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## METHOD OF SOLVING THE PROBLEM OF SITUATIONAL MANAGEMENT OF THE SEMANTIC KERNEL OF WEB CONTENT

*Research conducted over the past ten years in the field of search engine optimization on the Internet shows the creation of a new phenomenon - virtual promotion [1]. Its main goal is to increase the level of sales of goods through technologies that exist in virtual space. In terms of properties, virtual promotion is similar to a logistics channel, but with the characteristics of a marketing channel. That is, virtual promotion can be described as the establishment of a channel for the transmission of a special message from the company to a potential buyer of its goods or services. This article proposes to consider the problem of creating and managing such a message in cyberspace. To do this, it is proposed to solve the problem of situational management of the semantic kernel of web content. At the first stage the review of properties of a semantic kernel is carried out. This analysis allows us to formulate the problem of situational management of the semantic kernel. The main idea of this problem is that the current situation is a variant of the semantic kernel of web content. Then the paper proposes a mathematical model for estimating the current situation and choosing the target situation. Conditions are also proposed to determine the need for transition between situations. The article also describes the algorithmic support for the implementation of the method of solving the problem of situational management. The result of the algorithm is K-applicant, ie the semantic kernel that describes the class of needs, which was identified at the stage of clustering. The prospect for further research is the software implementation of this algorithm on the NodeJS platform.*

*Keywords: Virtual promotion of a product, situational management, semantic kernel, web content.*

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## МЕТОД ВИРІШЕННЯ ЗАДАЧІ СИТУАЦІЙНОГО УПРАВЛІННЯ СЕМАНТИЧНИМ ЯДРОМ ВЕБ КОНТЕНТУ

*Дослідження, що було проведено за останні десять років у сфері пошукової оптимізації в мережі Інтернет, свідчать про створення нового феномену – віртуальне просування [1]. Його основна ціль полягає у підвищенні рівня продажу товару завдяки технологіям, що існують у віртуальному просторі. За властивостями віртуальне просування схоже з логістичним каналом, але з характеристиками, що має маркетинговий канал. Тобто віртуальне просування можна описати як встановлення каналу передачі спеціального повідомлення від підприємства до потенційного покупця його товару чи послуги. В статті запропоновано розглянути задачу створення та управління таким повідомленням у віртуальному просторі. Для цього пропонується вирішувати задачу ситуаційного управління семантичним ядром веб контенту. На першому етапі проведено огляд властивостей семантичного ядра. Цей аналіз дозволив сформулювати постановку задачі ситуаційного управління семантичним ядром. Головна ідея цієї задачі полягає в тому, що в якості поточної ситуації розглядається варіант семантичного ядра веб контенту. Тоді в роботі пропонується математична модель для оцінювання поточної ситуації та вибору цільової ситуації. Також пропонується умови для визначення необхідності переходу між ситуаціями. Також в статті описано алгоритмічне забезпечення для реалізації методу вирішення задачі ситуаційного управління. Результатом виконання алгоритму є K-претендент, тобто семантичне ядро, що описує клас потреби, який було виявлено на етапі кластеризації. Перспективою для подальших досліджень є програмна реалізація даного алгоритму на платформі NodeJS.*

*Ключові слова: віртуальне просування продукту, ситуаційне управління, семантичне ядро, ВЕБ контент.*

### Introduction

The process of virtual promotion is similar to the logistics channel, where there are several concepts of work. From our point of view, the concept of “continuous replenishment” [1] is suitable for virtual promotion. This means that goods, and in our case knowledge about goods, should be concentrated in the main nodes of the logistics network. That is, it is necessary to place knowledge about the product or the need it covers on the Internet, where it will be read or downloaded by users - potential buyers of goods or services. In other words, you need to place knowledge about the product on the Internet and wait for the search engine database to be updated. A network of cross-references between network nodes is also formed to confirm both the originality of information about the product and the primary source of this data in the form of: a) a corporate website, b) a profile on a social network, or c) a profile on a trading platform.

