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Toehold purchase problem: a comparative analysis of two strategies

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Abstract. Toehold purchase, defined here as purchase of one share in a firm by an investor preparing a tender offer to acquire majority of shares in it, reduces by one the number of shares this investor needs for majority. In the paper we construct mathematical models for the toehold and no-toehold strategies and compare the expected profits of the investor and the probabilities of takeover the firm in both strategies. It turns out that the expected profits of the investor in both strategies coincide. On the other hand, the probability of takeover the firm using the toehold strategy is considerably higher comparing to the no-toehold strategy. In the analysis of the models we apply the apparatus of incomplete Beta functions and some refined bounds for central binomial coefficients.

Key words: Toehold, tender offer, mixed strategy, takeover, beta function.

INTRODUCTION

This paper is about the toehold purchase problem. By a toehold we mean either the number or the fraction of shares owned by an outside investor considering or preparing a tender offer to acquire majority of shares and take over. By a tender offer we mean a proposal made by an investor to shareholders to tender their shares, with the hope to obtain majority of shares and take over. At the time of such an offer, an investor may already own, say, one-share-toehold. In our model the firm is going to be widely held and each shareholder will own one share. Outside investor will make a tender offer to all shareholders if s/he does not own a toehold and to all shareholders excluding self when s/he does own a toehold. For our purposes we consider the terms `tender offer' and `bid' as synonyms. Sometimes there is an upper bound on the number of possible stake (shareholding) that the outside investor may hold at the time s/he places a tender offer. Here surfaces one of the questions of toehold literature. If an investor is allowed to hold only a certain fraction of shares when s/he wishes to place a tender offer (but not more), would s/he always want to hold this maximum possible stake? If not, why not? Probably with this question in mind, a number of toehold theories look at optimal toeholds in a variety of settings and under variety of assumptions about market structure, ownership structure (how many shares each shareholder owns), information structure or the number of investors (one, two or more); see Grossman, Hart [17], Bagnoli, Lipman [3], [4], Singh [21], Ravid, Spiegel [19], Betton, Eckbo [6], Bris [8], Goldman, Qian [16], Ettinger [15], Betton, Eckbo, Thorburn [7], Chatterjee, John, Yan [11]. Similar problems were considered also in [1], [5], [9], [10], [12], [13].

Our approach is different in that we specifically assume that there is only one investor who is considering a tender offer and that if this investor does decide to purchase a toehold then s/he purchases only one share. If there is no toehold, then our assumptions follow the lines of Bagnoli and Lipman [3]. If investor purchases a toehold, then the circumstances of the tender offer are different. The difference does not only lie in the fact that the offer is made to one fewer shareholders. In this case investor's tender offer might (and generally would) take into account the effect of potential takeover on the worth of a toehold. Our setting is rudimentary in that there are no asymmetries of information, toehold is one share and key to toehold purchase is either yes or no answer. The two strategies (no-toehold and toehold) of the outside investor are described in Section 2. The main results of Section 2 are Theorems 1 and 2. In Theorem 1 we calculate the principal parameters of the non-toehold strategy: the price of a share X_0 suggested by the investor in the tender offer, the probability σ_0 that a shareholder will sell her/his share to the investor, the probability P_0 of takeover the firm, and the expected profit Π_0 of the investor. In Theorem 2 we calculate the respective parameters X_1, σ_1, P_1, Π_1 for the toehold strategy. Comparing the obtained formulas for these parameters we discovered that both strategies yield the same expected profit $\Pi_1 = \Pi_0$ and the same probability $\sigma_0 = \sigma_1$ that a shareholder will sell her/his share to the investor. On the other hand, the probability P_1 of takeover the firm using the toehold strategy is higher than the corresponding probability P_0 for the no-toehold strategy. This follows from Theorem 4 that yields some lower and upper bounds on the parameters X_i, P_i, Π_i, $i \in \{0,1\}$, of our models. The proof of Theorem 4 (presented in Appendix) is not trivial and uses the mathematical apparatus of incomplete beta functions and some non-trivial bounds on the central binomial coefficients. In Section 4 we make some mathematical conclusions that follow from the analysis of our models.

MODELS

We assume that a firm has $2n+1$ shareholders. Each shareholder owns one share. The worth of each share, if the firm continues to be run by incumbent management, is normalized to 0. There is also an outside investor **B** who is considering takeover bid. If investor takes over, the value of each share is increased to 1.

Now we consider two strategies of the investor **B** who is willing to take over the firm buying a majority of shares.

0. The first strategy will be referred to as the *no-toehold strategy* and its parameters will be labeled by the subscript 0. Following the no-toehold strategy, the investor **B** makes a tender offer to all $2n+1$ shareholders suggesting a price X for each share. Shareholders decide independently whether to accept or to reject the tender offer. They may use mixed strategies, i.e. accept the offer with certain probability σ. Simple majority of $n+1$ shares is necessary for takeover. Tender offer is unconditional in the sense that if less than n shareholder accept the tender offer, then **B** has to purchase shares from those shareholders who accepted the offer, even though in that case **B** becomes a minority shareholder, the worth of each share value remains at 0 and such purchase is ex post unprofitable for **B** as long as $X > 0$.

Suppose shareholders use symmetric mixed strategies, in which in response to tender offer X all of them accept the tender offer with probability $\sigma \in (0,1)$ and reject it with probability $(1-\sigma)$. For the pair (X,σ) to be equilibrial, each shareholder has to be indifferent between tendering and not tendering her share, or otherwise she would not use mixing strategy. If she tenders, she ends up with X, and if she does not, her unsold stake is worth more than 0 if among remaining $2n$ shareholders at least $n+1$ shareholders tender their shares. That happens with probability $\sum_{k=n+1}^{2n} C_{2n}^k \sigma^k (1-\sigma)^{2n-k}$. In that case the firm is taken over. A shareholder who did not tender her share remains a minority shareholder who "free-rides" on investor's improvement in firm value from 0 to 1. So the pair (X,σ) can be a suspect for a symmetric mixed strategy equilibrium only if:

$$X = \sum_{k=n+1}^{2n} C_{2n}^k \sigma^k (1-\sigma)^{2n-k}, \tag{1}$$

where: by $C_n^k = \frac{n!}{k!(n-k)!}$ we denote the binomial coefficients.

The investor's expected profit Π is calculated using three variables: the number of tendered shares, probability that exactly that many shares are tendered, and the share value:

$$\Pi = (0-X)\sum_{k=1}^{n} kC_{2n+1}^k \sigma^k (1-\sigma)^{2n+1-k} +$$
$$+(1-X)\sum_{k=n+1}^{2n+1} kC_{2n+1}^k \sigma^k (1-\sigma)^{2n+1-k}.$$

After a suitable rearrangement and substituting for X the sum (1) we obtain:

$$\Pi = \sum_{k=n+1}^{2n+1} C_{2n+1}^{k} k\, \sigma^k (1-\sigma)^{2n+1-k} -$$
$$-X \sum_{k=1}^{2n+1} C_{2n+1}^{k}\, k\, \sigma^k (1-\sigma)^{2n+1-k} =$$
$$= (2n+1) \sum_{k=n+1}^{2n+1} C_{2n}^{k-1} \sigma^k (1-\sigma)^{2n+1-k} -$$
$$-X(2n+1) \sum_{k=1}^{2n+1} C_{2n}^{k-1} \sigma^k (1-\sigma)^{2n+1-k} =$$
$$= (2n+1) \sum_{k=n}^{2n} C_{2n}^{k} \sigma^{k+1} (1-\sigma)^{2n-k} -$$
$$-X(2n+1)\, \sigma \sum_{k=0}^{2n} C_{2n}^{k} \sigma^{k} (1-\sigma)^{2n-k} =$$
$$= (2n+1) \sum_{k=n}^{2n} C_{2n}^{k} \sigma^{k+1} (1-\sigma)^{2n-k} -$$
$$-(2n+1)\, \sigma X (\sigma + (1-\sigma))^{2n} =$$
$$= (2n+1)\Big(\sum_{k=n}^{2n} C_{2n}^{k} \sigma^{k+1} (1-\sigma)^{2n-k} - \sigma X\Big) =$$
$$= (2n+1) \sum_{k=n}^{2n} C_{2n}^{k} \sigma^{k+1} (1-\sigma)^{2n-k} -$$
$$-(2n+1)\sigma \sum_{k=n+1}^{2n} C_{2n}^{k} \sigma^{k} (1-\sigma)^{2n-k} =$$
$$= (2n+1) \sum_{k=n}^{2n} C_{2n}^{k} \sigma^{k+1} (1-\sigma)^{2n-k} -$$
$$-(2n+1) \sum_{k=n+1}^{2n} C_{2n}^{k} \sigma^{k+1} (1-\sigma)^{2n-k} =$$
$$= (2n+1) C_{2n}^{n} \sigma^{n+1} (1-\sigma)^{n}.$$

The maximal value:

$$\Pi_0 = (2n+1) C_{2n}^{n} \sigma_0^{n+1} (1-\sigma_0)^{n} =$$
$$= C_{2n}^{n} \frac{(n+1)^{n+1} n^n}{(2n+1)^{2n}}$$

of the profit of the investor is attained for the probability:

$$\sigma_0 = \frac{n+1}{2n+1}$$

that corresponds to the price of a share:

$$X_0 = \sum_{k=n+1}^{2n} C_{2n}^{k} \sigma_0^{k} (1-\sigma_0)^{2n-k} =$$
$$= \sum_{k=n+1}^{2n} C_{2n}^{k} \frac{(n+1)^k n^{2n-k}}{(2n+1)^{2n}}.$$

In this situation the probability of takeover the firm by the investor equals:

$$P_0 = \sum_{k=n+1}^{2n+1} C_{2n+1}^{k} \sigma_0^{k} (1-\sigma_0)^{2n+1-k} =$$
$$= \sum_{k=n+1}^{2n+1} C_{2n+1}^{k} \frac{(n+1)^k n^{2n+1-k}}{(2n+1)^{2n+1}}.$$

The no-toehold strategy will be denoted by $\mathcal{S}_0$. We summarize our description of this strategy in the following:

Theorem 1. *If the investor uses the no-toehold strategy $\mathcal{S}_0$ to take over a firm with $(2n+1)$ shareholders, then he should offer the price:*

$X_0 = \sum_{k=n+1}^{2n} C_{2n}^{k} \frac{(n+1)^k n^{2n-k}}{(2n+1)^{2n}}$,

for a share in the tender offer and can expect to take over the firm with probability:

$$P_0 = \sum_{k=n+1}^{2n+1} C_{2n+1}^{k} \frac{(n+1)^k n^{2n+1-k}}{(2n+1)^{2n+1}}$$

and expect for the profit:

$$\Pi_0 = C_{2n}^{n} \frac{(n+1)^{n+1} n^n}{(2n+1)^{2n}}.$$

To maximize their expected profit the shareholders should sell their shares to the investor with probability:

$$\sigma_0 = \frac{n+1}{2n+1}.$$

1. Now we consider a more complex strategy $\mathcal{S}_1$ called the *toehold strategy*. Following this strategy the investor **B** first tries to purchase one-share toehold from a shareholder **A** who is aware that **B** is about to launch a tender offer to acquire majority of shares suggesting the price X_0 for a share. We assume that **A** is the only shareholder from whom **B** is able to purchase a toehold, and **A** agrees to sell her share to the investor **B** for the price X_0.

After buying the toehold from the shareholder **A**, the investor announces a post-toehold tender offer to the remaining $2n$ shareholders, offering a price X_1 for a share. If σ_1 is the probability that a shareholder will tender her share for that price, then the equilibrium will occur if:

$$X_1 = \sum_{k=n}^{2n-1} C_{2n-1}^{k} \sigma_1^{k} (1-\sigma_1)^{2n-1-k},$$

which is equal to the probability that among $2n-1$ shareholders at least n will sell their shares.

The probability of takeover the firm in the post toehold tender is equal to:

$$P_1 = \sum_{k=n}^{2n} C_{2n}^{k} \sigma_1^{k} (1-\sigma_1)^{2n-k},$$

and the expected profit Π_1 of the investor for the toehold strategy is equal to:

$$\Pi_1 = (-X_0 + 1 \cdot P_1) +$$
$$+(0 - X_1) \sum_{k=1}^{n-1} k C_{2n}^{k} \sigma_1^{k} (1-\sigma_1)^{2n-k} +$$
$$+(1 - X_1) \sum_{k=n}^{2n} k C_{2n}^{k} \sigma_1^{k} (1-\sigma_1)^{2n-k} =$$
$$= (-X_0 + P_1) -$$

$$-X_1 2n\sigma_1 \sum_{k=1}^{2n} C_{2n-1}^{k-1}\sigma_1^{k-1}(1-\sigma_1)^{2n-k}+$$
$$+2n\sigma_1 \sum_{k=n}^{2n} C_{2n-1}^{k-1}\sigma_1^{k-1}(1-\sigma_1)^{2n-k}=$$
$$=(-X_0+P_1)-$$
$$-2n\sigma_1 X_1 \sum_{k=0}^{2n-1} C_{2n-1}^{k}\sigma_1^{k}(1-\sigma_1)^{2n-k-1}+$$
$$+2n\sigma_1 \sum_{k=n-1}^{2n-1} C_{2n-1}^{k}\sigma_1^{k}(1-\sigma_1)^{2n-k-1}=$$
$$=(-X_0+P_1)-$$
$$-2n\sigma_1 X_1(\sigma_1+(1-\sigma_1))^{2n-1}+$$
$$+2n\sigma_1 \sum_{k=n-1}^{2n-1} C_{2n-1}^{k}\sigma_1^{k}(1-\sigma_1)^{2n-k-1}=$$
$$=(-X_0+P_1)-$$
$$-2n\sigma_1 \sum_{k=n}^{2n-1} C_{2n-1}^{k}\sigma_1^{k}(1-\sigma_1)^{2n-1-k}+$$
$$+2n\sigma_1 \sum_{k=n-1}^{2n-1} C_{2n-1}^{k}\sigma_1^{k}(1-\sigma_1)^{2n-k-1}=$$
$$=(-X_0+P_1)+2nC_{2n-1}^{n-1}\sigma_1^{n}(1-\sigma_1)^{n}=$$
$$=(-X_0+P_1)+nC_{2n}^{n}\sigma_1^{n}(1-\sigma_1)^{n}=$$
$$=-X_0+\sum_{k=n}^{2n} C_{2n}^{k}\sigma_1^{k}(1-\sigma_1)^{2n-k}+$$
$$+nC_{2n}^{n}\sigma_1^{n}(1-\sigma_1)^{n}.$$

To find the maximal value of the expected profit Π_1, consider the derivative:

$$\frac{d\Pi_1}{d\sigma_1}=\frac{d}{d\sigma_1}\sigma_1^{2n}+\frac{d}{d\sigma_1}\sum_{k=n}^{2n-1} C_{2n}^{k}\sigma_1^{k}(1-\sigma_1)^{2n-k}+$$
$$+\frac{d}{d\sigma_1}nC_{2n}^{n}\sigma_1^{n}(1-\sigma_1)^{n}=$$
$$=2n\sigma_1^{2n-1}+\sum_{k=n}^{2n-1} C_{2n}^{k}(k\sigma_1^{k-1}(1-\sigma_1)^{2n-k}-$$
$$-(2n-k)\sigma_1^{k}(1-\sigma_1)^{2n-k-1})+$$
$$+n^2C_{2n}^{n}\sigma_1^{n-1}(1-\sigma_1)^{n-1}(1-2\sigma_1)=$$
$$=\sum_{k=n}^{2n} 2nC_{2n-1}^{k-1}\sigma_1^{k-1}(1-\sigma_1)^{2n-k}-$$
$$-\sum_{k=n}^{2n-1} 2nC_{2n-1}^{k}\sigma_1^{k}(1-\sigma_1)^{2n-1-k}+$$
$$+n^2C_{2n}^{n}\sigma_1^{n-1}(1-\sigma_1)^{n-1}(1-2\sigma_1)=$$
$$=\sum_{k=n-1}^{2n-1} 2nC_{2n-1}^{k}\sigma_1^{k}(1-\sigma_1)^{2n-k-1}-$$
$$-\sum_{k=n}^{2n-1} 2nC_{2n-1}^{k}\sigma_1^{k}(1-\sigma_1)^{2n-1-k}+$$
$$+n^2C_{2n}^{n}\sigma_1^{n-1}(1-\sigma_1)^{n-1}(1-2\sigma_1)=$$
$$=2nC_{2n-1}^{n-1}\sigma_1^{n-1}(1-\sigma_1)^{n}+$$
$$+n^2C_{2n}^{n}\sigma_1^{n-1}(1-\sigma_1)^{n-1}(1-2\sigma_1)=$$
$$=nC_{2n}^{n}\sigma_1^{n-1}(1-\sigma_1)^{n-1}(1-\sigma_1)+$$
$$+n^2C_{2n}^{n}\sigma_1^{n-1}(1-\sigma_1)^{n-1}(1-2\sigma_1)=$$
$$=nC_{2n}^{n}\sigma_1^{n-1}(1-\sigma_1)^{n-1}(1-\sigma_1+n(1-2\sigma_1))$$

and observe that it is equal to zero at:

$$\sigma_1=\frac{n+1}{2n+1}=\sigma_0.$$

So, for $\sigma_1=\sigma_0=\frac{n+1}{2n+1}$ the expected profit Π_1 attains its maximal value:

$$\Pi_1=-X_0+\sum_{k=n}^{2n} C_{2n}^{k}\sigma_1^{k}(1-\sigma_1)^{2n-k}+$$
$$+nC_{2n}^{n}\sigma_1^{n}(1-\sigma_1)^{n}=$$
$$=-\sum_{k=n+1}^{2n} C_{2n}^{k}\sigma_0^{k}(1-\sigma_0)^{2n-k}+$$
$$+\sum_{k=n}^{2n} C_{2n}^{k}\sigma_1^{k}(1-\sigma_1)^{2n-k}+nC_{2n}^{n}\sigma_1^{n}(1-\sigma_1)^{n}=$$
$$=C_{2n}^{n}\sigma_1^{n}(1-\sigma_1)^{n}+nC_{2n}^{n}\sigma_1^{n}(1-\sigma_1)^{n}=$$
$$=(n+1)C_{2n}^{n}\frac{(n+1)^n n^n}{(2n+1)^{2n}}=\Pi_0.$$

The above discussion can be summed up in:

Theorem 2. *If the investor follows the toehold strategy S_1, then he buys a toehold from the shareholder **A** offering the price X_0 for her share and then in the post-toehold offer he offers the price:*

$$X_1=\sum_{k=n}^{2n-1} C_{2n-1}^{k}\frac{(n+1)^k n^{2n-1-k}}{(2n+1)^{2n-1}},$$

for a share, in which case the shareholders will sell their shares with probability:

$$\sigma_1=\frac{n+1}{2n+1}=\sigma_0,$$

the investor can takeover the firm with probability:

$$P_1=\sum_{k=n}^{2n} C_{2n}^{k}\frac{(n+1)^k n^{2n-k}}{(2n+1)^{2n}},$$

and can expect for the profit:

$$\Pi_1=C_{2n}^{n}\frac{(n+1)^{n+1}n^n}{(2n+1)^{2n}}=\Pi_0.$$

As we see from Theorems 1, 2, the no-toehold and toehold strategies yield the same profit $\Pi_0=\Pi_1$ and the same probability $\sigma_0=\sigma_1=\frac{n+1}{2n+1}$ of selling their shares by the shareholders in the tender offers. On the other hand, the prices for a share and the probabilities P_0 and P_1 of takeover the firm are different for these two strategies. The precise estimate of the differences P_1-P_0 and X_1-X_0 will be given in Corollary 1. Now, let us consider a simple example.

2.1. **A firm with 3 shareholders**. In case of 3-shareholders (which corresponds to $n=1$) the values of all parameters from Theorems 1 and 2 can be easily calculated:

• $\sigma_0=2/3$ is the probability that shareholders will sell their shares to the investor for the price;

- $X_0 = 4/9$ suggested by the investor in the no-toehold strategy,
- $P_0 = 20/27$ is the probability of taking over the firm in no-toehold strategy,
- $\Pi_0 = 8/9$ is the expected profit of the investor in the no-toehold strategy,
- $\sigma_1 = 2/3$ is the probability that a shareholder will tender her share to the investor for the price,
- $X_1 = 2/3$ suggested by the investor in the post-toehold tender offer,
- $P_1 = 8/9$ is the probability of taking over the firm in the toehold strategy,
- $\Pi_1 = 8/9$ is the expected profit of the investor in the toehold strategy.

