An approach to the mathematical description of the criterion for the effectiveness of a new object of research – virtual promotion is presented in the paper. The emergence of this new object of research is connected, on the one hand, with the classical theory of marketing, and on the other with modern Internet technologies. Marketing is based on the 4P principle: product, price, location and promotion. Promotion is a component of this principle. But in modern conditions, this phenomenon is changing under the influence of the Internet. Now this 4P component is becoming a fully virtual instrument. The traditional scheme of promotion functioning is as follows. A message is created to a potential buyer and the delivery channel of this message undergoes a change. It is based on the principle: money – goods – money. While the new sales scheme is described by the scheme: we attract a client, make money on a client, we spend money. In the new scheme, we deal with product knowledge in the form of the so-called semantic core of web content. Knowledge describes for a potential client how a given product can cover his need for something. Using the logistic principles of the transfer of goods, this semantic core is loaded into the specified Internet nodes. That is, virtual promotion is formed as two channels: logistics and marketing. The first one performs three operations: concentration, formatting and distribution of semantic cores on the Internet. The second manages this process, forming a virtual promotion map. This map is a graph of Internet nodes. It is required to define such a tree of Internet nodes so that virtual promotion has maximum efficiency. The paper analyzes modern metrics related to the processes of search engine optimization on the Internet. Unfortunately, these metrics evaluate only statistically after the fact of visiting a web resource or the budget of the Internet site in which the advertising message about the product was placed. Therefore, based on the conversion metric, a criterion for the effectiveness of virtual promotion was proposed in the work, which takes into account both the attractiveness of the semantic core and the attractiveness of the Internet site where the semantic core will be located. The criterion reflects the income that we receive depending on the attractiveness of the semantic kernel and the Internet site.

Keywords: semantic kernel, search engine optimization, conversion.
The traditional definition of product promotion speaks of increasing the efficiency of sales, sales and demand [2–4]. However, the central place in the promotion process is given to the formation of messages that inform potential customers about the product, packaging, brand, advertising exhibitions, demonstrations, business and more. Accordingly, the effectiveness of sales will depend on the effectiveness of the message about the product to potential customers. In other words, the effectiveness of virtual promotion is determined by the effectiveness of the communication channel between the company and customers, where the message about the product is transmitted.

Thus, it is possible to define virtual promotion as an impersonal channel of communication with a potential client. Let's analyze the existing metrics for evaluating the effectiveness of such a channel.

**Related works.** Marketing theory defines sales efficiency as profitability of sales [2–4]. This indicator expresses the share of profit from each earned UAH as a percentage. Or it is the ratio of net income to the amount received from the sale of products, which is expressed as a percentage [2–4]. Then the impact of promotion is determined by the costs that the company incurs on the formation of the communication channel and the message itself. Profitability can also be affected by the number of customers involved through the message and the communication channel.

Thus, it is necessary to determine the metrics and criteria that describe the effectiveness of the channel and the message. On the one hand, we need criteria that indicate the reduction of costs for the formation of the communication and communication channel, and on the other hand, we need metrics that determine the number of customers attracted through the channel and communication.

Currently, the indicator that can describe the effectiveness of the channel and the message on the Internet is traffic [5–6]. It describes the number of unique users who read messages in the channel per unit time.

The channel is also characterized by the budget and the traffic it generates. In [7] the indicator of conditional efficiency of the channel and message on the basis of the classical theory of marketing and search engine optimization was introduced [6]:

\[
E = \frac{T}{B}
\]

where \(T\) – traffic, \(B\) – budget.

\[
P = \frac{B}{\bar{T}}
\]

\[
O = \frac{T}{\bar{B}}
\]

where \(O\) – the average payback of the channel, and \(P\) – the price of attracting one customer of goods through this channel.

Another indicator of the efficiency of the channel is the rate of return on investment [5]:

\[
ROI = \frac{Pr - Ex}{Ex}
\]

where \(Pr\) – profit, \(Ex\) – expenses on channel formation.

The next important indicator is conversion (5).

\[
K = \frac{Q_{\text{clients}}}{N}
\]

where \(Q_{\text{clients}}\) – the number of customers attracted by the promotion channel, and \(N\) is the total number of channel visitors [7].

It reflects the achievement of the main goal - to attract the required number of buyers of goods.

All the above indicators correspond to one of the seven categories, namely: traffic, bounce rate, conversion, the cost of attracting one buyer, the average check, return on investment, repeat visits. But these indicators are only metrics, unfortunately, the criterion of effectiveness among them is not identified. Modern theory of Internet promotion is based only on the metric approach.