The main idea of virtual promotion is that we need to form a channel and a special message in it. This message is called the semantic core. This approach is completely new and alternative. This is a new look at the problem of search engine optimization on the Internet [1].

Thus, understanding the physical content of virtual promotion means that a powerful promotion channel on the Internet is being created, called thematic search [2]. To create other channels, it is also necessary to unify the message so that it is distributed in the same content and format on the Internet with a link to the corporate website. In our work [3], for the first time, it was proposed to use as a message the semantic core of web content generated by a company that is interested in selling a given product or in satisfying a given need on its own using Internet technologies [3, 4].

This paper proposes an alternative approach to solving the problem of search engine optimization on the Internet. The essence of the approach is to change the semantic core of web content step by step in the promotion channel in order to improve the main values of WEB metrics. The step-by-step change of the core is based on the method of situational control [5].

Thus, the article proposes a new look at the problem of search engine optimization on the Internet by generating special web content and a strategy for changing it in the promotion channel.

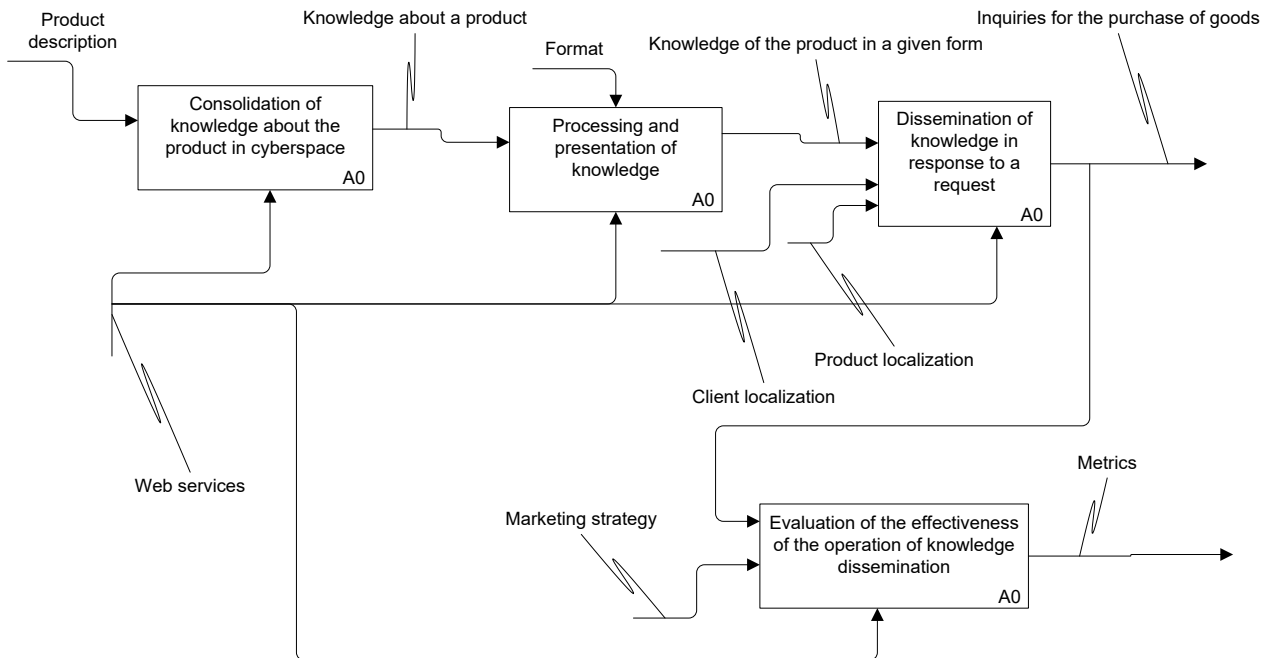
**Problem statement**

In [5] the first attempt to solve the problem of search engine optimization on the Internet as a problem of situational management was described. According to the classical theory of situational management [6], we have the following statement of the problem:

$$S_i : E_{i1} \xrightarrow{U_i} E_{i2} , \tag{1}$$

where  $S_i$  - the full situation,  $E_{i1}, E_{i2}$  - current situations,  $U_i$  - the rule of logical transformation from one current situation to another.