Looking at these data, we see that both strategies yield the same profit but the toehold strategy is much better than the no-toehold strategy in the sense of probability of takeover the firm. It turns out that the same situation happens for all $n \in \mathbb{N}$, see Corollary 1 below. In this corollary we shall prove that the difference $P_1 - P_0$ of probabilities for the toehold and no-toehold strategies is strictly positive and has order $P_1 - P_0 \approx \frac{1}{2\sqrt{\pi n}}$.

EXPLICIT ANALYTIC EXPRESSIONS FOR PARAMETERS OF THE MODELS

For deriving the lower and upper bounds presented in Theorem 4 we shall transform the binomial sums appearing in the expressions of the parameters of our models and obtain precise analytic formulas for these parameters, after which we shall evaluate them using some bounds on central binomial coefficients and simple bounds giving by Taylor series. Our principal tool in finding explicit analytic expressions for the parameters of the model is use of incomplete beta functions.

By definition, the *beta function* is the function:

$$B(a,b) = \int_0^1 t^{a-1}(1-t)^{b-1}dt,$$

depending on two real positive parameters a, b. For fixed a, b the function:

$$B_x(a,b) = \int_0^x t^{a-1}(1-t)^{b-1}dt,$$

on the variable $x \in [0,1]$ is called the *incomplete beta function*. A remarkable property of the incomplete beta function is that for positive integer numbers a, b its value is proportional to a tail of the binomial series:

$$\begin{aligned}\sum_{k=a}^{a+b-1} C_{a+b-1}^k x^k (1-x)^{a+b-1-k} &= \\ = aC_{a+b-1}^a B_x(a,b) &= \qquad (2)\\ = aC_{a+b-1}^a \int_0^x t^{a-1}(1-t)^{b-1}dt.\end{aligned}$$

This equality plays a fundamental role in our subsequent arguments and will be referred to as the *beta-equality*. For the proof of the beta-equality and other information on (incomplete) beta functions, we refer the reader to the survey paper of Dutka [14].

Beta functions will be used in the proof of the following theorem that gives explicit analytic formulas for the parameters describing the no-toehold and toehold strategies.

Theorem 3. *The parameters of the models can be calculated by the following formulas:*

(1) The price: $X_0 = \sum_{k=n+1}^{2n} C_{2n}^k \frac{(n+1)^k n^{2n-k}}{(2n+1)^{2n}}$ suggested by the investor in the no-toehold strategy can be found by the formula:

$$X_0 = \frac{1}{2} - \frac{1}{2^{2n+1}} C_{2n}^n \left(1 - \frac{1}{(2n+1)^2}\right)^n + \\ + \frac{n}{2^{2n}} C_{2n}^n \int_0^{\frac{1}{2n+1}} (1-t^2)^{n-1}dt.$$

(2) The probability:

$$P_0 = \sum_{k=n+1}^{2n+1} C_{2n+1}^k \frac{(n+1)^k n^{2n+1-k}}{(2n+1)^{2n+1}},$$

of taking over the firm in the no-toehold strategy can be found as:

$$P_0 = \frac{1}{2} + \frac{(2n+1)}{2^{2n+1}} C_{2n}^n \int_0^{\frac{1}{2n+1}} (1-t^2)^n dt.$$

(3) The expected profits $\Pi_0 = \Pi_1 = C_{2n}^n \frac{n^n (n+1)^{n+1}}{(2n+1)^{2n}}$ of the investor can be found by:

$$\Pi_0 = \Pi_1 = \frac{(n+1)}{2^{2n}} C_{2n}^n \left(1 - \frac{1}{(2n+1)^2}\right)^n.$$

(4) The probability $P_1 = \sum_{k=n}^{2n} C_{2n}^k \frac{(n+1)^k n^{2n-k}}{(2n+1)^{2n}}$ of takeover the firm in the post-toehold strategy is equal to:

$$P_1 = \frac{1}{2} + \frac{1}{2^{2n+1}} C_{2n}^n \left(1 - \frac{1}{(2n+1)^2}\right)^n + \\ + \frac{n}{2^{2n}} C_{2n}^n \int_0^{\frac{1}{2n+1}} (1-t^2)^{n-1}dt.$$

(5) The price: $X_1 = \sum_{k=n}^{2n-1} C_{2n-1}^k \frac{(n+1)^k n^{2n-1-k}}{(2n+1)^{2n-1}}$ for a share offered by the investor in the post-toehold tender offer can be calculated as:

$$X_1 = \frac{1}{2} + \frac{n}{2^{2n}} C_{2n}^n \int_0^{\frac{1}{(2n+1)}} (1-t^2)^{n-1}dt.$$

Proof. 1. To deduce the formula for the price X_0, we use the beta-equality (2) with parameters $a = n+1$ and $b = n$. In this case we get the equality:

$$\begin{aligned}\sum_{k=n+1}^{2n} C_{2n}^k x^k (1-x)^{2n-k} &= \\ = (n+1)C_{2n}^{n+1} \int_0^x t^n (1-t)^{n-1}dt &= \qquad (3)\\ = nC_{2n}^n \int_0^x t^n(1-t)^{n-1}dt.\end{aligned}$$

For $x = \frac{1}{2}$ this equality turns into:

$$nC_{2n}^n \int_0^{\frac{1}{2}} t^n(1-t)^{n-1} = \sum_{k=n+1}^{2n} C_{2n}^k \frac{1}{2^{2n}} =$$

$$= \frac{1}{2}\left(-C_{2n}^{n}\frac{1}{2^{2n}} + \sum_{k=0}^{2n} C_{2n}^{k}\frac{1}{2^{2n}}\right) =$$
$$= \tfrac{1}{2}\left(1 - C_{2n}^{n}\tfrac{1}{2^{2n}}\right).$$

Because:

$$\sum_{k=0}^{2n} C_{2n}^{k}\frac{1}{2^{2n}} = \left(\frac{1}{2}+\frac{1}{2}\right)^{n} = 1.$$

Then (3) can be written as:

$$\sum_{k=n+1}^{2n} C_{2n}^{k}x^{k}(1-x)^{2n-k} =$$
$$= nC_{2n}^{n}\Big(\int_{0}^{\frac{1}{2}} t^{n}(1-t)^{n-1}dt +$$
$$+ \int_{1/2}^{x} t^{n}(1-t)^{n-1}dt\Big) =$$
$$= \frac{1}{2} - \frac{1}{2^{2n+1}}C_{2n}^{n} +$$
$$+ nC_{2n}^{n}\int_{0}^{x-\frac{1}{2}}\Big(\frac{1}{2}+u\Big)^{n}\Big(\frac{1}{2}-u\Big)^{n-1}du =$$
$$= \frac{1}{2} - \frac{1}{2^{2n+1}}C_{2n}^{n} +$$
$$+ nC_{2n}^{n}\int_{0}^{x-\frac{1}{2}}\Big(\frac{1}{2}+u\Big)\Big(\frac{1}{4}-u^{2}\Big)^{n-1}du =$$
$$= \frac{1}{2} - \frac{1}{2^{2n+1}}C_{2n}^{n} +$$
$$+ nC_{2n}^{n}\Big(\frac{1}{2}\int_{0}^{x-\frac{1}{2}}\Big(\frac{1}{4}-u^{2}\Big)^{n-1}du \ -$$
$$- \frac{1}{2}\int_{0}^{x-\frac{1}{2}}\Big(\frac{1}{4}-u^{2}\Big)^{n-1}d\Big(\frac{1}{4}-u^{2}\Big)\Big) =$$
$$= \frac{1}{2} - \frac{1}{2^{2n+1}}C_{2n}^{n} +$$
$$+ \frac{n}{2^{2n-1}}C_{2n}^{n}\int_{0}^{x-\frac{1}{2}}(1-(2u)^{2})^{n-1}du -$$
$$- \frac{1}{2}C_{2n}^{n}\Big((x-x^{2})^{n} - \frac{1}{4^{n}}\Big) =$$
$$= \frac{1}{2} + \frac{n}{2^{2n}}C_{2n}^{n}\int_{0}^{2x-1}(1-t^{2})^{n-1}dt -$$
$$- \frac{1}{2}C_{2n}^{n}x^{n}(1-x)^{n}.$$

For: $x = \sigma_0 = \frac{1}{2} + \frac{1}{2(2n+1)}$ the latter formula yields the required formula for the price X_0:

$$X_0 = \sum_{k=n+1}^{2n} C_{2n}^{k}\sigma_0^{k}(1-\sigma_0)^{2n-k} =$$
$$= \frac{1}{2} - \frac{1}{2^{2n+1}}C_{2n}^{n}\Big(1 - \frac{1}{(2n+1)^{2}}\Big)^{n} +$$
$$+ \frac{n}{2^{2n}}C_{2n}^{n}\int_{0}^{\frac{1}{2n+1}}(1-t^{2})^{n-1}dt.$$

2. By analogy we deduce the formula for the probability:

$$P_0 = \textstyle\sum_{k=n+1}^{2n+1} C_{2n+1}^{k}\frac{(n+1)^{k}n^{2n+1-k}}{(2n+1)^{2n+1}},$$

of takeover the firm in the no-toehold strategy. Writing down the beta-equality (2) for the parameters $a = n+1$ and $b = n+1$, we get:

$$\sum_{k=n+1}^{2n+1} C_{2n+1}^{k}x^{k}(1-x)^{2n+1-k} =$$
$$= (n+1)C_{2n+1}^{n+1}\textstyle\int_{0}^{x} t^{n}(1-t)^{n}dt. \qquad (5)$$

For $x = \frac{1}{2}$ this equality turns into:

$$(n+1)C_{2n+1}^{n+1}\int_{0}^{\frac{1}{2}} t^{n}(1-t)^{n} =$$
$$= \sum_{k=n+1}^{2n+1} C_{2n+1}^{k}\frac{1}{2^{2n+1}} = \frac{1}{2}.$$

After suitable rearrangements, for $x = \sigma_0 = \frac{n+1}{2n+1}$ the equality (5) transforms into the desired equality:

$$P_0 = \sum_{k=n+1}^{2n+1} C_{2n+1}^{k}x^{k}(1-x)^{2n+1-k} =$$
$$= (n+1)C_{2n+1}^{n+1}\Big(\int_{0}^{\frac{1}{2}} t^{n}(1-t)^{n}dt +$$
$$+ \int_{\frac{1}{2}}^{x} t^{n}(1-t)^{n}dt\Big) = \frac{1}{2} +$$
$$+ (n+1)C_{2n+1}^{n+1}\int_{0}^{x-1/2}\Big(\frac{1}{2}+u\Big)^{n}\Big(\frac{1}{2}-u\Big)^{n}du =$$
$$= \frac{1}{2} + \frac{(2n+1)}{2^{2n+1}}C_{2n}^{n}\int_{0}^{2x-1}(1-t^{2})^{n}dt =$$
$$= \frac{1}{2} + \frac{(2n+1)}{2^{2n+1}}C_{2n}^{n}\int_{0}^{\frac{1}{2n+1}}(1-t^{2})^{n}dt.$$

3. The formula for the profits $\Pi_0 = \Pi_1 = C_{2n}^{n}\frac{n^{n}(n+1)^{n+1}}{(2n+1)^{2n}}$ follows from the observation that:

$$\frac{n^{2}+n}{(2n+1)^{2}} = \frac{1}{4}\Big(1 - \frac{1}{(2n+1)^{2}}\Big).$$

4. Taking into account that $\sigma_1 = \sigma_0 = \frac{n+1}{2n+1}$ and looking at the formula for X_0 proved in Theorem 3(1), we see that:

$$P_1 = \sum_{k=n}^{2n} C_{2n}^{k}\sigma_1^{k}(1-\sigma_1)^{2n-k} =$$
$$= C_{2n}^{n}\sigma_1^{n}(1-\sigma_1)^{n} + X_0 =$$
$$= \frac{1}{2^{2n}}C_{2n}^{n}\Big(1 - \frac{1}{(2n+1)^{2}}\Big)^{n} + \frac{1}{2} -$$
$$- \frac{1}{2^{2n+1}}C_{2n}^{n}\Big(1 - \frac{1}{(2n+1)^{2}}\Big)^{n} +$$
$$+ \frac{n}{2^{2n}}C_{2n}^{n}\int_{0}^{\frac{1}{2n+1}}(1-t^{2})^{n-1}dt =$$
$$= \frac{1}{2} + \frac{1}{2^{2n+1}}C_{2n}^{n}\Big(1 - \frac{1}{(2n+1)^{2}}\Big)^{n} +$$
$$+ \frac{n}{2^{2n}}C_{2n}^{n}\int_{0}^{\frac{1}{2n+1}}(1-t^{2})^{n-1}dt.$$

5. The beta-equation (2) written for $a = n$ and $b = n$ yields:

$$X_1 = \sum_{k=n}^{2n-1} C_{2n-1}^{k} \sigma_1^k (1-\sigma_1)^{2n-1-k} =$$

$$= nC_{2n-1}^{n} \int_0^{\sigma_1} t^{n-1}(1-t)^{n-1} dt =$$

$$= nC_{2n-1}^{n} \int_0^{\frac{1}{2}} t^{n-1}(1-t)^{n-1} dt +$$

$$+nC_{2n-1}^{n} \int_{\frac{1}{2}}^{\sigma_1 - \frac{1}{2}} t^{n-1}(1-t)^{n-1} dt =$$

$$= \sum_{k=n}^{2n-1} C_{2n-1}^{k} \frac{1}{2^{2n-1}} +$$

$$+ nC_{2n-1}^{n} \int_0^{\frac{1}{2(2n+1)}} (\frac{1}{2}+u)^{n-1}(\frac{1}{2}-u)^{n-1} du =$$

$$= \frac{1}{2} \sum_{k=0}^{2n-1} C_{2n-1}^{k} \frac{1}{2^{2n-1}} +$$

$$+ \frac{n}{2} C_{2n}^{n} \int_0^{\frac{1}{2(2n+1)}} (\frac{1}{4}-u^2)^{n-1} du =$$

$$= \frac{1}{2} + \frac{n}{2^{2n-1}} C_{2n}^{n} \int_0^{\frac{1}{2(2n+1)}} (1-4u^2)^{n-1} du =$$

$$= \frac{1}{2} + \frac{n}{2^{2n}} C_{2n}^{n} \int_0^{\frac{1}{(2n+1)}} (1-t^2)^{n-1} dt.$$

Using the formulas from Theorem 3, one can derive the following lower and upper bounds for the parameters of our models, see [2] for details.

Theorem 4. *The parameters of the models lie in the following intervals:*

$$\frac{1}{\sqrt{\pi n}}\left(-\frac{1}{6n}-\frac{1}{64n^2}\right) < X_0 - \frac{1}{2} < \frac{1}{\sqrt{\pi n}}\left(-\frac{1}{6n}+\frac{5}{24n^2}\right)$$

$$\frac{1}{\sqrt{\pi n}}\left(\frac{1}{2}-\frac{5}{16n}+\frac{1}{48n^2}\right) < X_1 - \frac{1}{2} < \frac{1}{\sqrt{\pi n}}\left(\frac{1}{2}-\frac{5}{16n}+\frac{1}{12n^2}\right)$$

$$\frac{1}{\sqrt{\pi n}}\left(\frac{1}{2}-\frac{5}{48n}+\frac{1}{16n^2}\right) < P_0 - \frac{1}{2} < \frac{1}{\sqrt{\pi n}}\left(\frac{1}{2}-\frac{5}{48n}+\frac{6}{16n^2}\right)$$

$$\frac{1}{\sqrt{\pi n}}\left(1-\frac{13}{24n}+\frac{3}{16n^2}\right) < P_1 - \frac{1}{2} < \frac{1}{\sqrt{\pi n}}(1-\frac{13}{24n}+\frac{4}{16n^2})$$

$$\frac{1}{\sqrt{\pi n}}\left(n+\frac{5}{8}-\frac{1}{4n}\right) < \Pi_i < \frac{1}{\sqrt{\pi n}}\left(n+\frac{5}{8}-\frac{1}{24n}+\frac{1}{3n^2}\right).$$

Looking at the bounds for the probabilities P_0, P_1 and the prices X_0, X_1 we can notice that $P_0 < P_1$ and $X_0 < X_1$. An estimation of the differences $P_1 - P_0$ and $X_1 - X_0$ is given in the following corollary of Theorem 4.

Corollary 1.

$$\frac{1}{\sqrt{\pi n}} \cdot \left(\frac{1}{2}-\frac{31}{48n}-\frac{3}{16n^2}\right) < P_1 - P_0 <$$
$$< \frac{1}{\sqrt{\pi n}} \cdot \left(\frac{1}{2}-\frac{31}{48n}+\frac{3}{16n^2}\right)$$

and

$$\frac{1}{\sqrt{\pi n}} \cdot \left(\frac{1}{2}-\frac{7}{48n}-\frac{3}{16n^2}\right) < X_1 - X_0 <$$
$$< \frac{1}{\sqrt{\pi n}} \cdot \left(\frac{1}{2}-\frac{7}{48n}+\frac{1}{24n^2}\right).$$

Remark 5 The difference $X_1 - X_0 \approx \frac{1}{2\sqrt{\pi n}}$ can be interpreted as the price for the information that the investor possesses a toehold.

The lower and upper bounds of Theorem 4 can be derived using the following lower and upper bounds for functions appearing in the formulas in Theorem 3.

Lemma 1. *For every $n \in \mathbb{N}$ and a real number $x > 0$ the following inequalities hold:*

(1) $1 - x + \frac{1}{2}x^2 - \frac{1}{6}x^3 < e^{-x} < -x + \frac{1}{2}x^2$,

(2) $1 - x < \frac{1}{1+x} < 1 - x + x^2$,

(3) $1 - nx < (1-x)^n < 1 - nx + \frac{n(n-1)}{2}x^2$.

Lemma 2. *The following lower and upper bounds hold for every $n \in \mathbb{N}$:*

(1) $\frac{1}{2n} - \frac{1}{4n^2} + \frac{1}{12n^3} < \frac{1}{2n+1} < \frac{1}{2n} - \frac{1}{4n^2} + \frac{1}{8n^3}$,

(2) $1 - \frac{1}{4n} + \frac{1}{8n^2} < (1 - \frac{1}{(2n+1)^2})^n <$
$< 1 - \frac{1}{4n} + \frac{9}{32n^2}$,

(3) $\frac{1}{2n} - \frac{7}{24n^2} + \frac{11}{48n^3} < \int_0^{\frac{1}{2n+1}} (1-t^2)^n dt <$ $< \frac{1}{2n} - \frac{7}{24n^2} + \frac{18}{48n^3}$,

(4) $\frac{1}{2n} - \frac{7}{24n^2} + \frac{5}{48n^3} < \int_0^{\frac{1}{2n+1}} (1-t^2)^{n-1} dt <$ $< \frac{1}{2n} - \frac{7}{24n^2} + \frac{12}{48n^3}$.

Lemma 3. *The lower and upper bounds:*

$\frac{4^n}{\sqrt{\pi n}}\left(1 - \frac{1}{8n} + \frac{1}{64n^2}\right) < C_{2n}^n < \frac{4^n}{\sqrt{\pi n}}\left(1 - \frac{1}{8n} + \frac{1}{48n^2}\right)$

hold for every $n \in \mathbb{N}$.

These bounds on the central binomial coefficients can be derived from the following refined version of the Stirling formula for factorials, proved in [18] and [20].

Lemma 4. *For every $n \geq 1$*

$$n! = \sqrt{2\pi n}(\frac{n}{e})^n e^{r_n}$$

where:

$$\frac{1}{12n} - \frac{1}{2^6 n^3} < r_n < \frac{1}{12n}.$$

CONCLUSIONS

1. The analysis of our models witnesses that both strategies (toehold and no toehold) of taking over the firm with $2n + 1$ shareholders yield the same profit $\Pi_0 = \Pi_1 \approx \sqrt{\frac{n}{\pi}}$ but the probability $P_1 \approx \frac{1}{2} + + \frac{1}{\sqrt{\pi n}}$ of taking over for the toehold strategy is higher than the corresponding probability $P_0 \approx \frac{1}{2} + + \frac{1}{2\sqrt{\pi n}}$ for the no-toehold strategy.
2. The equilibrium price $X_1 \approx \frac{1}{2} + \frac{1}{2\sqrt{\pi n}}$ for a share offered by the investor in the tender offer announced after buying a toehold is higher that the corresponding price $X_0 \approx \frac{1}{2} - \frac{1}{6n\sqrt{\pi n}}$ in the tender offer without toehold.