Thus, there is an urgent problem of formulating a criterion for the effectiveness of virtual promotion. This criterion should describe the benefit of the message in the promotion channel and the benefit of the channel itself. And since virtual promotion is a two-tier system, the benefits must be determined at two levels coordinated in time.

**Problem statement.** First, you need to consider the mechanism of the object's functioning - virtual promotion. It includes two levels of marketing and technological
The first level describes the nodes of the virtual promotion map. Each node is a separate, either a WEB site, or a social network profile, or a video blog, or a telegram channel. Each node at the technological level has an IP address and domain name according to the OSI model. Also, the node is characterized by a set of software components that are installed in it. These software components support a specific set of information technologies. Therefore, the virtual promotion map consists of a description of profiles and domain names, as well as a set of technologies that function to increase the traffic of these nodes. The main metric of a node is traffic [8].

Thus, virtual promotion is described by a map on which a tree of Internet nodes is presented, in which it is planned to place the specified information about the product that needs to be sold. We will consider the corporate website (its domain name) as the root of the tree. The leaves of the tree will be domain names of profiles in social networks, web pages with product descriptions, domain names of telegram channels, web pages of marketplaces, links to video blogs and other links on the Internet. That is, the map at the first level is a lot of links. The second element of the map is the semantic core and its evolution [9]. The third slice of the virtual view map is the technology pool. This is a tree of technologies to stimulate attendance of the map node at a given point in time.

Then a criterion is required that reflects the usefulness or effectiveness of the virtual promotion map.

**Proposed approach.** Let’s expand our understanding of the virtual promotion map as follows. Let each node of the map be characterized by its current state. This is a metric according to the theory of situational management [10]. Let the current state describe the conversion of node (5) [11]. Our goal is to build such a virtual promotion map that provides maximum conversion.

Let’s assume that the map is generated and its nodes are known. Then, at each node, we observe the appearance of visitors (network users) at a given time interval. Some of them will place an order for the purchase of a given product. The number of visitors and the number of buyers are generally described by CTR, CTI, CTB, CPV and CPUU [12]. All of these metrics include the number of users and the number of buyers.

On the other hand, the number of map nodes will be limited for financial reasons. The fact is that it is possible to ensure a steady increase in the value of conversion in the modern Internet only at the expense of constant financial costs. This means that we will assume that there is a certain budget B, which is allocated for the implementation of the virtual promotion map [11–12].

Let’s designate as \( I_{tj} \) – income, which provides the \( j \)-th node for the time interval \( t \). Then \( u_{tj} \) – the number of buyers in the \( j \)-th node for the time interval \( t \). It is required to deliver the maximum to the criterion:

\[
\sum_{t \in T} \sum_{j} I_{tj} u_{tj} \rightarrow \max, \tag{6}
\]

In general, \( r_{tj} \) there is a function that depends on the number of nodes of the virtual promotion map (configuration), as well as on the attractiveness of the semantic core of the web content that is located in the node. It also depends on the price of placing this semantic core in the map node.

\[
u_{tj} = f_t\left(b_{tj}, M_{tj}\right) = U_1\left(b_{tj}\right) + U_2\left(M_{tj}\right), \tag{7}\]

where \( U_1 \) – cost function for the placement of the semantic core in the \( j \)-th node, \( U_2 \) – the function of assessing the attractiveness of the semantic core, which is located in the \( j \)-th node. The first function allows you to estimate the number of users who are interested in the semantic core due to its placement in this particular node of the map. The first function also shows the level of trust of Internet users to the information located in this site. This function is similar to the CTR metric. The second shows how many users are interested in the semantic core due to its attractiveness. This function is similar to the CTI metric. Then we have:

\[
\sum_{t \in T} \sum_{j} \frac{I_{tj}}{U_1\left(b_{tj}\right) + U_2\left(M_{tj}\right)} \rightarrow \max, \tag{8}\]

**Summary.** Criterion (8) is similar to the conversion metric, but it describes the income received on average from one customer. This situation is more suitable for Internet sales, since the number of sellers is unlimited and it is difficult for a potential buyer to decide. On the other hand, the seller, if a purchase is made, needs to get the maximum income from each client.

Formula (8) also takes into account two main ways of attracting a customer: the correct choice of a product message (semantic core) and the correct choice of a node for placing such a message.

**Future work.** The next step in the work is to clarify the restrictions that are imposed from the side of the map node itself. Since each node has its own purpose on the Internet and its metrics do not always coincide with the above. In addition, you need to set the type of functions \( U_1 \) and \( U_2 \).

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