We will assume that the current situation corresponds to the current version of the semantic kernel. We have the following process that implements the marketing channel of virtual promotion - Figure 1. That is, we have the current situation. In which case should this kernel be replaced with a new one?



**Fig. 1. Modern scheme of virtual promotion marketing channel**

The first case. Whether there is a criterion of usefulness or a criterion of effectiveness of virtual promotion. This criterion can assess the profitability of sales of goods through a given channel of promotion on the Internet. Then you can evaluate the promotion complex consisting of the semantic kernel and the promotion channel. We will assume that such an estimate is presented in the form of a graph of the relationship between the value of profitability and time. If the value of the profitability of this complex decreases over a period of time, then such a semantic kernel must be changed. The first attempt to write such a criterion for assessing the efficiency of the channel and the kernel is presented in [7].

The second case. The main metrics for search engine optimization on the Internet [8] show a steady decline (or increase) over time. Such metrics are traffic, number of leads, bounce rate, conversion, number of repeat visits. These metrics belong to the class of WEB metrics. All these metrics show the conditional efficiency of the promotion channel with a given semantic kernel.

The third case. An enterprise decides to change product characteristics or marketing segment for your sale. In this way, the entire text complex  $TD$  is changed, and that needs to repeat the task of synthesizing the kernel again.

In the paper it is suggested to look at the first aspect of the formation of the efficiency criterion for the complex (the channel and the kernel), and also to improve the metrics that indicate the mental efficiency. We will

mean that, like  $j = \overline{1, J}$  - the number of nodes in the channels of passing through the Internet, where the semantic kernel will be located.  $B_{ij}$  - budget, which can be accepted for the placement of the kernel in the  $j$ -th node for the period of time  $t$ .  $u_{ij}$  - the number of leads, which was taken for a period of time  $t$ . The period of time  $t \in T$  may be 24 hours. We remind you that lead is the action of a potential buyer on a web resource that leads him to: 1) purchase on the web site, 2) pay for the product on the website or 3) enter your contact details at the special form for the remote purchase of the product in the office [9]. Then  $u_{ij} = u_{ij}^1 + u_{ij}^2 + u_{ij}^3$ . Our goal is to maximize the component  $u_{ij}^2$ . It is reasonable to [10-11] to modify the criterion of effectiveness for offensive

$$\sum_{t \in T} \sum_{j \in J} \frac{B_{ij}(tr_{ij})}{(u_{ij}^1(tr_{ij}) + u_{ij}^2(tr_{ij}) + u_{ij}^3(tr_{ij}))} \rightarrow \min, \quad (2)$$

where  $tr_{ij}$  is the traffic received by the  $j$ -th node for the time period  $t$ . The physical meaning of criterion (2) is to reduce the cost of attracting a buyer to purchase a product or service on the Internet. Then the index  $u_{ij} = u_{ij}^1 + u_{ij}^2 + u_{ij}^3$  corresponds to the conversion of traffic into the appropriate form of lead. For us, the most interesting is the second type of lead, when the buyer pays for the goods or services directly online. We transform the formula (2):

$$\begin{aligned} \sum_{t \in T} \sum_{j \in J} \frac{1}{(u_{ij}^1(tr_{ij}) + u_{ij}^2(tr_{ij}) + u_{ij}^3(tr_{ij}))} &= \sum_{t \in T} \sum_{j \in J} \frac{1}{\frac{u_{ij}^1(tr_{ij})}{B_{ij}(tr_{ij})} + \frac{u_{ij}^2(tr_{ij})}{B_{ij}(tr_{ij})} + \frac{u_{ij}^3(tr_{ij})}{B_{ij}(tr_{ij})}} =, \\ \sum_{t \in T} \sum_{j \in J} \frac{1}{(O^1(tr_{ij}) + O^2(tr_{ij}) + O^3(tr_{ij}))} &\rightarrow \min, \\ \text{or } \sum_{t \in T} \sum_{j \in J} P(tr_{ij}) &\rightarrow \min, \end{aligned} \quad (3)$$

where  $O^1(tr_{ij})$  is the payback of the channel on the first type of lead, which guarantees the placement of the semantic kernel in the  $j$ -th node for a period of time  $t$ . The higher the payback of the channel and the message, the lower the price of attracting a buyer  $P(tr_{ij})$  to a given node for a given period of time.