3. The difference $X_1 - X_0 \approx \frac{1}{2\sqrt{\pi n}}$ can be interpreted as the price for the information that the investor possesses a toehold.

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Traffic simulation in a telecommunication system based on queuing systems with different input flows

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Abstract. The simulation method of queuing system for traffic simulation in telecommunication system is studied. Different types of input flow are considered: uniform distributed, Poisson distributed and self-similar flow with different Herst indexes.
Key words: Herst index, self-similar flow, queuing system, Poisson flow.

INTRODUCTION

When simulating a telecommunication system analytical methods [9] of queuing systems theory (QS), time-probability graphs, differential and difference equations and colored Petri nets are widely used [1, 2, 11, 18, 19, 21, 22]. These methods enable the analytical solutions of rather complex systems [17], but provided that the input flow of QS is described by the probability model with uniform or Poisson distributions [16].

At the same time numerous scientific researches devoted to the description of experimentally found timing diagrams of the traffic intensity, particularly in the Internet, go that the input process is more complicated. Thus, for traffic simulation in telecommunication system it is better to choose the simulation method of QS, which as opposed to analytical methods of QS simulation (suitable for flows with uniform distribution) has an important feature that is the ability to select any probability model of the input flow [8].

MATERIALS AND METHODS

Having analyzed the scientific researches, we concluded that it is necessary to simulate traffic of a telecommunication system with different types of input flows [8, 9].

Topology of a telecommunication network which uses multipath routing of the Internet traffic and for which the simulation was conducted is shown in **Fig. 1**.

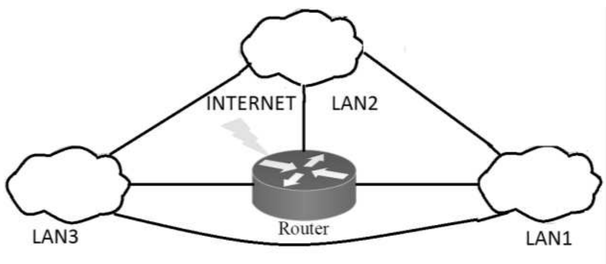

Fig. 1. Mesh network topology with multipath routing

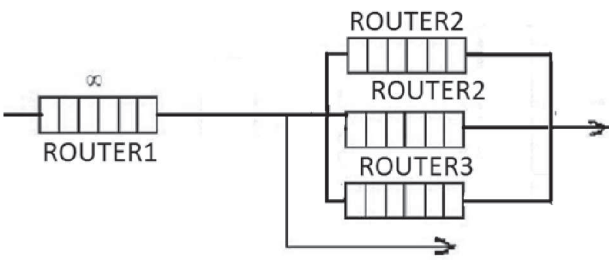

Fig. 2. Multichannel network model with routing and buffering of requests

Traffic simulation was conducted for flows with uniform and Poisson distributions and also for self-similar flows with different self-similarity coefficients.

Poisson flow (**Fig. 3**) is a random process, characterized by the probability of the number of requests [16]:

$$p(N,\tau)=\frac{(\lambda\cdot\tau)^{N}\cdot e^{-\lambda\cdot\tau}}{N!}\,. \tag{1}$$

where: N – the number of requests, τ – the time of incoming requests, $p(N,\tau)$ – the probability of N requests incoming over time τ, λ – the intensity of flow.

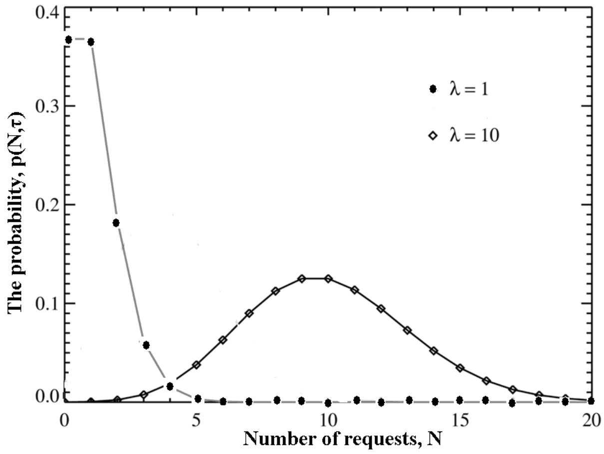

Fig. 3. Poisson distribution for different values of intensity

For self-similar flows generation the model of fractal Brownian signal (FBS) was used that is described by the following formula [10, 11, 20]:

$$X^{(H)}(i)\approx\frac{1}{\Gamma\left(H+\frac{1}{2}\right)}\cdot\left\{\sum_{j=0}^{[n\cdot(i+1)-1]}\left[(i+1)-\frac{j}{n}\right]^{H-1/2}\cdot\right.$$

$$\left.\cdot\xi(j)-\sum_{j=0}^{i\cdot n-1}\left(i-\frac{j}{n}\right)^{H-1/2}\cdot\xi(j)\right\}, \tag{2}$$

where: H – the Hurst parameter, n – the time scaling parameter of the self-similar signal (minimal value of this parameter is equal to 1), $X^{(H)}(i)$ – the value of FBS sample with number "i", $\xi(i)$ – the number from the set with normal distribution which has zero mathematical expectation and dispersion equals to one.

Generation of real numbers $\xi(i)$ with normal distribution with through Box-Miller algorithm is based on using of two different linear congruent generators:

$$x_{1,n+1}=(a_1\cdot x_{1,n}+d_1)\bmod N\,, \tag{3}$$

$$x_{2,n+1}=(a_2\cdot x_{2,n}+d_2)\bmod N\,, \tag{4}$$

where: n – index of current iteration, $x_{1,n}$, $x_{2,n}$, $x_{1,n+1}$, $x_{2,n+1}$ – numbers obtained by the first and second congruent generators in the current and previous iterations respectively, a_1,d_1,N and a_2,d_2,N – parameters of the first and second congruent generators respectively, which should be mutually prime and rather big numbers.

The sequences of real numbers generated by Eq. (3) and Eq. (4) are transformed according to the following transforming [23]:

$$\nu=x_{1,n}^2+x_{2,n}^2\,, \tag{5}$$

$$y_{1,n}=x_{1,n}\cdot\sqrt{\frac{-2\cdot\log(\nu)}{\nu}}\,, \tag{6}$$

$$y_{2,n}=x_{2,n}\cdot\sqrt{\frac{-2\cdot\log(\nu)}{\nu}}\,, \tag{7}$$

where: $x_{1,n}$, $x_{2,n}$ – uniformly distributed pseudorandom numbers, $y_{1,n}$, $y_{2,n}$ – pseudorandom numbers with Gaussian distribution.

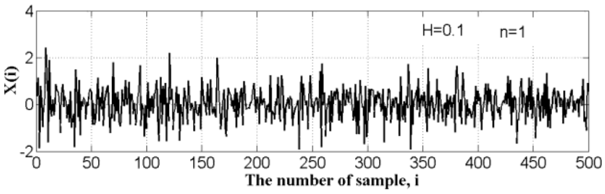

Fig. 4a. Timing diagrams of FBS with different Hesrt indexies and the time scaling factors: (H=0,1; n=1), (H=0,1; n=50), (H=0,9; n=1), (H=0,9; n=50) – a), b), c) and d) respectively

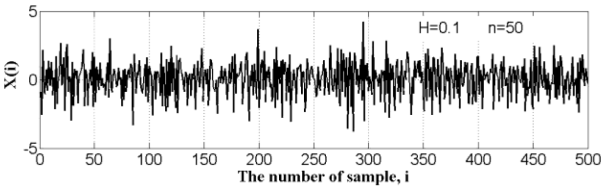

Fig. 4b. Timing diagrams of FBS with different Hesrt indexies and the time scaling factors: (H=0,1; n=1), (H=0,1; n=50), (H=0,9; n=1), (H=0,9; n=50) – a), b), c) and d) respectively

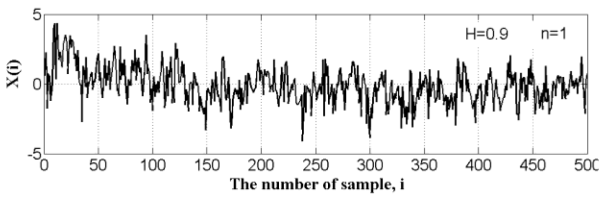

Fig. 4c. Timing diagrams of FBS with different Hesrt indexies and the time scaling factors: (H=0,1; n=1), (H=0,1; n=50), (H=0,9; n=1), (H=0,9; n=50) – a), b), c) and d) respectively

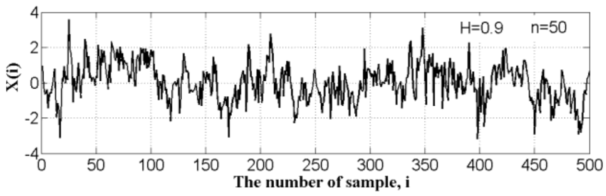

Fig. 4d. Timing diagrams of FBS with different Hesrt indexies and the time scaling factors: (H=0,1; n=1), (H=0,1; n=50), (H=0,9; n=1), (H=0,9; n=50) – a), b), c) and d) respectively

If the sum of the squares of numbers $x_{1,n}$ and $x_{2,n}$ in Eq. (5) is greater than one, the calculation by Eq. (6) and Eq. (7) are not performed, and thus starts the next iteration.

Time diagram of FBS generated according to Eq. (2) indicates their chaotic behaviors (Fig. 4) [3, 4, 13, 14, 15].

The essence of the proposed traffic simulation method with self-similar distribution is the following:

– from generated values in accordance with Eq. (2) we subtract the minimal value of the same numerical series that makes it possible to obtain the graph with nonnegative values;

– we multiply terms of created numerical series by the same coefficient, the value of which we select provided that obtained numerical series had equal intensity values;

– we round obtained values to the integer number, as they represent the number of requests which come to the network over one time interval that is similar for all types of traffic;

– thus, we obtained the specified flow intensity, which is simulated by integer numbers during each time iteration;

– time spaces between transmission of requests to systems over one time iteration are estimated inversely proportional to the number of req. over one iteration.

RESULTS AND DISCUSSION

The first result obtained in our research was calculation of the requests mean service time in the network depending on the network load. The calculation was done for different flow intensities. We determined that for intensity value $0{,}9 \cdot 10^5$ requests/hour balancing of the process of req. transmission is observed: so mean time does not depend on the number of req.

We also found out that the traffic with different types of distribution would be transmitted differently through the network (**Fig. 5**).

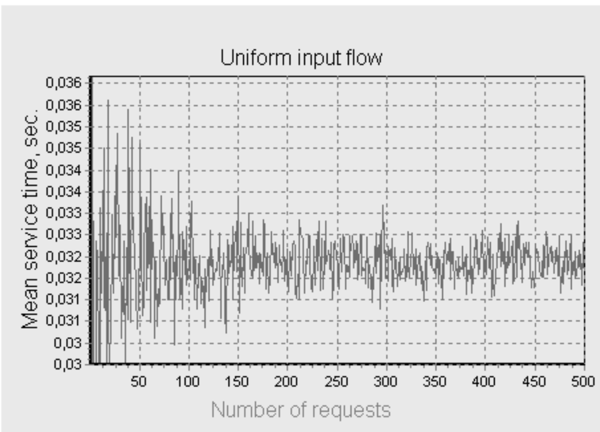

Fig. 5a. The dependence of traffic transmission time on the input flow intensity that is equal to $0{,}9 \cdot 10^5$ requests/hour with different distributions – uniform, Poisson and self-similar when H=0,3: a), b) and c) respectively

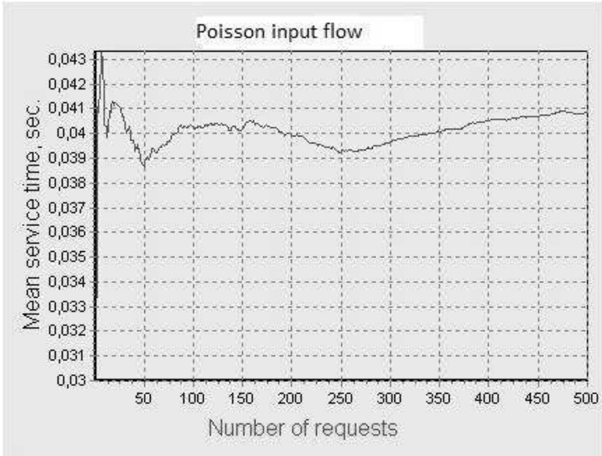

Fig. 5b. The dependence of traffic transmission time on the input flow intensity that is equal to $0{,}9 \cdot 10^5$ requests/hour with different distributions – uniform, Poisson and self-similar when H=0,3: a), b) and c) respectively

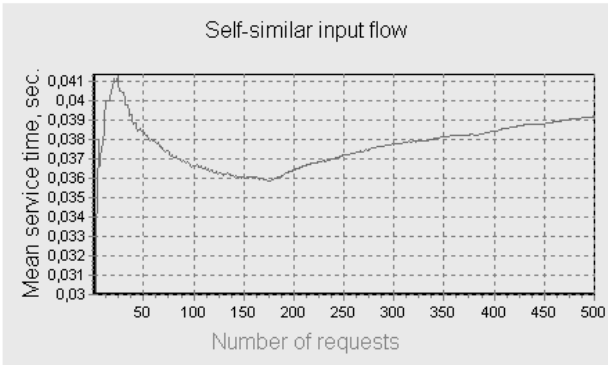

Fig. 5c. The dependence of traffic transmission time on the input flow intensity that is equal to $0{,}9 \cdot 10^5$ requests/hour with different distributions – uniform, Poisson and self-similar when H=0,3: a), b) and c) respectively

Herewith, maximum value of the requests mean service time is for Poisson traffic (**Fig. 5**). The calculated average value of the req. mean service time in the network for flows with different distribution is shown in **Table 1**.

Table 1. Requests mean service time in the network.

Type of traffic	Req. mean service time in the network, sec.
Uniform	0,033
Poisson	0,041
Self-similar	0,039

We also determined some relation of self-similar traffic transmission for different Hurst exponents (**Fig. 6**). From the obtained results of the research of the dependence of self-similar traffic transmission time for different Hurst exponents it follows that minimum average value of self-similar traffic transmission occurs provided that the number of requests is equal to 270, 120…270, and 270 for H=0.1; 0,5 and 0,9 respectively.

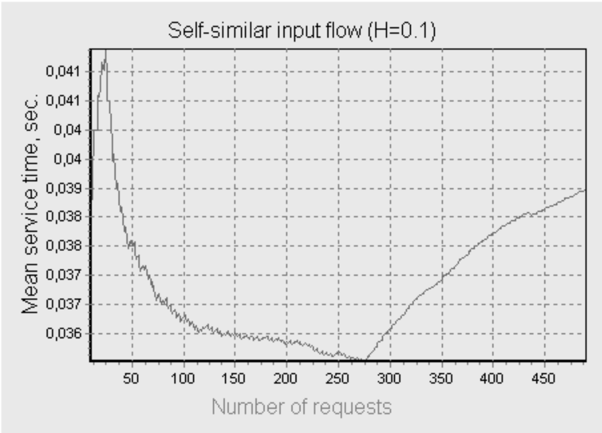

Fig. 6a. The dependence of characteristics of the output flow when flow intensity equals to $0{,}9 \cdot 10^5$ requests/hour for self-similar input traffic with Hurst exponents 0,1; 0,5, 0,9: a) b) and c) respectively

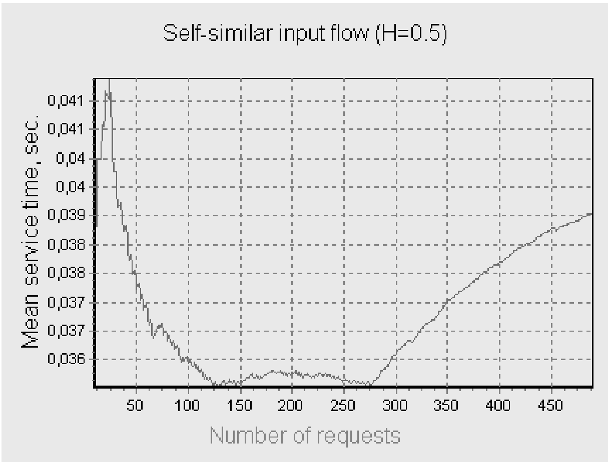

Fig. 6b. The dependence of characteristics of the output flow when flow intensity equals to $0{,}9 \cdot 10^5$ requests/hour for self-similar input traffic with Hurst exponents 0,1; 0,5, 0,9: a) b) and c) respectively

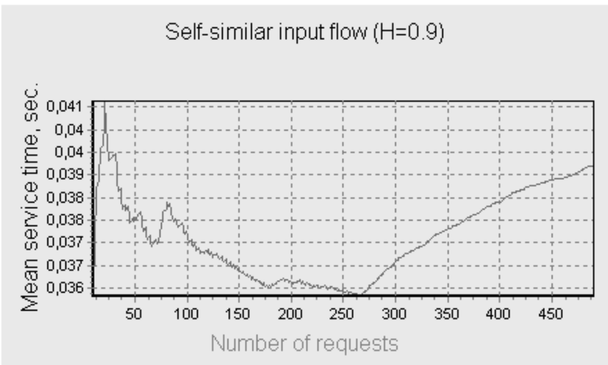

Fig. 6c. The dependence of characteristics of the output flow when flow intensity equals to $0{,}9 \cdot 10^5$ requests/hour for self-similar input traffic with Hurst exponents 0,1; 0,5, 0,9: a) b) and c) respectively

If we decrease the input traffic intensity to $1{,}8 \cdot 10^3$ the characteristics of transmission through the network of flows with Poisson and self-similar distributions are identical and they differs from the characteristic for uniform distribution. We can make such conclusion on the basis of data shown in **Fig. 7**.

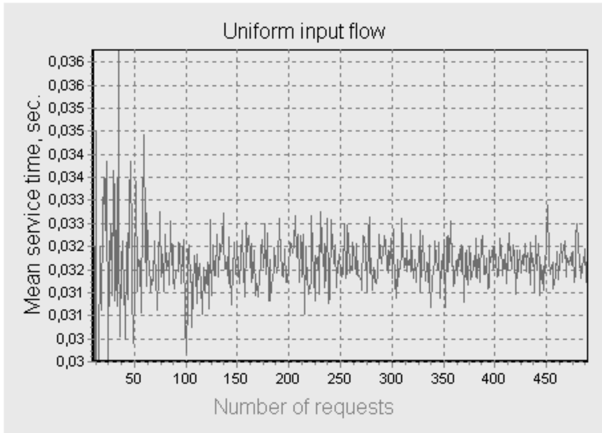

Fig. 7a. Requests mean service time in the network for uniform, Poisson and self-similar traffics when the intensity of the input flow is equal to $1{,}8 \cdot 10^3$ req./hour: a) and b) respectively

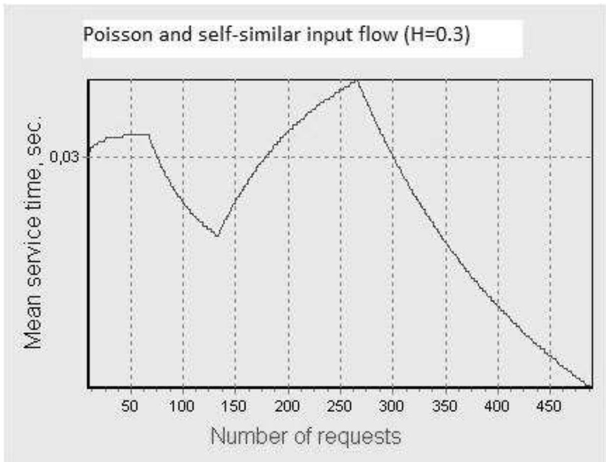

Fig. 7b. Requests mean service time in the network for uniform, Poisson and self-similar traffics when the intensity of the input flow is equal to $1{,}8 \cdot 10^3$ req./hour: a) and b) respectively

CONCLUSIONS

1. On the basis of the conducted simulation we determined that there are some divergences between traffics simulated by different flows. In particular, the results obtained for the flow with uniform distribution differ from the results obtained when simulating the traffic by the self-similar and Poisson flows. Herewith, flows with self-similar and Poisson distributions are identical when the intensity is equal to $1{,}8 \cdot 10^3$ req./hour.

