(X_2, A_2)}{dt} \uparrow \right].
\]

4. Compromise by conflicting parties on the structure and distribution of the volume of the data loggers.

5. Peaceful resolution of the contradiction lay in one of the parties refusal to carry out actions that result in a reduction of stock or an obstacle to the increase in flow of opponent's network, which constitutes the main contradiction (the cost of rivalry exceeds the expected dividends from winning, in conflict).

The escalating dynamics of the network conflict has three phases, comprising 9 stages [XVIV]:

1. The first phase consists of initial three stages. At the first stage, the actions of conflicting parties includes collaborative activity and cooperation and allows both networks to increase the stock and flow of fillers, as well as their structural capabilities. At the second stage, the goals of conflicting parties differed. In doing so, the participants seek to compel the opponent's network to accept the conditions by putting it over a barrel. The third stage involves the implementation of actions aimed at impeding the achievement of opponent's goals. Thus, at this stage, the Net\(_1\) network may be able to create conditions to reduce or impede the growth of the volume of stored and nontransferable fillers or the structural opportunities of the Net\(_2\) network.

A case in point is (figure 2.1) "territory" - a space in which both networks operate and where the interests of the parties are most likely to clash. The attacks and counterattacks are very real because of the intersections

\[ \text{Net}_1 \cap \text{Net}_2 \Rightarrow [X_1 \cap X_2] \& [A_1 \cap A_2]. \]

In general, in the first phase, when the parties to the conflict realize the state of tension, it is possible to take a constructive decision in the context of the interaction [XVIV].

2. The second phase includes stages from four to six. The conflict in this phase is of a antagonistic nature. At the fourth stage, the escalation of the network conflict has led conflicting parties to an awareness that it will not be possible to complete the conflict jointly and peacefully. The fifth stage is characterized by the inability of the parties to reach a compromise. At the sixth stage, network rivalry is characterized by the desire of one network to reduce the resource or structural opportunities of the opponent's network.

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Denis G. Plotnikov et al
\[
\left[ \frac{d \ln \text{Res}(X_1, A_1)}{dt} \right] \downarrow \& \left[ \frac{d \ln \text{Res}(\text{Net}1)}{dt} \right] \downarrow \]

with parallel developing its own capacities

\[
\left[ \frac{d \ln \text{Res}(X_2, A_2)}{dt} \right] \uparrow \& \left[ \frac{d \ln \text{Res}(\text{Net}2)}{dt} \right] \uparrow
\]

and using threats strategies and drastic measures.

3. The third phase, consisting of stages from seven to nine, is radical, since it is the destruction of the opponent's network. The seventh stage is characterized by the actions that reduce the opponent's ability to respond. Subsequently, in the eighth stage, the aim is to impress the adversary, to influence its "will". In this case, it would be blow to:

- filler in two possible options: a drastic reduction in the unit value of the filler (collapse in oil price, spamming, defamation of resources, etc.)

\[
\text{Atak}[\text{Net}_2] \Rightarrow [\{C(X) \downarrow \downarrow\}] \& [\{C(A) \downarrow \downarrow\}];
\]

or destroying filler objects on the affected network

\[
\text{Atak}[\text{Net}_2] \Rightarrow [\{V(X) \downarrow \downarrow\}] \& [\{V(A) \downarrow \downarrow\}];
\]

- structure of the opponent's network

\[
\text{Atak}[G(\text{Net}_2)] \Rightarrow [\{X_1 \downarrow \downarrow\}] \& [\{A_1 \downarrow \downarrow\}];
\]

finally, the most realistic option is when both the filler and the structure of opponent's network are attacked (hybrid blow).

In the final stage, escalation reaches the point where the goal of the destruction of adversary can be achieved even by self-destruction [XVIV].

A specific network conflict does not need to include all the phases and stages of escalation and de-escalation considered, but in order to adequately describe the conflict situation, each party needs to know clearly what phase of the dynamics development is in the network conflict, and to be ready for a response in accordance with that knowledge.

IV. Discussion of the results

The network device of modern communications is now ubiquitous. The financial, transport, information and other interactions of individuals and entities are now carried out through local and global network structures. In addition to the positive contacts in these networks, there are also conflict situations that result in a variety of conflict according to their parameters. Traditional conflict resolution does not consider network conflicts with all due attention. In addition, most network formalities do not take into account the weight of modern networks in terms of the topology of their fillers. Thus, the methodology proposed in the article seems to be relevant and original from the development perspective of traditional conflict theory through the apparatus of weighted evaluation of

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Denis G. Plotnikov et al
network, i.e., using the capacities and resources of their vertices and arcs in the dynamics of these parameters during the network interaction of the parties to the conflict. In this regard, the authors' evaluations through the relative sensitivity of the above-mentioned parameters are considered to be new.

The innovations outlined above offer prospects for a more adequate analysis of intranet and internet conflict situations. The automation of calculations will make it possible to assess in real time the nature of the conflict, its depth and the resource dynamics of evolving conflict.

As a possible application of the proposed methodology, the information processes [XXI-XVII] related to the risks of network filler distribution could be considered. Problems also arise, for example, in the risk of epidemics in information networks. In corporate networks, this is usually due to the spread of computer viruses and worms that embedded into the attacked network by the conflicting party. In social networks, this is a problem of diffusion of destructive content for the assessment of which software complex "Netepidemic" can be recommended; this complex implements the algorithms proposed in the studies [XXI-XVII]. The systematic dynamics of network resources will provide answers to many of the conflict questions, including the intranet collision of competing content, risks and chances of occurrence of their adherents.

At the level of interconnectivity, the description of the administrator's struggle for the client in virtual space is of interest. Statistics on the resource and topological social networks, which are constantly updated in the public domain, give an opportunity to analyse the dynamics of interest in users of changing communications and traffic, which is essential for analytical work on the proposed methodology.

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Denis G. Plotnikov et al

27
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