Let's take as a basis the classic problem of linear programming to describe the mathematical model of the channel with the kernel from the standpoint of the cost of attraction. Then formula (3) has the following modification:

$$\sum_{t \in T} \sum_{j \in J} w_j P(tr_{ij}) \rightarrow \min, \sum_{j \in J} w_j = 1,$$

where  $w_j$  is the weighting factor that takes into account the importance of the  $j$ -th node in the promotion channel. The higher the payback of the channel and the message, the lower the price of attracting a buyer  $P(tr_{ij})$  to a given node for a given period of time.

The first block of task conditions will mean that the traffic in the node is a positive value and an integer:  $tr_{ij} \geq 0, tr_{ij} = \{0, 1, 2, \dots\}$ .

For the promotion channel to be successful, it is necessary to enter the threshold of its profitability:

$$\sum_{t \in T} \sum_{j \in J} \frac{Pr_{ij}}{P(tr_{ij}) + Ex_{ij}} \geq \sum_{t \in T} R_t,$$

$R_t$  - is the rate of return, which is set by the company for a period of time  $t$ . It shows the lowest value that guarantees the success of Internet promotion.  $Pr_{ij}$  - income received by the enterprise, if the buyer ordered a

product or service, reading the semantic kernel in the  $j$ -th node for a period of time  $t$ .  $Ex_{ij}$  - additional costs borne by the enterprise from the placement of the semantic kernel in the  $j$ -th node for a period of time  $t$ .  $P(tr_{ij})$  - the price of attracting customers in the  $j$ -th node for a period of time  $t$ . Then we have the following optimization problem:

$$\sum_{t \in T} \sum_{j \in J} w_j P(tr_{ij}) \rightarrow \min, \quad (4)$$

$$\sum_{t \in T} \sum_{j \in J} \frac{Pr_{ij}}{P(tr_{ij}) + Ex_{ij}} \geq \sum_{t \in T} R_t, \quad (5)$$

$$\sum_{j \in J} w_j = 1, \quad (6)$$

$$tr_{ij} \geq 0, \quad tr_{ij} = \{0, 1, 2, \dots\}. \quad (7)$$

The physical meaning of the problem (4)-(7) is that you need to estimate the minimum cost of attracting one buyer, having a given channel and semantic kernel. The problem with this task is that the traffic-dependent form of the function  $P(tr_{ij})$  is unknown.

Then the problem of situational management in modern conditions is formulated as follows [6]. We denote the current situation  $C = \langle K, F \rangle$ , where  $K$  - the current version of the semantic kernel, and  $F$  - a function that expresses the evaluation of the efficiency of the channel and the kernel, i.e. the result of solving the problem (4)-(7). Then the full situation  $S = \langle C, C_R \rangle$  is formed, as a combination of the current situation and the goal that the company sets for the promotion process. This goal primarily  $C_R$  applies to conditions (5), i.e. the rate of return on the channel and the kernel of the promotion. We will assume that the current situation belongs to the class  $C \in Q'$ . And the target situation of the class. Then you need to form the following management  $U \in \Omega$  to achieve the target situation:

$$C \in Q' \xrightarrow{U \in \Omega} C_R \in Q'' \text{ or } (Q', Q'') \rightarrow U \in \Omega \quad (8)$$

where  $\Omega$  - a set of control options, in other words, options for transforming the kernel or changing the semantic kernel to another. We believe that the structure of the promotion channel remains unchanged, because it is the subject of further research.

Thus, the problem of situational management of the semantic kernel has the following wording: we must choose  $U \in \Omega$  the transformation of the semantic kernel of web content based on the classification of the current situation  $C \in Q'$  and adequate assessment  $F$  of the promotion channel and the kernel as a whole, which should lead to a new target  $C_R \in Q''$  (channel and kernel) by the marketing department of the enterprise.