2. If the intensity is increased to $0{,}9 \cdot 10^5$ req./hour the difference in calculating of such average transmission time of one req. for flows with self-similar and uniform distributions is equal to $8 \cdot 10^{-3}$ seconds,

and for flows with self-similar and Poisson distributions the difference is equal to $2{,}0 \cdot 10^{-3}$ seconds. In our opinion this is the substantial divergence for the Poisson and self-similar flows.

3. We also determined that there is no the substantial dependence of the mean service time on the self-similarity coefficient (Hurst exponent) of the flow, but processes of transmission self-similar flows with different Hurst exponent are differ from each other considerably.

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Life cycle business modelling

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Abstract. The article deals with the task of life cycle business modelling. In the article the strategic orientation of enterprises is examined from the point of estimation view of its possibility to cost creation. A problem consists in development of management mechanism of the difficult mutually concerted multistage complex of tasks in industries of cost creation for a consumer and cost of enterprise, as in turn laid out on the row of the recommended project measures. This task was set forth in terms of the dynamic programming. The brought analysis over of this task allowed forming the comfortable and transparent algorithm of her decision, and her erection in an eventual result to the task of the linear programming.

Key words: enterprise developments strategy, consumer value, enterprise value, dynamic programming, algorithm, task of the linear programming.

INTRODUCTION

Strategic orientation of enterprises in recent years is taken into consideration from the point of view of the enterprise ability to create value. Such business theorists and practitioners as Osterwalder A., Yves P. (2002), Jansen W.,Steenbakkers W., Jäegers H.(2007), Chesboro G. (2008), Debalak D. (2009), Dzhonson M., Kristensen K., Kagermann Kh. (2009), Casadesus-Masanell R., Ricart J.E. (2010), Jabloński M (2011) [1-13] are looking for specific factors and models that distinguish those companies, which consistently achieve success and those which managed to get only a short-term competitive advantage. To a large extent it depends on the well designed and effectively implemented business model of the enterprise, which should be selected individually for each enterprise.

According to the dominant and widespread today concept of system approach, functions of planning, organizing, regulation, motivation and control are the basic, which are combined by the processes of communication, decision-making and management. The processes of setting goals for the future, tasks projects defining and decision-making for their achievement in the conditions of uncertainty – belong to the initial stage of any entity activity, which depending on the level of detail can be seen as a series of interrelated activities aimed at making the predictions, plans and programs. Its main purpose is to analyze and identify the main trends and tendencies of enterprise developments, predicting of conditions changing and factors of strategic development, creation of scientific base for the development of long-term economic policies and making efficient solutions for its implementation.

If to treat the business model as a management concept to create value for customers and society as well as enhancement of enterprise value based on existing key competencies and chosen strategic set in order to achieve the goals, than in order to ensure sustainable (balanced) enterprise development – there should be the balance between two strategically important concepts (lines) of the enterprise development [14]:

- creating value for customers,
- creation of enterprise value.

These concepts should be cleverly intertwined, parallel initiated and implemented in real development projects. In particular, in order to create value for consumers, a variety of the following administrative tasks should be coordinated:

• quality of goods / services,

• the price of goods / services,

• customers service.

In turn, for the company value creation there is needs to coordinate the range of design tasks, namely [15]:

• orientation for maximum efficiency,

• orientation for maximum effectiveness,

• creation a positive image and a socially responsible company.

Thus, the set management tasks can be reduced to solving of two "portfolios" of the company business model. The purpose of each "portfolio" is to achieve internal and external competitive advantages, which can be realized in the presence of different directions of activity organization. Both portfolios, in turn, can be united in certain "strategic portfolio" of the business model. With such a "strategic portfolio" it is possible to identify the investment priorities and the basis for allocation of resources, reaching more efficiency of their use.

Clearly, these approaches should be mutually coordinated and alternatively initiated according to the possibility and feasibility of their implementation. A separate problem which arises before the developers of business model "portfolio" of the company – it is synergy achievement between the various activities.

Thus, a reasonable "strategic set" of the enterprise can be formed by using the concept of management problems consistent solution as a tool to ensure the success of the enterprise for the sustainable development and profits maximizing. Only in case of their development and implementation the company can fulfils its eproductive process, closing the cycle of money circulation in case of a successful sale of goods in the markets.

MATERIALS AND METHODS

In terms of "portfolio" analysis, strategic planning is seen as a building block of enterprise "portfolio", enabling interchange ability of tasks to performing, depending on the characteristics and the chosen strategies. Such modular approach allows to increase the application flexibility of the developed strategies. Therefore, the following tasks should be considered throughout the life cycle (further LC), namely phases, which are passed by enterprise from development, implementation and initial growth, maturity and decline.

According to the Chief Information Officer Council (2001) Enterprise Life Cycle (ELC) in enterprise architecture is the dynamic, iterative process of changing the enterprise over time by incorporating new business processes, new technology, and new capabilities, as well as maintenance, disposition and disposal of existing elements of the enterprise [16]., the life cycle consists of the following five distinct stages (Figure 1).

- *Pre-start-up* – during this period, the company develops and implements a new idea. In this case, sales equal zero, and the volume of investment increases with approaching the final stage.
- *Start-up (Implementation)* – sales are growing slowly.
- *Growth* – sales quantity, consequently, the profit level.
- *Maturity* – sales growth slows down.

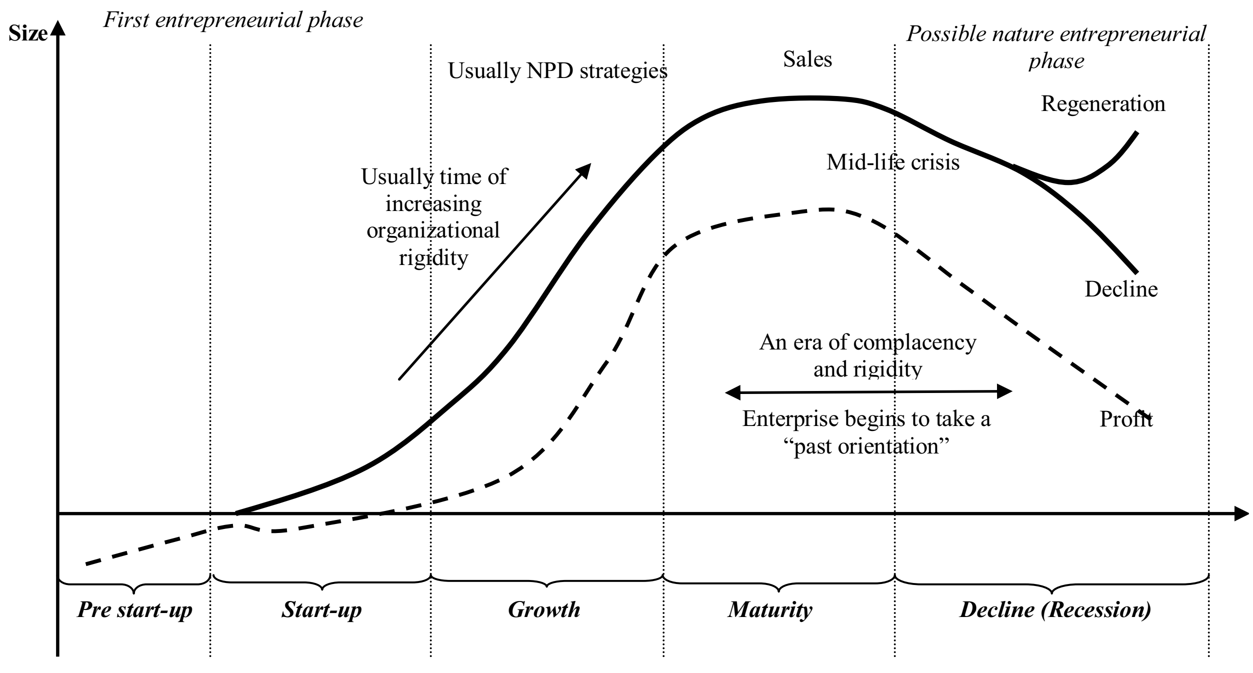

Fig. 1. The Enterprise Life cycle

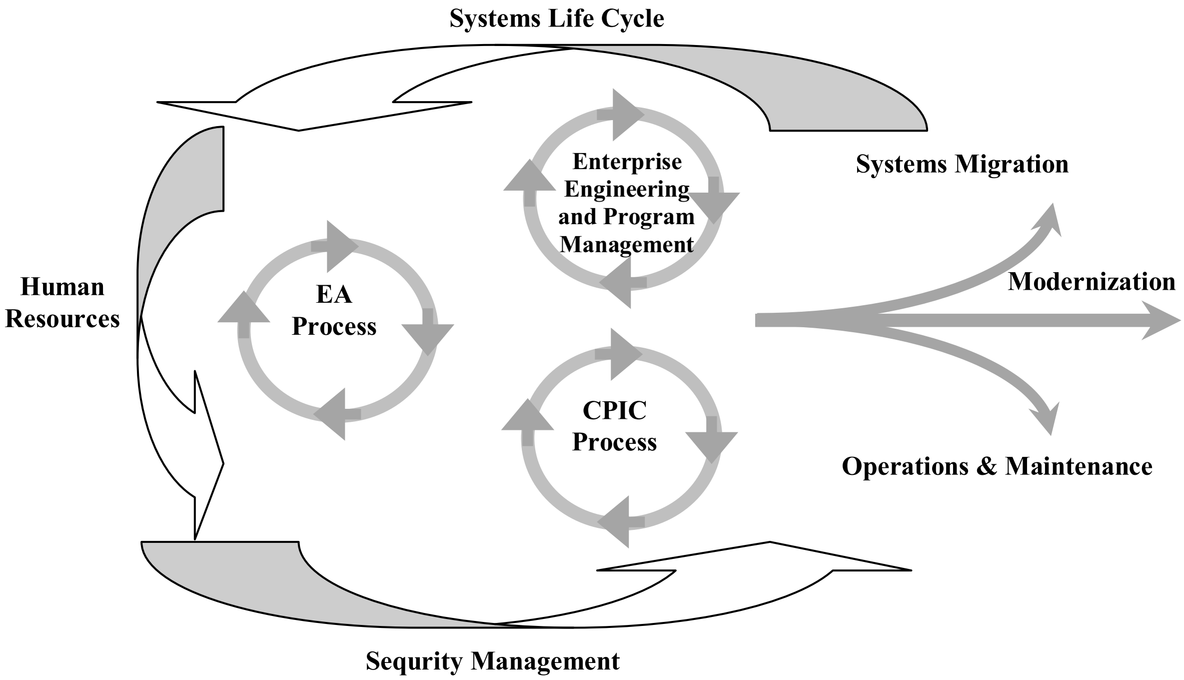

Fig. 2. The Enterprise Lifecycle as a concept in Enterprise Architecture

Decline (Recession) – reducing of sales and reducing of income.The enterprise life cycle is a concept in Enterprise Architecture (EA). The Enterprise Architecture process is closely related to other processes, such as enterprise engineering and program management cycle, more commonly known as the Systems Development Life Cycle. This concept aids in the implementation of an Enterprise Architecture, and the Capital Planning and Investment Control (CPIC) process that selects, controls, and evaluates investments [17]. Overlying these processes are human capital management and information security management. When these processes work together effectively, the enterprise can effectively manage information technology as a strategic resource and business process enabler. When these processes are properly synchronized, systems migrate efficiently from legacy technology environments through evolutionary and incremental developments, and the Agency is able to demonstrate its return on investment (ROI) [17]. The figure 2 above illustrates the interaction of the dynamic and interactive cycles as they would occur over time.

Since the yield at different stages of the life cycle is different, it is necessary to take into account the need to maintain the total profitability. Coordinating rules and life cycles time during the execution of the tasks from “portfolio”, the company is able to increase its competitiveness by complementarities, synergy, which provides additional benefits which cannot be achieved in a situation, when “strategic portfolio” is a simple sum of individual available areas development plans. Synergy is formed by mutual support and complementarities of different tasks.

Sometimes, it is advisable for enterprise managers to build all models to form an overall picture in terms of different perspectives. Each approach has its “for” and “against”, but in any case it is important that, after reaching the analytical completeness and accuracy in describing the situation, we may set the foundation for solving more complex problem – the formation and management of “portfolio” in order to get the best results from the use of enterprise resources.

”Portfolio” of tasks concerning creating of value for customers can be represented as a series of constant – parallel their performance. In this regard, there is need for effective organizing and planning of tasks lifecycle performing for timely decisions management that will reduce the impact of unavoidable disturbances. At the same time, it should be taken into consideration that during the transition from one task to another – the relative value of alternative tasks changes. Therefore, one of the main problems, which occur within strategic management, is to predict the nature and stages of life cycle.

The balance between different tasks depends on the decisions, taken by enterprise management on more or less of their relationship (mutual support). Of course, there may be different variants: balanced portfolio, in which “life cycles” are balanced in terms of passing phases and in terms of volumes. But, the most often we meet with unbalanced portfolios where the volumes are different, and there is a non-compliance of time / cost indicators etc. In such circumstances, it is difficult to take a decision.

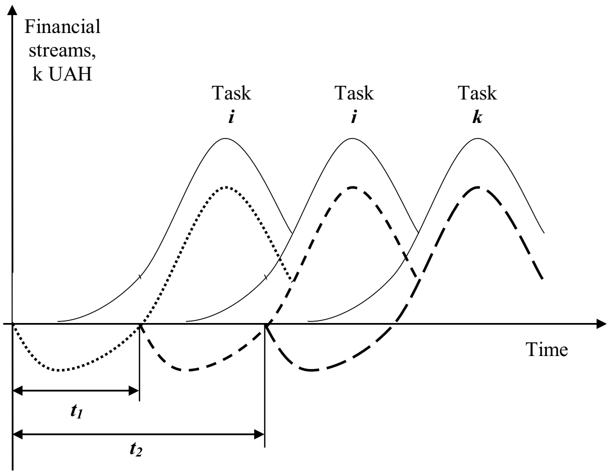

Fig. 3. The model of task realization lifecycles split by strategic management

Unlike most matrix models, which are used for the “portfolio” analysis and planning, it is advisable to use a method of dynamic programming in the analysis of “strategic portfolio”.

RESULTS AND DISCUSSION

Dynamic programming – this is a mathematical apparatus, with the help of which multi steps optimal control problem are solved [18, 19]. In this programming for process control among the set of all feasible solutions – all are looking for the best in terms of certain criteria, namely, such a solution that provides extreme (the highest or the lowest) value of the objective function – some numerical characteristics of the process. Multi – steps system is understood as multi – stages process structure or distribution of management for a number of successive stages that correspond usually to different periods of time.

Their solution will enable to predict measures concerning overcome of critical situations caused by the need to make a decision at some stage of the life cycle, and establish the most effective strategy of the company for implementation and the achievement of its overall objectives. Thus, in general, dynamic programming makes it possible not only to see the future of created new product, but also to set a goal and develop an appropriate plan of action [18].

The dynamic programming uses approach of simplification of difficult problem solving search by splitting it into simpler subproblems, usually by recursion. While some problems cannot be solved in this way, decisions which comprise multiple points in time indeed are often divided recursively into subproblems. Bellman called this as the principle of optimality. Similarly, in economic sciences about planning problem, which can be broken down into sub-problems recursively, we can say that it will have optimal substructure.

In the dynamic programming for the controlled process among the set of all acceptable methods for strategic management – all are looking for the best in terms of some criterion that is leading to extreme (the largest or the smallest) value of the objective function – some numerical characteristics of the process. Multi-steps of strategic management in this sense are understood as multi-steps program structure which is divided into a series of sequential stages, steps that correspond, usually, to different levels of management. In terms of mathematical optimization, dynamic programming means simplification of finding of overall optimal solution by finding solutions to subproblems obtained by problem partitioning into sequential subproblems ranked by level.

If subtasks can be nested recursively inside larger problems, so that dynamic programming techniques can be applied, there is a relationship between the solution of the general problem, and a solution of subproblems. In the optimization methods this ratio is expressed by Bellman equation [20, 21].

The problem of strategic portfolio management of design tasks can be presented to maximize the objective function:

$$\Pi=\sum_{i=1}^{n}\left(\lambda\cdot\sum_{j=1}^{n}\left(\frac{V_j\left(t_j^{(V)},t_i\right)\cdot\varphi_{i,j}\left(t_i\right)}{\left(1+q\right)^i}\right)+\right.$$
$$\left.+\mu\cdot\sum_{j=1}^{n}\left(\frac{W_j\left(t_j^{(W)},t_i\right)\cdot\psi_{i,j}\left(t_i\right)}{\left(1+q\right)^i}\right)\right)\to\max\,, \qquad (1)$$

where: $t_j^{(V)}$ – current time of strategic project implementation of j’s customer value creating project, searching value; $t_j^{(W)}$ – current time of strategic project implementation of j’s company value creating project, searching value; $V_j\left(t_j^{(V)},t_i\right)$ – value of the function profit that describes value creation for customers; $W_j\left(t_j^{(W)},t_i\right)$ – value of the function profit that describes the creation of enterprise value; $\varphi_{i,j}\left(t_i\right)$ – value of efficiency function in the combination of different projects time realization of creating value for customers; $\psi_{i,j}\left(t_i\right)$ – function value of efficiency in the combination of different projects time realization of creating value of enterprise; t_i – current time of strategic project implementation; n – number of time periods that are allocated for the project realization; q – discount rate, w/or loosing assumption stakes as a constant for whole the period; k – number of projects are considered in each direction (k=3) at branches customer or company value creating; λ,μ –weighting factors, shows comparable weight of branch value for company; satisfy the conditions $\lambda+\mu=1,\quad 0\le\lambda,\mu\le1$.

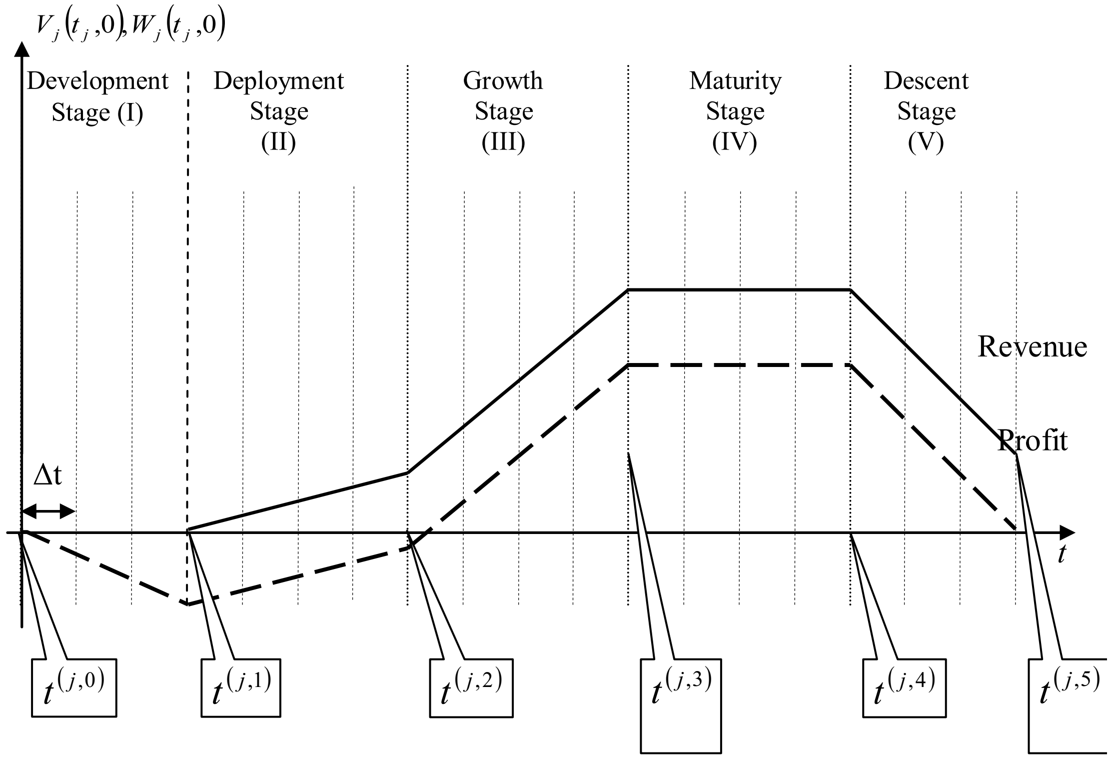

Fig. 4. Discrete model of project objectives life cycle

Additional constraints for this problem of dynamic programming can be the following limitations:

- at the ensuring of a certain level of income during a specified period of the strategic portfolio:

$$V_j\left(t_j^{(V)},t_i\right)+W_j\left(t_j^{(W)},t_i\right)\geq \Pi^{const}, \quad i^{(1)}\leq i\leq i^{(2)}, \tag{2}$$

- at the duration of the project realization:

$n \leq N$. (3)

Function $V_j\left(t_j^{(V)},0\right)$ is shown in Fig. 4.

Function $V_j\left(t_j^{(V)},t_i\right)$ harmonized to:

$$V_j\left(t_j^{(V)},t_i\right)=\begin{cases} 0, & t_i\leq t^{(j,0)}+t_j^{(V)}, \\ a^{(j,0)}+b^{(j,0)}\cdot\left(t_i-t^{(j,0)}-t_j^{(V)}\right), & t^{(j,0)}+t_j^{(V)}\leq t_i<t^{(j,1)}+t_j^{(V)}, \\ a^{(j,1)}+b^{(j,1)}\cdot\left(t_i-t^{(j,1)}-t_j^{(V)}\right), & t^{(j,1)}+t_j^{(V)}\leq t_i<t^{(j,2)}+t_j^{(V)}, \\ a^{(j,2)}+b^{(j,2)}\cdot\left(t_i-t^{(j,2)}-t_j^{(V)}\right), & t^{(j,2)}+t_j^{(V)}\leq t_i<t^{(j,3)}+t_j^{(V)}, \\ a^{(j,3)}+b^{(j,3)}\cdot\left(t_i-t^{(j,3)}-t_j^{(V)}\right), & t^{(j,3)}+t_j^{(V)}\leq t_i<t^{(j,4)}+t_j^{(V)}, \\ a^{(j,4)}+b^{(j,4)}\cdot\left(t_i-t^{(j,4)}-t_j^{(V)}\right), & t^{(j,4)}+t_j^{(V)}\leq t_i<t^{(j,5)}+t_j^{(V)}, \\ 0, & t_i\leq t^{(j,5)}+t_j^{(V)}. \end{cases}$$

It is clear that the effect will be reduce while few projects aimed making profit will be started at the same time. To account this properly, it is proposed to use functions $\varphi_{i,j}(t_i)$ and $\psi_{i,j}(t_i)$, which acquire different meanings: 1) the absence of overlapping project tasks, 2) combination of two tasks; 3) combination of three tasks. For different project tasks will be use indices $j,\bar{j},\bar{\bar{j}}$, then function formula $\varphi_{i,j}(t_i)$ for $V_j\left(t_j^{(V)},t_i\right)$ will be shown:

$$\varphi_{i,j}(t_i)=\begin{cases}1.0, & \left(\left(V_j(t_i)\neq 0\right)\wedge\left(\left(V_{\bar{j}}(t_i)=0\right)\wedge\left(V_{\bar{\bar{j}}}(t_i)=0\right)\right)\right),\\ 0.8, & \left(\left(V_j(t_i)\neq 0\right)\wedge\left(\left(V_{\bar{j}}(t_i)\neq 0\right)\wedge\left(V_{\bar{\bar{j}}}(t_i)=0\right)\right)\vee\left(\left(V_{\bar{j}}(t_i)=0\right)\wedge\left(V_{\bar{\bar{j}}}(t_i)\neq 0\right)\right)\right),\\ 0.6, & \left(\left(V_j(t_i)\neq 0\right)\wedge\left(\left(V_{\bar{j}}(t_i)\neq 0\right)\wedge\left(V_{\bar{\bar{j}}}(t_i)\neq 0\right)\right)\right),\end{cases}$$

where using the restriction: $j\neq\bar{j}\neq\bar{\bar{j}}$.

Similarly, we can introduce the function $W_j\left(t_j^{(W)},t_i\right)$.

$$W_j\left(t_j^{(W)},t_i\right)=\begin{cases}0, & t_i\leq t^{(j,0)}+t_j^{(W)},\\ \alpha^{(j,0)}+\beta^{(j,0)}\cdot\left(t_i-t^{(j,0)}-t_j^{(W)}\right), & t^{(j,0)}+t_j^{(W)}\leq t_i<t^{(j,1)}+t_j^{(W)},\\ \alpha^{(j,1)}+\beta^{(j,1)}\cdot\left(t_i-t^{(j,1)}-t_j^{(W)}\right), & t^{(j,1)}+t_j^{(W)}\leq t_i<t^{(j,2)}+t_j^{(W)},\\ \alpha^{(j,2)}+\beta^{(j,2)}\cdot\left(t_i-t^{(j,2)}-t_j^{(W)}\right), & t^{(j,2)}+t_j^{(W)}\leq t_i<t^{(j,3)}+t_j^{(W)},\\ \alpha^{(j,3)}+\beta^{(j,3)}\cdot\left(t_i-t^{(j,3)}-t_j^{(W)}\right), & t^{(j,3)}+t_j^{(W)}\leq t_i<t^{(j,4)}+t_j^{(W)},\\ \alpha^{(j,4)}+\beta^{(j,4)}\cdot\left(t_i-t^{(j,4)}-t_j^{(W)}\right), & t^{(j,4)}+t_j^{(W)}\leq t_i<t^{(j,5)}+t_j^{(W)},\\ 0, & t_i\leq t^{(j,5)}+t_j^{(W)}.\end{cases}$$

Function representing formula $\psi_{i,j}(t_i)$ for $W_j\left(t_j^{(W)},t_i\right)$ shows below:

$$\psi_{i,j}(t_i)=\begin{cases}1.0, & \left(\left(W_j(t_i)\neq 0\right)\wedge\left(\left(W_{\bar{j}}(t_i)=0\right)\wedge\left(W_{\bar{\bar{j}}}(t_i)=0\right)\right)\right),\\ 0.8, & \left(\left(W_j(t_i)\neq 0\right)\wedge\left(\left(W_{\bar{j}}(t_i)\neq 0\right)\wedge\left(W_{\bar{\bar{j}}}(t_i)=0\right)\right)\vee\left(\left(W_{\bar{j}}(t_i)=0\right)\wedge\left(W_{\bar{\bar{j}}}(t_i)\neq 0\right)\right)\right),\\ 0.6, & \left(\left(W_j(t_i)\neq 0\right)\wedge\left(\left(W_{\bar{j}}(t_i)\neq 0\right)\wedge\left(W_{\bar{\bar{j}}}(t_i)\neq 0\right)\right)\right).\end{cases}$$

where using the restriction: $j\neq\bar{j}\neq\bar{\bar{j}}$.

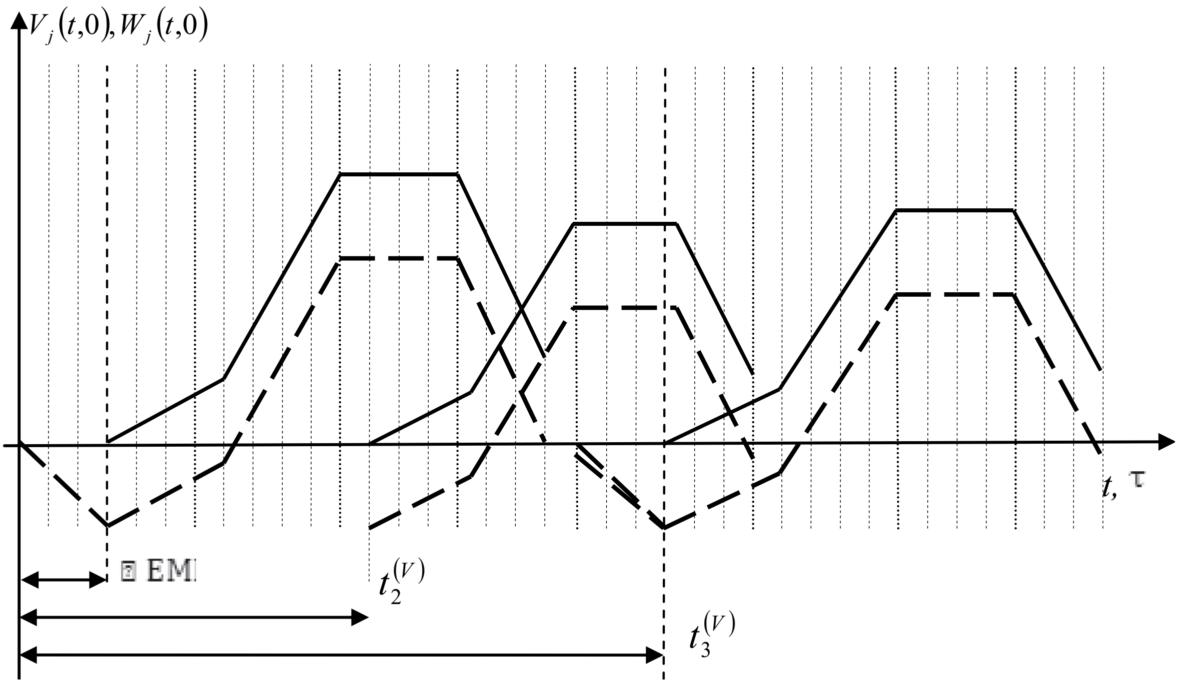

Fig. 5. Combining project tasks in one chosen direction

Thus, the problem dynamic programming can be represented as the date of the start of the project tasks $t_j^{(V)}$, $t_j^{(W)}$ in the following form:

- objective function:

$$\Pi=\sum_{i=1}^{n}\left(\lambda\cdot\sum_{j=1}^{n}\left(\frac{V_j\left(t_j^{(V)},t_i\right)\cdot\varphi_{i,j}\left(t_i\right)}{\left(1+q\right)^i}\right)+\right.$$

$$\left.+\mu\cdot\sum_{j=1}^{n}\left(\frac{W_j\left(t_j^{(W)},t_i\right)\cdot\psi_{i,j}\left(t_i\right)}{\left(1+q\right)^i}\right)\right)\to\max; \qquad (4)$$

- limitations:

$$V_j\left(t_j^{(V)},t_i\right)+W_j\left(t_j^{(W)},t_i\right)\geq\Pi^{const},\quad i^{(1)}\leq i\leq i^{(2)}, \qquad (5)$$

$$n\leq N. \qquad (6)$$

The list of specified limits may be increased for clarifying and making more strict requirements if needed for the implementation of the proposed measures.

To solve dynamic problem of dynamic programming it is proposed to use the following algorithm.

I. In this case, at the first stage during problems solving occurs at the level of two strategic concepts allocation of enterprise development:

• creation of value for customers, is described by the equation $V_j\left(t_j^{(V)},t_i\right)$,

• creation of value of enterprise, described by the equation $W_j\left(t_j^{(W)},t_i\right)$.

Each of these lines can be developed independently, only with regard to the total capacity of the enterprise.

II. At the second stage it is enough to select the sequence of the set tasks. For this k!=6 possible variants are consistently calculated of project activities consecutive implementation in each component of the portfolio in a certain direction. As a result, this one is selected – which provides maximization of the expected result.

III. At the third stage, the problem is reduced to a linear programming problem with a search of unknown quantities $t_j^{(V)}$, $t_j^{(W)}$, which in their content define the execution combination of design tasks (Figure 4).

Being aware of the management role and place of such strategic portfolio of enterprise development as part of the overall business planning of the enterprise, it is necessary to choose correctly the methods for its implementation, taking into account the chosen prediction horizon, the existing knowledge base, restrictions criteria, existing and probable factors of influencing etc.

CONCLUSIONS

The analysis result of the presented algorithm of "strategic portfolio" is the following:

• developments of overall strategic recommendations on spectrum management of development objectives,

• the problem solving of the type and extent of "portfolio" diversification,

• providing of synergistic interaction of project activities,

• possibility of system prompt review of strategic objectives and general strategies of the company.

Thus, this is the unique way according to which all elements are combined, creating value for both the consumer and the enterprise, and is a competitive advantage core which is achieved through implementation of the business model of the enterprise activity.

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Choosing of typhlocommentator, description of subject in videocontent for sightless and visually impaired person

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Abstract. The statement of problem of choosing of typhlocommentator is considered in this article, the description of the subject among the number of possible typhlocommentator. The mathematic model of such a task is given and an approach of solving it has been worked out. When researching the problem of access of weak-sight people to the video content, it is required to understand that more than a most part of the information is provided to the viewer in the form of an image. Yes, blind people hear all words of actors, sounds of the environment, processes at the screen, but it is difficult for them to identify the person to whom the specific words belong, what happens with heroes at the very specific moment, what is depicted in the given scene, it is difficult for them to understand reaction of actors, which the latter often express with the help of movements or mimics. Typhlo-comments to video content for blind people and people with weak-sight are one of the real steps towards solution of the problem of limitation of access to such content.
Key words: typhlocomment, typhlocommentator, films for sightless, description of the subject, video content.

INTRODUCTION

There are about 600 thousand weak-sight people living in the Ukraine, of them 100 thousand people are totally blind. Overall in the world about 285 million people with visual impairment and 45 million are totally blind. Science development, society computerization and using of multimedia technologies created conditions for development of computer communication systems for weak-sight people.

One of achievements of the mankind, which is largely unavailable and not completely understandable for the blind people, is a video content – movies, popular scientific and cognitive programs. Sighted person sees through the eyes of about 80% of the information is in video content. Totally blind person can get only about 16% of the information coming through the auditory organ. Currently the matter of accommo-dation and using of achievements of the mankind in adaptation of blind people to the society is of critical importance [1].

Currently massive cinema is almost inaccessible to people with visual impairments. Here are the main problems:

– Distance from cinemas residence that our reality mobility aid for blind, is almost the main problem of access to them without assistance,

– Usually inaccessibility of the building cinema;

–Incomplete clarity of the video content,

– High prices, given that blind people usually adequate resources to be able to develop and learn through video content,

– Healthy people, often after watching a movie, reading a book, based on which the film was set in the blind is usually the opposite – one of the few available ways of such a person is reading, which is written in Braille, and often after reading this book, blind would see his screen version, which unfortunately is usually not available for this group of people.

Currently mass cinemas are almost unavailable to people with a limited eyesight due to the matter of availability of the building itself, non-adaptivity of the content, not to mention prices as the blind man has few opportunities to provide for himself at a sufficient level, to be able to develop and learn through video content.

Nowadays when the film industry has technical capabilities being sufficient for realization of any artistic design, it seems that there is no necessity to speak, what a huge world opens to each people present in the cinema hall or sitting in front of the TV set or monitor.

When researching the problem of access of weak-sight people to the video content, it is required to understand that more than a most part of the information is provided to the viewer in the form of an image. Yes, blind people hear all words of actors, sounds of the environment, processes at the screen, but it is difficult for them to identify the person to whom the specific words belong, what happens with heroes at the very specific moment, what is depicted in the given scene, it is difficult for them to understand reaction of actors, which the latter often express with the help of movements or mimics.

Typhlocomments to films for blind people are one of the real steps towards solution of the problem of limitation of access to such content. It opens up a large space for society adaptation not only for adults, but also for children with visual problems, who could watch cartoons, learn how to count, and learn the alphabet using video with typhlocomment.

Nearly hundreds of movies produced in Europe are adapted for the blind, in China, where special departments at the professional film studios are working on the voice over process, this number varies from 10 to 15, in Russia it reaches 5 per year. Ukraine has not created this kind of video content yet.

MATERIALS, METHODS AND RESULTS

Typhlocomment is an off-screen description of the video sequence made by the script writer and read by the typhlocommentator. It is not subtitles, not an audio version of the film and not a version of the audio-book. It is a method to see a film or any other type of the video content with full or partial blindness. It represents a comment of visual effects – gestures, objects, costumes, scenery in the theatre, movies, museums and at exhibitions. Thus, blind people may imagine the whole spectrum of visual ploys used by the author. In the given situation it is also required to account that the people concerned shall have good hearing and good imagination. [1]

Typhlocommentator – the profession in the film industry, voiceover commentator who has typhlocomment for blind and visually impaired people.

Typhlocommentator is a background, "hum" simply describing the plot.

Creation of typhlocomments is a fine work of script writers and sound producers, who balance between the art of description and selection of short, but maximally informative key words.

Typhlocommentator upon preparation and further reading of the text shall comply with the following rules:

– Prior to commencement of work it is required to see the movie or other video content 1-3 times with closed eyes in order to try to understand the essence, to pick out the main leitmotif of the movie and to build all comments with comprehension of the final essence of the movie,

– To mark out moments, on which it will be necessary to focus attention, and to detach them as they are obscure without visual look,

– Typhlocommentator shall not express his own tastes, opinions about actors or their roles (beautiful, old, crooked, interesting etc.), the viewer shall make his conclusions after seeing (hearing) of the movies on his own,

– Typhlocommentator shall not express emotions; his voice shall be calm and even monotonous. It is important not to fill the emotional spirit of the movie with the intonation,

– To comply with timeframes as set between cues of actors,

– Not to overlap significant sounds having essence load in the script.

For adequate description of the plot it is necessary to build a mathematical model of such a process. Let's introduce the following designations for achievement of the given goal:

S_i – *i*-numbered plot,

$t(S_i)$ – duration of the *i*-numbered plot,

$Sem(S_i)$ – semantics of the *i*-numbered plot.

Any plot S_i may be described with the help of multitude of typhlocomments. Let's designate such a multitude as $F_i = \left\{ f_{i^1}, f_{i^2}, \ldots, f_{i^{n_i}} \right\}$. Where $t(f_{i^j})$ – duration of the j-numbered typhlocomment describing the i-numbered plot; $Sem(f_{i^j})$ – semantics of the j-numbered typhlocomment describing the i-numbered plot.

The task lies in selection from the multitude F_i of such the j-numbered typhlocomment, for which:

$$t\left(f_{i^j}\right) \le t\left(S_i\right), \tag{1}$$

and the relevant semantics are almost equal:

$$Sem\left(S_i\right) \cong Sem\left(f_i^j\right). \tag{2}$$

If realization of condition (1) is obvious (attention shall be paid that the typhlocomment is not overlapping dialogues of the plot, for realization of condition (2) expert assessments are required and domain ontology.

In computer science and information science, ontology formally represents knowledge as a set of concepts within a domain, and the relationships between pairs of concepts. It can be used to model a domain and support reasoning about entities.

In theory, ontology is a "formal, explicit specification of a shared conceptualisation" [2]. Ontology renders shared vocabulary and taxonomy which models a domain with the definition of objects and/or concepts and their properties and relations [3].

Ontologies are the structural frameworks for organizing information and are used in artificial intelligence, the Semantic Web, systems engineering, software engineering, biomedical informatics, library science, enterprise bookmarking, and information architecture as a form of knowledge representation about the world or some part of it. The creation of domain ontologies is also fundamental to the definition and use of an enterprise architecture framework.[4-7]

A domain ontology (or domain-specific ontology) models a specific domain, which represents part of the world. Particular meanings of terms applied to that domain are provided by domain ontology. For example the word card has many different meanings. An ontology about the domain of poker would model the "playing card" meaning of the word, while an ontology about the domain of computer hardware would model the "punched card" and "video card" meanings. [8-10]

An upper ontology (or foundation ontology) is a model of the common objects that are generally applicable across a wide range of domain ontologies. It employs a core glossary that contains the terms and associated object descriptions as they are used in various relevant domain sets. There are several standardized upper ontologies available for use, including Dublin Core, GFO, OpenCyc/ResearchCyc, SUMO, and DOLCE, WordNet, while considered an upper ontology by some, is not strictly ontology. However, it has been employed as a linguistic tool for learning domain ontologies [3].

The Gellish ontology is an example of a combination of an upper and domain ontology.

Since domain ontologies represent concepts in very specific and often eclectic ways, they are often incompatible. As systems that rely on domain ontologies expand, they often need to merge domain ontologies into a more general representation. This presents a challenge to the ontology designer. Different ontologies in the same domain arise due to different languages, different intended usage of the ontologies, and different perceptions of the domain (based on cultural background, education, ideology, etc.) [10-11].