So our task includes four subtasks: kernel synthesis (initial version), kernel evaluation - task (4)-(7), kernel classification and selection of a new class of kernel, ie changing the kernel to another taking into account the requirements of marketing services.

The advantages of this approach are significant. Because the problem under consideration is dynamic. A typical scheme for solving the problem of linear or nonlinear programming is as follows [12]. We believe that a mathematical model exists. Then you must first choose the basic parameters of the problem, for example, based on the Monte Carlo method or mathematical statistics. That is, you need to collect initial data and process them. Then, having a record of the problem and a standard solution method, the optimal Pareto alternative is sought. Finally, you can check the stability of the solution. In our case, this is not possible, because you can collect input data in the process of solving the problem. Therefore, the situational approach allows, so to speak, to adapt the probable solution of the problem in the process of its solution. This is similar to the task of opening a safe when you turn the knob and test the lock for opening.

#### Proposed approach

In the paper it is offered to solve a problem of situational management according to the following UML scheme [13-14] - figure 2.

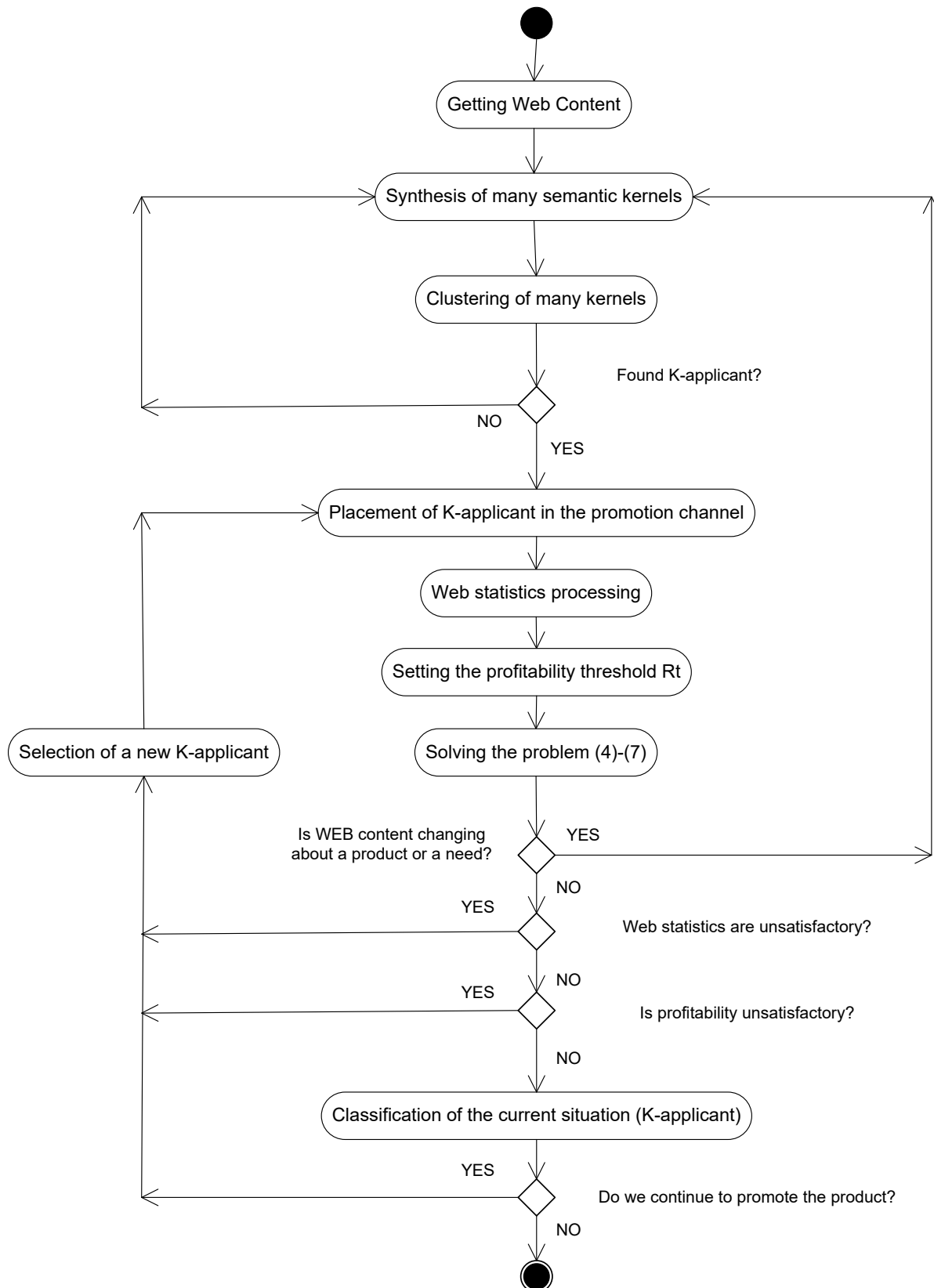


Fig. 2. The scheme of solving the problem

Consider the content of this scheme for solving the problem of situational management of the semantic kernel. At the first stage we will receive web content from the enterprise for synthesis of set of semantic kernels. Next, the clustering process is performed in order to create a set of needs classes, as well as centroids of each class. We believe that every centroid of needs class is a K-applicant. Place it in the promotion channel in each  $j$ -th node.

Next we follow the metrics of WEB statistics. We set the profitability threshold of the channel as a whole at a given period of time  $t$ . Based on these input data we solve problem (4)-(7) to evaluate the efficiency of the channel with the K-applicant installed in it.

We are checking the conditions for the transition to a new K-applicant. If all web content changes, we re-synthesize the whole set of semantic kernels and repeat the whole algorithm first. If the results of WEB statistics or profitability are unsatisfactory, then choose a new kernel (new current situation) and run it into the promotion channel. If these conditions are satisfactory, it is necessary to classify the K-applicant and continue the process of placing it in the channel. If the promotion of goods or needs stops, then the algorithm ends its execution.