At present, merging ontologies that are not developed from a common foundation ontology is a largely manual process and therefore time-consuming and expensive. Domain ontologies that use the same foundation ontology to provide a set of basic elements with which to specify the meanings of the domain ontology elements can be merged automatically. There are studies on generalized techniques for merging ontologies [4] but this area of research is still largely theoretical.

Ontology engineering (or ontology building) is a subfield of knowledge engineering that studies the methods and methodologies for building ontologies. It studies the ontology development process, the ontology life cycle, the methods and methodologies for building ontologies, and the tool suites and languages that support them [5].

Ontology engineering aims to make explicit the knowledge contained within software applications, and within enterprises and business procedures for a particular domain. Ontology engineering offers a direction towards solving the interoperability problems brought about by semantic obstacles, such as the obstacles related to the definitions of business terms and software classes. Ontology engineering is a set of tasks related to the development of ontologies for a particular domain. [12-14]

In order for the typhlocomment not to overlap dialogues of the plot let's divide the i-numbered plot by subplots, within which dialogues are absent: $S_i \supseteq S_1 \cup S_2 \cup ... \cup S_{m_i}$. Then:

$$t(S_i) = t(S_1) + t(S_2) + ... + t\left(S_{m_i}\right). \tag{3}$$

Then multitude of conditions shall be fulfilled:

$$t\left(f_{kj}\right) \le t(S_k), k = 1,2,...,m_i . \tag{4}$$

Let's select from the multitude F_i those elements, for which condition (4) is complied with. Thus, we'll build some subset of typhlocommentators $F_i \supseteq \tilde{F}_i = \left\{\tilde{f}_{i1}, \tilde{f}_{i2}, ..., \tilde{f}_{ir_i}\right\}$.

Now it is required to comply with condition (2) for elements of the given multitude.

Let we have N experts$\left(E_1, E_2, ..., E_N\right)$, who assess correspondence of the semantics of the typhlocommentator and the plot corresponding thereto. Let's designate $O\left(E_i, \tilde{f}_j\right)$ – assessment of the i-numbered expert of the j-numbered typhlocommentator. The higher assessment, the more adequate the typhlocommentator describes the relevant plot. [15] Assessment scale is the finite one. Let's designate aggregate assessment of the j-numbered typhlocommentator: $O_j = \sum_{i=1}^{N} O\left(E_i, \tilde{f}_j\right)$.

Then we shall select the typhlocommentator $\tilde{f}_k$ for which:

$$\tilde{k} = \mathop{\mathrm{a}}_{j} O_j .$$

Thus, we'll get the algorithm of selection of the typhlocommentator for description of the i-numbered plot as set forth at Fig. 1.

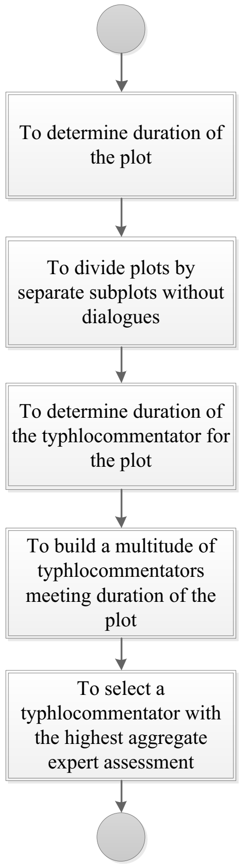

Fig. 1. Diagram of activity for selection of the typhlocommentator for description of the plot

There are two types of typhlocomment:

• Direct typhlocomment (when the commentator is working directly with the blind spectator mode "on-line");

• Prepared typhlocomment (commentary prepared in advance and applied using a special software and hardware on the video content). [16-17]

Modern digital technologies have made it possible to use prepared typhlocomment automatically by a computer with the imposition of additional scale typhlocomment on video. [18-20]

Preparing text of typhlocomment to video by using a personal computer and appropriate software.

Our software "Audio Editor" includes the following functions:

1) Analysis of both the audio and video tracks to pause in which you can well read tiphlocomments.

2) Chanting through the program's interface typhlocommentars in places that the program considers necessary to fill a Comment for the blind.

3) Edit typhlocomments and main track.

4) Overlay typhlocomments on video track.

CONCLUSIONS

Setting of the task of selection of the typhlocommentator for description of the plot among multitude of probable typhlocommentators has been considered in the article. Mathematical model of such of the given task has been adduced; approach to solution thereof has been developed.

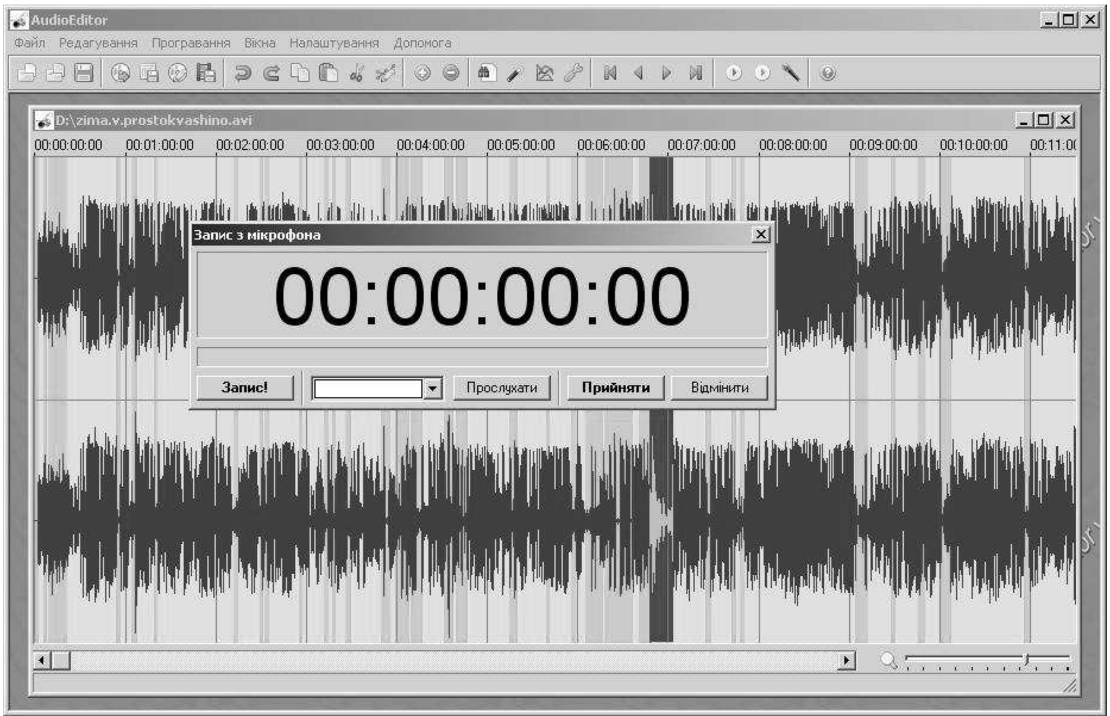

Fig. 2. Green space marked for insertion typhlocomments. Then, the recording of voice comments microphone

The definition of typhlocomment is also provided, the rules that have to be adhered to by an actor, who read typhlocomment for the video content, are defined. It is important to remember, that the text which is being read by an actor, his intonation, emotions expressed by his voice will be the "eyes" of those people watching the video content.

Implement software which allows adapting the video content for the blind and visually impaired people.

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Economic evaluation of investment involvement mechanisms

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Abstract. The research has revealed the entity of investment activity and defined its characteristics. The way of investment attraction mechanisms economic evaluation has been offered within the investigation. The notions of an enterprise investment attraction have been characterized. The way of the level of an enterprise investment attraction has been provided. On the basis of the process of investment attraction level of an enterprise-recipient an economic evaluation of investment attraction has been fulfilled.

Key words: investments, investor, recipient, investment attraction, an economic evaluation.

INTRODUCTION

Under globalization and a rapid development of high technologies it is of the urgent importance to provide necessary resources to the business entity of commercial activities. This is caused by the fact that one of the development conditions is the keeping of non-stop process of innovation activity fulfillment as a result of which the actual technologies are improved; new methodologies are invented and implemented, etc.

An effective realization of the procedures of enterprise investment attraction is a vast condition of a successful enterprise activity under modern fast-flowing conditions of external environment. The existence of the instruments which guarantee such possibilities to the business entity may be treated as an important condition of their fast development and successful long-term perspectives.

MATERIALS AND METHODS

The importance of investment for an economic development providing of both separate entities and the whole economics have been testified by such prominent researchers as A. Smith, D. Ricardo, T.Maltus, D. Mill, A.Marshal, E. Bem-Baverk, Y. Fisher, J. Keyns and others [1, 2, 3, 4, 5]. A separate acquisition goes to such modern researchers as E.Domar and R.Harrod [6],who gave grounds to the role of investment in a stable economic development providing. Special views on the given theme were provided by the researchers J.Suks, F.Lurren, J.Hellbrate,H.Murdal, D.Tobbin[7, 8], who contributed a lot to the development of investment theories on the basis of macroeconomics. Such researchers as D.Baley, L.Hitman, D.Rosenberg, H. Alexandera, U. Sharp [9, 10] accentuated their attention on the issues connected to the investment arising mainly on the micro level.

Among national and Russian researchers, whose investigations touched upon the investment, we can name V. Zolotohorodov, M. Nazarov, V.Kovalyov, O.Pyroh, T.Samoylov, T. Teplov 30[] and many others. Such authors as I. Alekseyev, I. Khoma, N. Shpak [11] proposed using the mechanisms for managing the involvement investments. In turn O. Goryachka, M. Adamiv [12] believe that involvement investments is appropriate when enterprise using this investments for implementation innovative projects. Such scholars as Yu. Shapovalov, B. Mandziy, D. Bachyk [13] believe that the choice of some economic mechanism should be based on mathematic modeling.

It is worth mentioning that the researchers, mentioned above, skipped the issues which were supposed to touch upon the peculiarities of the process of investment involvement fulfillment by separate business entities. So, the previous research [14, 15] has showed that the activity connected to investment involvement is characterized by certain peculiarities and can be treated as a separate important component of enterprise and economics development on the whole. The differentiation of the given characteristics and their common features research provided the possibility to make a conclusion that the involvement of investment should be treated as a certain mechanism which is applied by a certain enterprise when there is a necessity to implement a certain amount of investment. An enterprise (recipient), an investor, an investment and the methods of its involvement may be treated as a core component of such a mechanism.

The fact, which is the most obvious is that among the above mentioned elements we may form a large amount of different mechanisms of investment involvement, that is why an enterprise needs the methods of choosing the methods out of all possible ones. This can be fulfilled on the basis of application of the method of their evaluation which means the advantages of that mechanism with the highest evaluation. Taking into account the absence of evaluation methods of investment involvement in the sources mentioned above, we claim that it is appropriate to suggest one of such methods in the paper under consideration.

RESULTS AND DISCUSSION

To find the ways of the evaluation of mechanisms of investment involvement we need to previously research the peculiarities of the notion “mechanism”. The implementation of the given notion in different branches of science was researched following this aim.

For quite a long time the notion of mechanism has been greatly applied in mechanics and treated as a change of movement of certain physical bodies into the movement of other bodies. As a result, the theory of machines and mechanisms [16] claims that mechanism – is the system of bodies destined for the change of movement of one or more solid bodies into a necessary movement of other bodies. The key – characteristics of mechanism is a change of mechanic movement.

With the beginning of 60-ies of XX century the term “mechanism” started to be actively applied in economics of socialism. L. Balkin [17] defines the mechanism as a structure which consists of four elements: the form of social enterprise organization; the form of commercial connection; the form, structure and methods of planning and managing of ménage; the totality of commercial vehicles and stimuli which influence the enterprise and the participants of commercial activity.

Later the notion of mechanism starts being greatly applied in different branches of economics. Thereby the mechanisms of management, social-economic development appear, the terms “financial mechanism”, “commercial mechanism” and others appear in circulation [18, 19].

It should be noted that among national and foreign scientists, the treatment of the entity of mechanism in economics, differ. For instance, O. Derevyanko [20] is convinced that we should understand the notion of commercial mechanism as a way of certain commercial system functioning where its size does not matter. The thing of importance is that enterprise relations are on the basis of such functioning. This researcher imposes the characteristics of the process on the mechanism.

A. Chalenko[21] provides own understanding of economic mechanism. Including, this researcher treats the mechanism as a totality of resources of economic process and the ways of their combination. Some researchers also differentiate between the mechanisms of functioning and development of economic systems. A.Ivasenko [22] reveals the entity of the mechanisms of financial support on their basis, which are predetermined by the totality of financial resources of the processes of functioning and development and the ways of their combination as well. T.Zotova [23] treats a mechanism as a certain totality of interrelated elements which fulfill a certain function. The researcher is inclined towards a systemic approach concerning a mechanism treatment and also takes into account the possibilities of functional approaches implementation towards a treatment of such a notion.

Modern treatment of economic mechanisms is formulated on the basis of the works by L. Hurvits, R.Mayeron and A.Muskin [24]. The contribution of these researchers into economic theory was awarded by Nobel Prize in 2007. Relevantly to the given researchers’ views, any interrelation between economic subjects can be considered as a certain strategic game whose form will act as a mechanism. Under the term ‘game’ the above mentioned researchers understand the description of the process how players may act and what will be the outcome of any action set. L. Hurvits [25] suggested more strict formulation of the mechanism. According to this researcher, the mechanism is an interrelation between the subject and the center which consists of three stages: each subject sends a certain message to the center, it processes all the messages, counts the result and publishes it.

Notwithstanding a rather strict formulation of economic mechanism according to L.Hurvits, we anyway should note that a lot remains unrevealed within the treatment of this research. But, the issue of mechanism center remains unsolved, as it is unknown whether it should be a certain “mechanic” or one more mechanism. Some scholars criticize “Hurvits mechanism” as such unable to account for resources necessary for its functioning, that is why it can not be considered an enough precise treatment of economic mechanisms.

The treatment of economic mechanism within the frame of methods IDEF0 attracts much attention (where

I – Integrated Computer Aided Manufacturing, DEF – DEFinition for Function Modeling, a 0 – the number of method in the family of IDEF models), invented in 1981 within the program of automatization of enterprises activity in the USA.According to the given methodology an enterprise activity is considered as a process represented in the frame of a functional block which changes "entrances" into"exits" if there are necessary resources[26]. According to methodology IDEF0 mechanism is considered as a separate resource.

Having researched the understanding of a notion "mechanism" in different branches of science it is possible to claim that it can be researched according to many criteria: according to the level of aimed result; the amount of the resources applied by certain mechanism; the time of the "work" of mechanism (in this aspect time is considered as a resource, but is separately evaluated), etc. The amount of implemented investment may be added to the results of a certain mechanism application. Then a relative evaluation of certain mechanism application of investment involvement may be found with the help of the following formula:

$$E = \frac{I_{fact}}{I_{plan}}, \qquad (1)$$

where: I_{fact}, I_{plan} -relatively factual and planned meaning of investment amount, grn.

Apart from that, we can note that the time of the process of investment involvement is also important and needs a separate consideration. That is why, the mechanism with the help of which an enterprise is able to involve more investment for a certain period of time may be considered better than its analogies.

A very important condition within the context of the theme under research is the fact that the way mentioned above may be applied only to the mechanisms which have already been used in enterprise activity. Of course, it is possible to use the existing economic-mathematical methods or an expert poll and receive predictable factual data of the amount of investment which will be able to be involved with the help of a certain mechanism.However, the received data will be based on a trifle retrospective base and characterized by a vast dependence on perceptive (the characteristic features of empiric and rational perception of reality) features of professionals who joined an expert poll. That is why we consider it to be wise to suggest our own way of economic evaluation mechanism which have not been applied by the enterprise (recipient) during its functioning.

If an enterprise acts as an initiator of investment involvement, then a final decision concerning investment will belong to an investor. Obviously, the result of the negotiation between enterprise and investor may depend on many factors. However, one on the most important factors is an investment attraction of an enterprise. The factor under consideration demonstrates how attractive a certain enterprise is for an investor. That is why, the bigger an investment attraction is, the bigger is the probability that a necessary amount of timely involved investment on profitable conditions will be the result of "implemented" mechanism. The problem of an enterprise investment attraction definition was investigated many researchers. Table 1 demonstrates some existing approaches to the treatment of investment attraction by different authors.

Table 1. Approaches to the treatment of the entity of enterprise investment attraction by different authors

№	Authors	Investment attraction treatment
1	A. Aheyenko [27]	An investment attraction of an enterprise depends on the totality of economic, organizational, social, law and political reasons, on the basis of which the necessity of investment into the given enterprise is defined.
2	I. Boyarko [28]	An enterprise investment attraction is considered as a quality characteristics of a possibility of investment into a certain enterprise.
3	O. Nosova [29]	The author considers an investment attraction as a complex characteristics of an enterprise and the potential of a certain region where the given enterprise works.
4	O. Pyroh [30]	The author suggests fulfilling a comparative analysis of a given enterprise with other potential objects of investment in the process of enterprise investment attraction definition.
5	H. Strokovych [31]	The author treats an enterprise investment attraction out of the position of systemic analysis (the totality of factors which influence a financial and commercial state of an enterprise) and economic-mathematical methods (a complex of indexes which express the efficiency of enterprise work).
6	O. Ksyuda [32]	The author defines an investment attraction on the basis of management and financial and commercial activity of an enterprise and also out of the position of possibilities of investment implementation.
7	N. Krasnokutska [33]	The researcher evaluates an investment attraction of an enterprise on the basis of a complex of economic-psychological characteristics of a given enterprise.

As it is obvious, the approaches to the entity of a notion “enterprise investment attraction” mentioned above prove the previous supposition about a dominating role of a given factor in the process of a decision-making concerning investment by an investor. However, the majority of the treatment of the notion mentioned above “investment attraction” differ according to the level of an external environment of an enterprise.The majority of researchers are inclined to think that an investment attraction depends on both internal factors (financial and commercial state of an enterprise, the level of staff efficiency, the unique technologies, etc), and the factors of external environment(the cooperation with the partner, the level of opposition with the partners in the branch, the specificities of the very branch, etc).

Thereby, the analysis of the level of a certain enterprise investment attraction is a complicated procedure, since during its fulfillment it is necessary to account a large amount of information, the part of which is unavailable, because it is hidden by an enterprise itself for certain reasons. An investor obviously tries to analyze the biggest amount of data when making the decision concerning the investment into this or that enterprise. All market traders are familiar with the given supposition. Thereby, a great “guru” of a technical analysis J.Murphy [34] in his paper “Technical Analysis of Features’ Markets” claimed that “market accounts for everything”. However, a potential investor is able to analyze only the information which is available for free access. These can be the data about the price dynamics of emitted documents by a certain enterprise, the data concerning economic conjuncture of the branch where the data about enterprise function, financial reports, etc. Some experts deny the necessity of all the factors accounting, since the conclusions of their accounting are usually very contradictory. In this way, U. Buffet [35] denies investors’ necessity to analyze a potential recipient’s reporting. The researcher suggests applying a simple system of indexes evaluated according to a certain grade.

Taking into consideration the above mentioned facts, we can claim that to ensure a successful process of investment involvement we need to possess certain data about a potential investor’s decision making concerning certain investment. As such information is not always freely available, we need to analyze an enterprise investment attraction on the basis of well-known methods of dynamics forecast of a certain investment instrument (the very shares of an enterprise-recipient are the priority). In addition to that the application of some of these methods often supplies contradictory results.

Thereby, an investment attraction evaluation should be fulfilled on the basis of the analysis of the results of some prediction methods application, by the way, in this case the amount of the data analyzed should be limited. Let us suppose, for instance, that we have a certain branch of an economics and three enterprises function within it. There is also one investor and one makes decisions concerning which may be direct and indirect. Let us also suppose that the investor will not refuse to invest. All the other factors have not been taken into account yet. Let us take as an example the following enterprises such as *A*, *B* and *C*. Thus, table 2 describes the dynamics of prices for shares of these three companies.

Table 2. Shares Price Dynamics of the Companies A, B and C for the period from 01.06.2014 to 12.08.2014

Date	A	B	C	Date	A	B	C	Date	A	B	C
01.06.2014	501,11	34,64	13,85	26.06.2014	467,71	32,74	13,77	21.07.2014	465,25	31,36	13,65
02.06.2014	498,68	34,49	13,83	27.06.2014	494,64	32,39	13,77	22.07.2014	469,45	31,48	13,6
03.06.2014	496,04	34,45	13,85	28.06.2014	506,71	31,66	13,76	23.07.2014	462,54	31,67	13,6
04.06.2014	492,81	34,13	13,85	29.06.2014	498,22	31,15	13,76	24.07.2014	456,68	31,45	12,89
05.06.2014	489,64	33,76	13,84	30.06.2014	495,27	31,23	13,74	25.07.2014	452,53	31,62	12,59
06.06.2014	486,59	33,07	13,83	01.07.2014	498,69	31,2	13,73	26.07.2014	453,32	31,63	12,79
07.06.2014	480,94	33,01	13,83	02.07.2014	488,58	31,88	13,69	27.07.2014	447,79	31,32	12,8
08.06.2014	487,75	33,3	13,84	03.07.2014	487,22	33,4	13,69	28.07.2014	440,99	31,4	12,87
09.06.2014	483,03	33,88	13,84	04.07.2014	491,7	33,55	13,67	29.07.2014	438,5	31,17	12,91
10.06.2014	483,41	33,86	13,83	05.07.2014	490,9	33,02	13,7	30.07.2014	440,51	31,74	12,85
11.06.2014	489,56	33,92	13,83	06.07.2014	488,59	33,26	13,7	31.07.2014	418,99	31,6	12,81
12.06.2014	487,96	33,58	13,84	07.07.2014	502,97	34,15	13,72	01.08.2014	426,31	31,79	12,94
13.06.2014	476,75	33,28	13,75	08.07.2014	501,02	34,75	13,73	02.08.2014	424,95	31,18	13,06
14.06.2014	482,75	33,27	13,78	09.07.2014	502,96	32,39	13,71	03.08.2014	431,76	35,19	13,04
15.06.2014	486,22	32,77	13,78	10.07.2014	502,36	31,61	13,71	04.08.2014	430,31	35,49	12,81
16.06.2014	481,53	32,51	13,78	11.07.2014	501,07	31,62	13,68	05.08.2014	430,2	36,02	12,94
17.06.2014	489,1	32,45	13,8	12.07.2014	507,74	31,39	13,71	06.08.2014	427,44	35,92	13,07
18.06.2014	490,64	32,74	13,8	13.07.2014	502,33	31,8	13,74	07.08.2014	426,51	35,42	13,24
19.06.2014	467,41	32,79	13,8	14.07.2014	497,91	31,79	13,63	08.08.2014	427,29	35,44	13,27
20.06.2014	472,3	33,64	13,79	15.07.2014	498,5	32,35	13,64	09.08.2014	420,73	34,46	13,25
21.06.2014	464,68	33,32	13,79	16.07.2014	489,57	32,23	13,64	10.08.2014	422,35	34,11	13,28
22.06.2014	455,32	32,93	13,77	17.07.2014	467,36	32,64	13,65	11.08.2014	415,05	34,09	13,26
23.06.2014	450,12	32,8	13,77	18.07.2014	454,45	32,47	13,66	12.08.2014	414,68	33,97	12,95
24.06.2014	464,9	33,03	13,77	19.07.2014	461,02	32,66	13,67				
25.06.2014	472,69	32,69	13,77	20.07.2014	464,98	31,84	13,63				

Notes: A, B, C – some companies.

Table 3. The Matrix of Correlation of Companies' Shares Definitions Time Rows of *A*, *B* and *C* and the meaning of standard deviations of prices time rows and their shares

Companies	*A*	*B*	*C*
A	1	-0,21916	0,775877
B	-0,21916	1	0,032563
C	0,775877	0,032563	1
Standard deviation:			
	Companies	Absolute*	Relative**
	A	27,58062	0,058633
	B	1,287893	0,039124
	C	0,363528	0,026855

*Notes: * absolute standard deviation counted as an average arithmetic number of a square of deviations of time row meaning from its average arithmetic number; ** relative standard deviation counted as a particle out of the extraction of time row deviation of standard deviation to its average arithmetic meaning.*

Table 4. Regression equation received from the data in Table 2

*C(A,B)**	$y = -118,45 + 0,13x_1 + 6,03x_2 - 0,02x_1x_2 - 0,000007x_1^2 - 0,08x_2^2$	$R^2 = 0,77$
*B(C,A)***	$y = 656,58 - 54,72x_1 - 1,16x_2 + 0,07x_1x_2 + 0,96x_1^2 - 0,0002x_2^2$	$R^2 = 0,25$
*A(C,B)****	$y = 20830,3 - 2278,7x_1 - 338,4x_2 + 3,78x_1x_2 + 83,53x_1^2 + 4,26x_2^2$	$R^2 = 0,75$

*Notes: ***A(C,B) – equation, in which the meaning of the shares prices of the companiesв A; ** B(C,A) –are dependent variable**;** equation, in which the meaning of the shares prices of the companiesв A; ** B(C,A) –are dependent variable**;** B; * C(A,B) – B; * C(A,B) – equation, in which the meaning of the shares prices of the companiesв A; ** B(C,A) –are dependent variable of the company C.*

Let us analyze a reciprocal influence of the exemplified indexes to one another. (tabl. 2) and define their standard deviation. It will provide the opportunity to evaluate the level of risk for each investment instrument under research (the level of field risk and other factors have not been taken into consideration yet) and find out whose share dynamics is the less dependent of others and as a result may be considered more stable.

As it is obvious from tabl.3, one can note a vast interdependence between the shares of the companies *A* and *C*, that can be considered unsuitable phenomenon for an investor who plans direct investment into one of these companies. Well, on the basis of the analysis the company B may be considered the most dependent of its opponents.

As it was previously mentioned, the given analysis of investment attraction of three mentioned companies was made without accounting of external and internal factors. It has been done with the aim of information simplification the investor possesses and is based on the analogy of "perfect gas" in physics.

The next step in the given analysis is a regression equation**.** As we take into account the dynamics of three companies only, then the regression will have two independent and one dependent variables. Apart from that, there exists a high correlation between some of these variable (tabl. 3), to supply the given equation a precise enough predicting features a quadratic dependence will be a separate component of it. Thereby, the equation of regression will have the following form:

$$y = b_o + b_1x_1 + b_2x_2 + b_{1,2}x_1x_2 + b_{1,1}x_1^2 + b_{2,2}x_2^2 \ . \qquad (2)$$

We receive three equations of regression of the aimed form with the help of method of the smallest squares (tabl. 4).

Received regression dependent variables are presented on fig. 1-3.

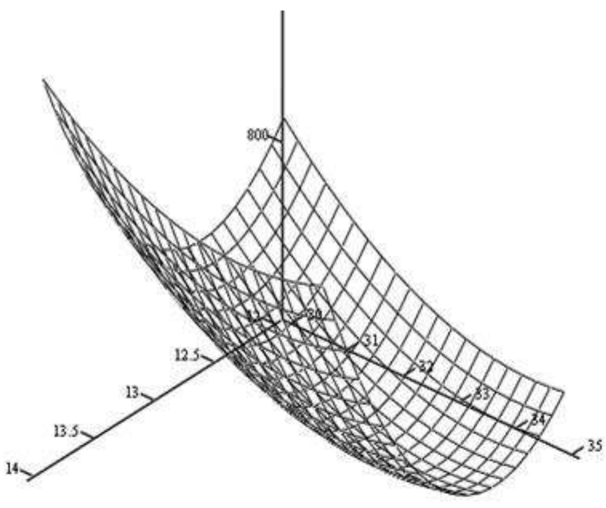

Fig. 1. The Dependence of the Dynamics of Companies Shares Prices of the Company A of the Prices of Companies B and C

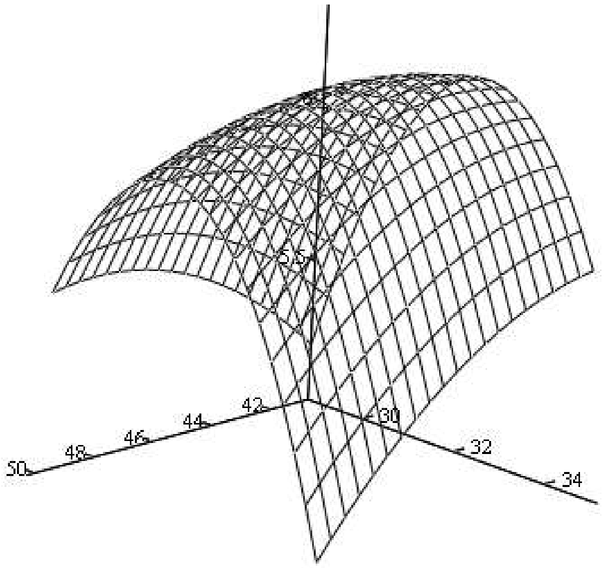

Fig. 2. The Dependence of the Shares of the Company C of the Shares Prices of the Companies A and B.

Notes: for the sake of comfort all the meanings of shares were made smaller tenfold, such a change does not influence the coefficients of regression (look at equality (3)), but it improves the image of the scheme of the given equation**.**

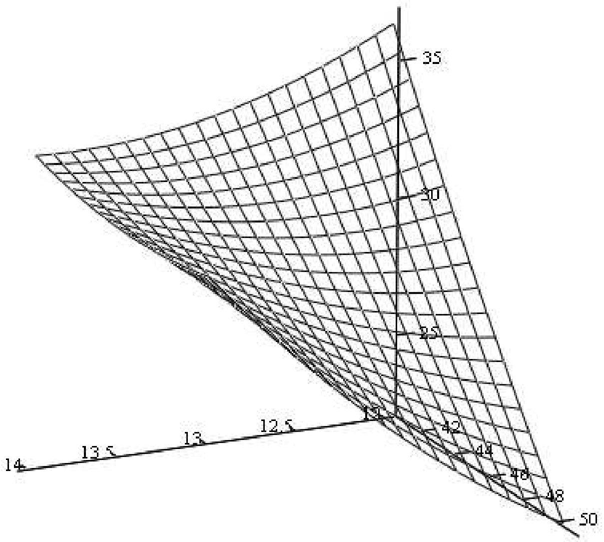

Fig. 3. The Dependence of Shares Prices of the Company B on the Dynamics of Shares Prices the Company A (changed according to the analogy to the fig. 2 (look the equality (4)) and *C*

Thereby, the fig. 1,2,3 provide the possibility to describe the character of investigated indexes dependence of one another. One can note that the fig. 2,3 are the most informative. They show that functional dependencies under research have precise extremes, that is why the dependencies presented on these pictures are the most prognostic (A and C companies shares prices). The equations which are the basis of fig. 2,3:

$$y = -118{,}45 + 1{,}26x_1 + 6{,}03x_2 -$$
$$-0{,}02x_1x_2 - 0{,}008x_1^2 - 0{,}08x_2^2, \quad (3)$$
$$y = 656{,}58 - 54{,}72x_1 - 11{,}62x_2 +$$
$$+0{,}69x_1x_2 + 0{,}96x_1^2 - 0{,}02x_2^2. \quad (4)$$

Thereby, we can judge the shares of A and C companies are suitable for portfolio investment. The investor who plans investing in a direct way will be more interested in the shares of the company B.

Further analysis may be fulfilled in a way of research of equation components influence importance on a particular endogen variable. This way, we reject unimportant variables (according to Student) and receive the following equations (tabl. 5).

As it is obvious, the equation of the company B price dependence may be considered absolutely useless for further application. Such marginal situation takes place for the reason that a very small amount of factors is analyzed. However, the given result testifies about an obvious conclusion: company B is independent of other companies A and C. That is why the investor who operates such relatively plain methods of time rows dynamics analysis and counts a small amount of information will conclude the following:

– A and C companies investments are profitable on condition of an investment portfolio formation(by the way, it is unnecessary to involve the shares of the company into it);

– when investor plans direct investment, the company B is the most appropriate choice out of the existing ones, since a large independence of competitors is its characteristics and a rather average level of risk is noticed(tabl. 3).

From the point of enterprise investment attraction it is appropriate to take into consideration the part of the company in the investment portfolio, formed out of the shares of three mentioned companies. We will count the structure of an investment portfolio for two types of operations: short (share sale) and long (share purchase). The simplest modern means of portfolio theory will be the most appropriate for this, the one formalized by Markovits. According to the level of profitability we choose 36,6 % of yearly or 0,1% of daily. As a result we receive such results B (x_{SHORT} – for a short position; x_{LONG} – for long position):

$$- \quad x_{SHORT} = \begin{bmatrix} 0{,}13 \\ 0{,}12 \\ 0{,}75 \\ 0{,}002 \\ 0{,}6 \cdot 10^{-4} \end{bmatrix}; x_{LONG} = \begin{bmatrix} -0{,}88 \\ 0{,}56 \\ 1{,}32 \\ -0{,}18 \\ 0{,}0002 \end{bmatrix}.$$

It is obvious the results for a long position is not acceptable, it testifies about the impossibility of the formation of portfolio out of the given shares for the given type of operations at the market and having the above mentioned level of daily profit. Having counted the other profitability one can be assured that an invest-

Table 5. Regression equations based on Student's criterion for determining the insignificant variables.

C(A,B)	$y = -118,45 + 0,13x_1 + 6,03x_2 - 0,02x_1x_2 - 0,08x_2^2$
B(C,A)	$y = -1,16x_2$
A(C,B)	$y = 20830,3 - 2278,7x_1 - 338,4x_2 - 83,53x_1^2 - 4,26x_2^2$

Table 6. The evaluation of predicted success of investment involvement mechanism by the companies under research.

Companies	**Direct investment**	**Portfolio investment**
A	Pessimistic prognosis**	An average expectancy prognosis**
B	Pessimistic prognosis	An average expectancy prognosis
C	*Optimistic prognosis**	Pessimistic prognosis***

*Notes: * an optimistic prognosis is an evaluation of investment involvement mechanism according to which there is a high probability of the fact that the company will involve a necessary amount of investment; ** an average expectancy prognosis is an average evaluation of how successful an investment involvement mechanism will be (such evaluation will be received when contradictory results of research are received being researched by different methods); *** pessimistic prognosis is an evaluation of investment involvement according to which there exists a low probability that an enterprise will involve a necessary amount of investment.*

ment portfolio out of the given shares possessing desired shape will be profitable only if a short position is opened. Taking into account the fact that investment involvement is possible only owing to long positions opening by the investor at the primary share market, then it is worth noting that the above mentioned companies will not interest a portfolio investor. From this point of view the shares of the company B may be considered as the most attractive for investors.

Thereby, having evaluated an investment attraction of three companies by the above mentioned means, let us define the evaluation of investment involvement mechanisms which can be applied by the companies mentioned. Well, as the analysis of three mentioned indexes provided contradictory results, we can show the following obvious results:

– involving the investment an enterprise is to choose the type of its investment attraction from the position of portfolio or direct investment and on this basis one is to build and apply a certain mechanism of investment involvement;

– investors orienting who are inclined to invest into the field where an enterprise-recipient functions is appropriate.

In this case we observe that in general the whole analysis shows that company B should be investor-oriented, who is inclined to invest directly. Companies B and C should apply investment involvement mechanisms from investors inclined to a portfolio investment. Mechanisms evaluation according to the grade “Optimistic prognosis”, “An average expectancy prognosis”, “Pessimistic prognosis” according to the analysis conducted are presented in the tabl.4.

As we see, the only optimistic prognosis of investment involvement mechanisms success is peculiar to the company B, however it is possible only when the company is a direct investment – oriented.On the basis of such supposition the investment involvement mechanisms evaluation for other companies were found out: direct and portfolio.

CONCLUSIONS

In the process of the given research conducting we have made an attempt of investment involvement mechanism evaluation on the basis of correlation of investment actually involved to a planned meaning of this index meaning, which is definitely possible on condition of the possession of the information about this mechanism application in the past. When retrospective data about investment involvement mechanisms are known, it is possible to apply versatile ways of actual investment amount meaning prognosis which are possible to involve. However, in this case there is a possibility to face the absence of enough amount of true information which complicates such analysis. That is why, we offered an economic investment involvement mechanisms on the basis of enterprise investment attraction definition which is a recipient.

It was analyzed the actual theoretical approaches towards the treatment of the notion entity of “investment attraction” and found out the absence of formalized means of mathematical analysis of the given index level. Taking into consideration the level of enterprise investment attraction we have presented the subsequence of shares prices time rows of three companies which are competitors whose investment attraction “in the eyes ” of a certain investor we were supposed to define. To simplify all that, we have consumed that given companies are one of the kind in their field and an investor has made a final decision to invest into this field. That is why we have skipped a great amount of information and simplified a mathematical apparatus of the analysis under consideration. As a result, we have found out the above mentioned companies investment attraction for an investor according to two positions: portfolio and direct investment. On the basis of these results we have analyzed the ability of investment involvement mechanisms to cope with the tasks imposed on them.

It is worth noting that further improvement of the given way of investment involvement mechanisms demands the research of a mathematical apparatus complication, the information amount rise for the analysis, the definition of new investor features for more precise results receiving.

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Mathematical model of the optimization of fire extinguishing time length in the woodworking enterprises` workshops

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Abstract. On the grounds of an analysis of the existing criteria of decision making during the fire extinguishing organization process the differential criteria is recommended for solving the optimization mathematical models. The mathematical model of the optimization of fire extinguishing time length in the woodworking enterprises` workshops is developed; it is based on the determination of a fire area during the time of its unobstructed development, the amount of the devices for the fire extinguishing agent supply, the amount of the fire and salvage units (hereinafter FSU), equipment and evacuation facilities, the duration of the fire isolation and extinguishing as well as its final liquidation. The Monte Carlo method is used for solving the mathematical optimization model. The solving of the mathematical optimization model is conducted by applying the computer_hardware and application program package, written in C++ language.

Key words: mathematical model, optimization, isolation, fire liquidation, fire extinguishing agent, fire extinguishing equipment.

INTRODUCTION

In order to solve the optimization problems, the issue of the optimization criterion selection occupies the first place after the adoption of the target function; the main provisions of the optimization criterion selection are considered within the framework of the decision making theory [1]. The total expenses in the form of the proximate fire damage and the expenses of FSUs on its liquidation were used for determining the fire damage in the works under number [2-4].

Nevertheless, for determining or forecasting such damage, the statistical data, similar to the investigated situation, is needed. Thus, the problem arises concerning the determining and adoption of the necessary criterion for solving the formulated optimization problem, the acceptance of which would not depend upon the statistical data.

Regarding the mathematical model of the optimization of a fire extinguishing time length in the woodworking enterprises` workshops, it may be stated that such optimization models have not been analyzed yet. There are regulatory documents for the approximate determining of the fire liquidation duration that incorporate the numerous statistical data [5]. However, such an approach cannot be substantiated in every particular case. Thus, the problem arises concerning more precise forecasting of a fire liquidation time by means of the development of the mathematical optimization model for determining the effective time for the fire extinguishing in the woodworking enterprises` workshops.

MATERIALS AND METHODS

In the work under number [6], the possibility of applying different decision making criteria for determining the forces and facilities the FSU needs for a fire response, is analyzed. The author analyses the following basic criteria: 1) minimax criterion (MM) as based on a pessimistic algorithm; 2) Baies-Laplace criterion; 3)

Savage`s criterion; 4) Hurwicz's criterion; 5) Hodges-Lehmann criterion; 6) Germeier`s criterion; 7) derivative criterion; 8) criterion of non-interaction; 9) optimistic criterion.

In order to make a decision concerning every aforementioned criterion it is necessary to elaborate a decision making matrix. One should introduce different possible variants of a fire spread and the appropriate variants of decision making with the proper amount of forces and facilities for fire liquidation into such a matrix. The appliance of these criteria for making a decision does not always yield rational results; nevertheless the sufficiently rational decisions may be obtained as based on them. Thus, for instance, an operations researcher T. Saati expresses his opinion regarding the decision making possibility as follows: "…an art of giving bad answers for those practical issues the answers for which, given by means of other methods, are much worse." [7]. In the works under number [8] and [9] the differential criterion was applied for the fire damage appraisal; the criterion include two partial criteria, namely the difference between the proximate fire damages B_o (the first partial criterion) and the expenses of FSUs that participated in its liquidation $B_п$ (the second partial criterion). The difference with regard to modulus should approximate the minimal value and as an exception it may equal zero.