Also uncertain is the step on the classification of the current situation (see figure 2). Based on the effect of aging of the semantic kernel, which was found in the research work [15], it is proposed to classify the current situation as one that corresponds to the present or as outdated. The outdated kernel needs to be changed to a new one anyway.

We offer a list of rules for the transition from one current situation to another, i.e. the rules for changing the current kernel to another. Let's divide the whole set of rules into two parts. The first part is the rules that affect the promotion process, i.e. management rules. The second group of rules is the rules that record the fact of aging of the nucleus or evolutionary rules.

The first group of rules is launched if the value of the profitability of the promotion is unsatisfactory. Let us denote this fact by the following formula:

$$\frac{\sum_{t \in T} R_t}{|T|} \geq \Delta^R \quad (9)$$

where the average profitability for a period of time  $T$  must not be lower than the specified value  $\Delta^R$ . If condition (9) is not met, the kernel should be updated.

The second group of rules is formed on the basis of analysis of web statistics. As mentioned, we have four main indicators of the semantic kernel: the number of "isa" rules, the frequency of occurrence in web content, the frequency of occurrence in the search engine database and the number of keywords in the semantic kernel. But they do not correspond to the statistics that are actually available to us in the analysis of the promotion process. Available metrics in the promotion channel node are traffic, number of paid online orders, and number of leads. These are real indicators that give attention to the efficiency of the node with the semantic kernel placed in it.

Let's analyze each indicator and try to establish the rule of changing the kernel to another based on it. The first indicator is traffic. It shows the number of semantic kernel impressions in the promotion channel node. As practice shows, the dynamics of this indicator is the most important, but also the most uncertain. It all depends on the product itself and the factors around it. There are situations when the value of this indicator increases and profitability decreases, so it is extremely difficult to determine the direct relationship between these indicators. Let us denote this indicator as  $tr_{ij}$  - the traffic received by the  $j$ -th node for the time period  $t$ . Then we have the condition:

$$\frac{\sum_{t \in T} tr_{ij}}{|T|} \geq \Delta_j^{tr} \quad (10)$$

where  $\Delta_j^{tr}$  is the rate of average traffic in the  $j$ -th node. If condition (10) is not met, the kernel should be updated. However, it should be noted that the fulfillment of condition (10) in some cases does not guarantee the need to change the kernel, because, for example, too small a budget for the placement of the semantic kernel in a given node does not increase traffic.

This is, so to speak, the first step in analyzing the need to update the kernel in the promotion channel. The second step is based on identifying the need to do so on the basis of other conventions that are not related to profitability or web statistics.

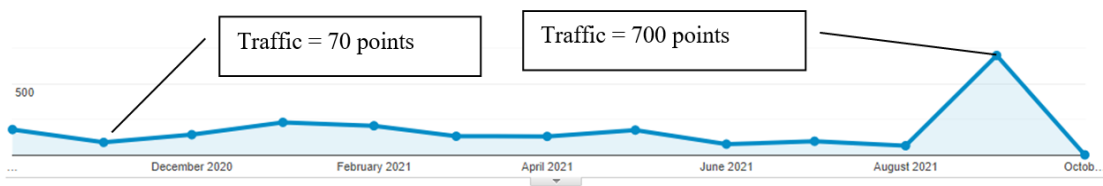
The above four cases of the need to update the kernel should also be considered through the prism of existing quantitative indicators. The first case when we discuss the evolution of the product on the market, and therefore its reflection on the Internet, can be recorded in terms of the following indicators, which can be monitored over time, and in a given node of the promotion channel. Such indicators may be:

- 1) the volume of sales of goods for a period of time in a given node;
- 2) conversion in a given node over time  $t \in T$ ;
- 3) profit received through a given node over a period of time  $t \in T$ .

These three indicators can capture the process of product evolution in the market, in particular in cyberspace. In this case, if the profit schedule has only one maximum, it is likely that the product goes into the stage of extinction. Therefore, let there be a graph of the dependence of profits on time:  $y = Pr(t)$ . If this graph has one extremum per maximum and the current value of this function is less than the extremum and newer in time, then the semantic kernel update needs to be updated:

$$\max_{t \in T} Pr(t) \geq Pr(t+1), (t+1) \notin T$$

Unfortunately, it is not possible to quantify other cases of kernel upgrades at present. Therefore, it is appropriate to introduce expert evaluation in the algorithm execution scheme. If the value is one, then an update is required. Values are set expertly by the company or team that performs the process of virtual promotion. Unfortunately, in this case, the execution of the scheme (Figure 3) will be in automated mode.



**Fig. 2. The scheme of solving the problem**

### Results

In 2020-2021, a study was conducted for a web resource in the American service market, in which the cycle of situational management of the semantic kernel was applied. This web resource provides a unique service for building a psychological portrait of a person based on personal information. The results of this study are reflected in the graph of web statistics - Figure 3. This graph reflects the change in the main web metric - traffic or the number of visits. Figure 3 shows that the result of applying the cycle was an increase in traffic over a given period of time by ten times. This graph was obtained in the environment Google Analytics.

The data in Figure 3 show the existence of the very fact of the existence of the semantic kernel. That is, this is a confirmation of the efficiency of the proposed new method for implementing search engine optimization technology on the Internet.

### Conclusions

The article considers new scientific results, namely:

- 1) for the first time the formulation of the problem of situational management of the semantic kernel and the method of its solution are formulated;
- 2) the method of search engine optimization on the Internet based on the concept of the semantic kernel was further developed;
- 3) for the first time the rules of transition between semantic kernels in the process of product promotion on the Internet are proposed, which is aimed at improving the efficiency of the search engine optimization process on the Internet;
- 4) for the first time proposed metrics and criteria for evaluating the effectiveness of the semantic kernel both individually and in the promotion channel on the Internet.

Further areas of research will be a deeper testing of the proposed method of controlling the kernels. You should test the transition rules and the strategy for increasing or decreasing the size of the semantic kernel in the Internet promotion channel.

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