The adoption of such a criterion may be substantiated on account of a general classification of the criterion problems [10]. The problems related to the fire liquidation pertain to the third class. A technical system should operate under different conditions, for each of which the quality of operating is defined by a partial criterion. The partial criteria in the problems of such a class possess the identical nature and dimensionality. The value of these partial criteria may be determined by the constraints for a class A fire presented in the work under number [8]. It should also be noted that the major part of fires in the woodworking enterprises` workshops pertain to the class A. Thus, it is reasonable to apply the criterion for solving the mathematical model of the optimization of fire extinguishing time length. Regarding the development of the mathematical model of the optimization of fire extinguishing time length in the woodworking enterprises` workshops it may be stated again that such optimization models have not been analyzed yet. However, the investigations concerning the determining of fire liquidation duration in relation to the amount of units of the appropriate fire extinguishing equipment were made [11].

The aim of the present paper is to develop the methodology of design and solving of the mathematical model of the optimization of fire extinguishing time length in the woodworking enterprises` workshops on the basis of theoretical and experimental investigations results.

RESULTS AND DISCUSSION

In order to substantiate the developing of mathematical model of the optimization of fire extinguishing time length in the woodworking enterprises` workshops, the predicted time since the moment of fire outbreak till the onset of its extinguishing by means of FSUs of the State Emergency Service (SES) of Ukraine will be determined, namely the predicted pre-burn time $\tau_{в.г}$:

$$\tau_{в.г} = \tau_{в.в}+\tau_{сп}+\tau_{о.о}+\tau_{з.с}+\tau_{зб}+\tau_{сл}+\tau_{роз}, \tag{1}$$

where: $\tau_{в.в}$ – designates the time since the moment of fire outbreak till the fire detection (in real terms the time varies from 4 to 8 min. [12]); an average value $\tau_{в.в}$ equals 6,5 min.; $\tau_{сп}$ – designates the time since the fire detection till the emergency call to FSU (3-4 min.) [12] (an average value of $\tau_{в.в}$ equals 3,5 min.); $\tau_{о.о}$ – designates the time for receiving and processing the call; $\tau_{о.о}$ = 1 min. [13]; $\tau_{з.с}$ – designates the time for mobilization of division forces and fire extinguishing facilities; $\tau_{з.с}$ = 3 min. (According to the Ministry of Internal Affairs of Ukraine order № 325 of 01.07.1993); $\tau_{зб}$ – the time of the fire service personnel assembly; $\tau_{зб}$ = 1 min. [13]; $\tau_{сл}$ – an average time for arriving at the fire scene; $\tau_{сл}$ = 13,9 min. (after the statistical processing of the results of the works under number [14, 15]); $\tau_{роз}$ – the time of operational deployment; $\tau_{роз}$ = 7 min. [12].

On the basis of the aforementioned statistical and regulatory data one may determine the average value of the pre-burn time length by means of the constraint (1):

$$\tau_{в.г} = 6{,}5+3{,}5+1+3+1+13{,}9+7 = 35{,}9 \text{ min.}$$

Whilst analyzing the obtained result one may draw a conclusion that the pre-burn time length is substantial enough that means during the mentioned period of time the burning object will suffer the substantial losses. For this purpose, the fire should be isolated and liquidated as soon as possible. Therefore, it is necessary to urgently develop the optimization model for the fire liquidation duration on the basis of the rational choice of forces and facilities for every fire class that in major cases reduces the damages for a burning object.

At the ***first*** stage the fire area during the pre-burn time is determined. It is based upon the main provisions of the fire spread theory. During the first 10 minutes rate of fire spread equals 0,5$v_л$, where $v_л$ – designates the linear rate of fire spread, m/min. If the time exceeds 10 minutes, the rate of fire spread equals $v_л$. In this case:

$$\tau_{в.г} = \tau_{в.г.1} + \tau_{в.г.2} ,$$

where: $\tau_{в.г.1} \le 10$ min.; $\tau_{в.г.2} > 10$ min.

Then, the radius of the fire spread appropriately equals:

$$R = R_1 + R_2 .$$

Under such conditions, the circular or angular fire area during the time of $\tau_{в.г} \le 10$ min. will be the following:

$$S_{\Pi 1} = 0,25 v_л^2 \tau_{в.г.1}^2 \alpha , \quad (2)$$

where: α – an angular coefficient that comprises the fire spread form: the circular form – 360º α = 3,14 rad; the angular form – 180º α = 1,57 rad; the angular form – 90º α = 0,785 rad.

The circular or angular fire spread area during the time of $\tau_{в.г}$ > 10 min. will be the following:

$$S_{\Pi} = S_{\Pi 1} + S_{\Pi 2} .$$

Then:

$$\begin{aligned} S_{\Pi} &= [0,25 v_л^2 \cdot 10^2 + (\tau_{в.г} - 10)^2 v_л^2]\alpha = \\ &= [25 + (\tau_{в.г} - 10)^2] v_л^2 \alpha. \end{aligned} \quad (3)$$

For the rectangular fire form with the width b_n provided that $\tau_{в.г} \le 10$ min., the fire area will be the following:

$$S_{\Pi 1} = 0,5 b_n v_л \tau_{в.г.1} . \quad (4)$$

On condition that $\tau_{в.г}$ > 10 min. the rectangular fire area will be the following:

$$S_{\Pi} = b_n v_л (\tau_{в.г} - 5) . \quad (5)$$

At the ***second*** stage the amount of the devices for the fire extinguishing agent supply to the point of fire outbreak is determined. For this purpose we will profit by recommendations of the works under number [16, 17]. On the grounds of the recommendations the amount of lances B for the fire extinguishing $(N_B^{\tilde{A}})$ and protection (N_B^3) is defined:

$$N_B^Г = \frac{Q_n^Г}{Q_B} , \quad (6)$$

$$N_B^3 = \frac{Q_n^3}{Q_B} , \quad (7)$$

where: $Q_n^Г$ i Q_n^3 – correspondingly designate the required predicted discharge of extinguishing agent for the fire extinguishing and protection l/sec.; Q_B – the extinguishing agent discharge of the lances B, l/sec. (provided that the extinguishing agent pressure equals 0,4 MPa and the bore diameter equals 13 mm *(d* = 13 mm), the discharge constitutes 3,7 l/sec.):

$$Q_n^Г = S_{\Pi} I_n^Г , \quad (8)$$

$$Q_n^3 = 0,25 K_з S_{\Pi} I_n^Г , \quad (9)$$

where: $I_n^Г$ – extinguishing agent application rate for the fire extinguishing, l/m²sec. (recommended value for the portable lances $I_n^Г$ = 0,2 l/sq.m per sec.); $K_з$ = 2,0…2,2 – a coefficient that comprises the extension of the protection area as compared to the fire area [11].

On the basis of the received data, the total amount of lances N_Σ for the fire liquidation is defined as follows:

$$N_\Sigma = N_B^Г + N_B^3 . \quad (10)$$

The defined value of N_Σ is rounded up to the whole number. Then, the amount of laces A (N_A) for fire extinguishing is calculated by the total amount of laces $N_B^Г$ as based on the recommendations [5]:

$$N_A = 0,3 N_B^Г . \quad (11)$$

Then, the total amount of laces N_B will be as follows:

$$N_B = N_\Sigma - N_A , \quad (12)$$

including the laces B for fire extinguishing:

$$N_B^Г = N_B - N_B^3 . \quad (13)$$

At the ***third*** stage the required number of the divisions $N_в$ for the fire liquidation is defined:

$$N_в = 0,25(2N_A + N_B + 0,17 N_\Sigma + 2) , \quad (14)$$

where: 0,25 – a coefficient that comprises an average amount of personnel of one division for the fire extinguishing (4 people); $2N_A$ – an amount of personnel for handling one lace A; 0,17 – a coefficient that comprises an amount of personnel for assisting a driver in setting adjusting the fire-fighting appliance for a water supply, for supervising the main lines, working for distributions etc.; 2 – an amount of personnel working at the safety and communication points.

The defined value of $N_в$ is rounded up to the whole number.

At the ***fourth*** stage the required amount of fire-service equipment is defined:

The total amount of:

– Pumper apparatus:

$$N_{п.а} = N_в , \quad (15)$$

– Special emergency vehicle:

$$N_{п.с} = 0,011 N_n \ge 1 , \quad (16)$$

where: N_n – the total amount of workers present in the workshop where the fire has broken out.

The defined value of $N_{п.с}$ is rounded up to the whole number.

The special emergency vehicles are used by FSUs that should have in theirs command the personal evacuation facilities and elastic trampoline.

At the ***fifth*** stage the time length of fire isolation, extinguishing and liquidation is determined. For this purpose, the results of a work under number [11] will be applied in the first approximation:

$$\tau_{лок} = \frac{6,39 S_{лок}^{0,893}}{2N_A + N_B^Г} K_I K_d , \quad (17)$$

where: $S_{лок}$ – an isolation area, m²; K_I – a coefficient that comprises the fire extinguishing agent application rate in the point of fire outbreak $I_n^Г$ (l/sq. m per sec); K_d – a coefficient that comprises the influence of a bore diameter *d* (mm) (the recommended value of the bore diameter for portable laces is 13 mm).

The values of the coefficients K_I i K_d may be determined by the constraints:

$$K_I = 1,62 - 3,04 I_n^Г , \quad (18)$$

$$K_d = 1,4983 - 0,0262 d . \quad (19)$$

The isolation area is determined, providing that the depth of the fire extinguishing agent supply to the point of fire outbreak for portable laces equals 5 m (h = 5 m) [5]:

– circular and angular fires:

$$S_{лок} = [2v_л(\tau_{в.г} - 5)h - h^2]\alpha \,, \quad (20)$$

– rectangular fire with the one-sided distribution:

$$S_{лок} = b_n h \,, \quad (21)$$

with the two-sided distribution:

$$S_{лок} = 2b_n h \,. \quad (22)$$

Then the time of fire extinguishing is defined $\tau_г$:

$$\tau_г = \tau_{лок}\left(\frac{S_П}{S_{лок}} - 1\right). \quad (23)$$

After that the time length of final fire extinguishing $\tau_{к.г}$ (the final liquidation of flashes after the fire extinguishing) by the constraint:

$$\tau_{к.г} = 0{,}25(\tau_{лок} + \tau_г). \quad (24)$$

On the grounds of the constraints (17), (23) and (24) the total time of the fire liquidation $\tau_л$ is defined:

$$\tau_л = \tau_{лок} + \tau_г + \tau_{к.г} \,. \quad (25)$$

At the ***sixth*** stage the computational method of the optimization differential criterion is defined. For this purpose we will profit by the recommendations of the work under number [9]. The fire damage appraisal is conducted by means of two partial criteria, namely the difference between the proximate fire damages B_o (the first partial criterion) and the expenses of FSUs that participated in its liquidation $B_п$ (the second partial criterion). The difference with regard to modulus, in the process of solving the mathematical optimization model, should approximate the minimal value and as an exception it may equal zero, i.e. it may be written as follows:

$$\left|\hat{A}_ï - \hat{A}_o\right| \Rightarrow \min \,. \quad (26)$$

The values of these criteria for a class A fire may be defined by the constraints:

$$\hat{A}_ï = C_{\hat{A}}\tau_ë^{-0{,}8725}, \text{ UAH} \quad (27)$$

$$B_o = C_o S_Ï \text{ , UAH} \quad (28)$$

where: C_B=1,68·10^5 – the proportionality coefficient [8]; C_o – an average price of 1 sq.m of the area of an object on which the fire has broken out, UAH/sq.m [18, 19].

At the ***seventh*** stage we will proceed with the development of the mathematical model of the optimization of fire extinguishing time length in the woodworking enterprise`s workshop. For this situation, the model is developed as follows:

the aim function

$$\tau_ë \Rightarrow \min, \quad (29)$$

by the criterion

$$\left|\hat{A}_ï - \hat{A}_o\right| \Rightarrow \min \,, \quad (30)$$

by the constraints

$$a_1 \le N_B^{\tilde{A}} \le b_1 \,, \quad (31)$$

$$a_2 \le N_B^{Ç} \le b_2 \,, \quad (32)$$

$$a_3 \le N_A \le b_3 \,, \quad (33)$$

$$a_4 \le \tau_{â.ã} \le b_4 \,, \quad (34)$$

$$p \ge [p], \quad (35)$$

where: a_1, a_2, a_3 – minimal values of the constraints, i.e. the currently available amount of the facilities and fire-extinguishing apparatus, that during the fire outbreak are on shift at the nearest fire station of FSU; a_4 – minimal predicted value of pre-burn time length, min.; the value a_4 may be defined by the constraint (1) involving such alterations:

$$a_4 = \tau_{в.г} = \tau_{в.в} + \tau_{сп} + \tau_{о.о} + \tau_{з.с} + \tau_{зб} + \tau_{сл} + \tau_{роз},$$

$$\tau_{в.в} = 5 \text{ хв}, \; \tau_{ñë} = \frac{60Lk_i}{V_{ñë}} \,,$$

where: L – the distance from the FSU to a point of fire outbreak, km; $k_н$ – a coefficient that comprises the unstraightness of a street network (in the practice of urban design its maximum value constitutes 1,4 ($k_н$ = 1,4); $V_{сл}$ – an average speed of fire vehicles, km/h (during the day time $V_{сл}$ = 32 km/h; during the night time – up to 60 km/h [20]); in this case:

$$a_4 = \frac{60Lk_i}{V_{ñë}} + 20{,}5 \text{ min}, \quad (36)$$

where: b_1, b_2, b_3 – maximum required values of limitations that are defined on the basis of computational constraints (6)…(13) that are specified at the second stage; b_4 – maximum statistical average value of pre-burn time:

$$b_4 = \frac{60Lk_i}{V_{ñë}} + 29 \text{ min}, \quad (37)$$

where: p – probability of penetration of the investigated probable point into the domain of feasibility; [p] – probability permissible value which influences the number of investigations for the adoption of an optimal value.

The Monte-Carlo method will be applied for solving the optimization model [21, 22]. The domain of feasibility, defined by the constraints (31)…(34), is encircled by m-dimensional parallelepiped in which the investigation is conducted. The most appropriate way of solving the formulated problem is to apply PC (personal computer). The sequence of pseudo-random numbers is developed μ_{ji} within the interval 0…1 by means of the computer transmitter. For the transformation of pseudo-random numbers μ_{ji} that are uniformly distributed in the interval 0…1 into the values $N_B^{\tilde{A}}$, $N_B^{Ç}$, $N_{\grave{A}}$ and $\tau_{в.г}$, the type of constraints as for instance for $N_{\grave{A}}$ is used:

$$N_{Ai} = a_3 + \mu_{3i}(b_3 - a_3)\,, \quad (38)$$

where: μ_{3i} – a pseudo-random number for determining the factor $N_{\grave{A}i}$ in a particular *i*-th calculation cycle.

In the process of calculation during every cycle of a programme operating the value $\tau_{л}$ is determined by a constraint (25) and the values of partial criteria are defined by the constraints (27) and (28) that are compared to the previous cycle values. These operations are conducted unless the condition (35) is satisfied. After the completion of programme operation, the following data is issued for publishing: $S_{П}$ at the beginning of a fire isolation, $\tau_{сл}$, $\tau_{л}$, $N_B^{\tilde{A}}$, $N_B^{Ç}$, $N_{\grave{A}}$, $N_{в}$, $N_{п.а}$, $N_{п.с}$, p.

In order to implement the optimization model, the application program package written in C^{++} language was designed for working with the OS Windows XP on a PC. The time of PC operating constituted 5…7 sec. for the 5 hundreds of trials (N_i − cycles) provided that the probability of penetration of the investigated i-th point into the domain of feasibility equals 0,94…0,96. (p = 0,94…0,96.)

CONCLUSIONS

1. The developed mathematical model of the optimization of fire extinguishing time length in the woodworking enterprises` workshops enables the immediate substantiated determining of forces and facilities for its liquidation.
2. The implementation of the mathematical model of the optimization of fire extinguishing time length into FSUs of the State Emergency Service enables the reducing of fire liquidation duration up to 38% and consequently enables the reducing of fire damages up to 26%.
3. The optimization model requires further development with regard to the equipping of FSUs with the latest fire extinguishing facilities.

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The peculiarities of enterprise innovational activity management system

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Abstract. This article outlines the peculiarities of management system analysis by innovational enterprise activity. Having analyzed the sources we have outlined the options according to which it is appropriate to apply such analysis. We have also offered optional parameters of management system evaluation by innovational activity and the importance of their consideration has been grounded.

Key words: innovations, innovational activity, innovation activity management system, parameters.

INTRODUCTION

An effective feature of a management system built by innovation activity are its acquiring stable competitive positions which are extremely important nowadays for both large and small enterprises of all the propriety forms.

Coordinated cooperation of all the elements of innovational activity system enables the rationality of the fulfillment of all the tasks. To exactly define the level of the innovational activity management system organization we need to analyze the system of enterprise management. In this case the necessity to define the ways and methods of innovational activity management system arises, since innovations and creative initiatives are the main vehicle of development and acquiring competitive preferences by the companies.

MATERIALS AND METHODS

The issue of management and enterprise innovational activity efficiency rise was investigated by: [1, 4,. 8, 17,. 21,. 23] etc. The issues connected to the realization of innovational activity at an enterprise have been well developed in the works by the above mentioned researchers. These are organizational aspects of innovational activity formation, economy and innovational activity organization, methods and ways of innovational activity evaluation results. Despite wide range research of enterprise innovation activity research certain aspects remained untouched by the researchers. The issues connected to the formation and evaluation of the systems of innovational activity management need more detailed research. Some views on the evaluation of management system including the system of management of innovational activity have been highlighted by [3; 8, 10, 12, 13, 14].

It is worth noting that the above mentioned researchers have not fully revealed the issue of the enterprise innovational system evaluation management. Thereby, the previous research [5; 7] showed that such issues solution connected to the formation and analysis of innovational system management may be considered as a separate essential factor of the development of both innovational activity and an enterprise itself on the whole.

RESULTS AND THEIR DISCUSSION

Every enterprise functions in harsh and changeable conditions. To survive and keep its positions at the market it is necessary to constantly analyze the activity of an enterprise on the whole and a management system which exists at a given enterprise as well. Innovational management system as any other system is characterized by certain parameters which contain the information about the features, state and the given system dimensions. «A parameter is a criterion relatively to which the evaluation and characteristics are realized» [2].

R.Fathutdinov defined the following parameters of the systems: 1) the parameters of product or service output (what should be produced, according to which indexes of quality, what are the expenditures, who is the customer, what is the deadline, who is the customer for sale and what is the price); 2) the parameters of admission (what resources and information for the process are necessary); 3) the parameters of the outer environment (political, economic, technological, social-demographic, cultural environments of the country of the region under consideration). A feedback is a communicational channel from the customers of the system to («output») the producers of the product and suppliers («admission») of the system. When the consumer's demands, market parameters are changed and novelties in technology and organization appear the «admission» of a system and the system itself must react to these alterations and make respective changes into the parameters of functioning [23].

The research conducted enable us to define the totality of innovational activity management system elements which can be presented as the parameters of the given system – management object (innovational activity); management subject(the head of the innovational activity department, innovational activity managers, other employees who have managerial functions in the very department); admission (finances, information, raw stuff, materials, energy, license, labor resources, law and norm support); output (innovational production, creative ideas, innovational technologies); management mechanism (administration aims, management functions, managerial decisions); outer environment (consumers, suppliers, inferiors, competitors, investors, law acts, the level of machines and technology).

The object of management or an innovational activity as such works the resources of innovational activity management system over, these are its admission elements. It also consumes and transforms them into output results of the functioning system. In other words it works them out, applies and spreads innovational products and technologies at the market.

Management subject is made up by management employees with certain dimensions of their activity, competence and the specificity of functions fulfilled as well as specificity of the functions fulfilled and also the totality of aims, functions and methods of management with the help of which a managerial influence is realized. The subject of management provides the employees with output results and ensures the provision of expected results at the stage of admission. The subject of management concludes about the activity of an object work and makes correction decisions on the basis of output results of innovational activity management system.

Innovational activity management system admission makes up the resources, elements (raw materials, energy, information, etc) which are disposed to processes and operations. The summation of external environment factors which influence the processes of the system under consideration and are not under direct management belong to the same innovational activity management system admission. Different instructions and other norms which ensure the placement and functioning of innovational activity management system are the elements of the system as well.

Innovational activity management system output is the product, service or other result of its activity. To achieve a maximum efficiency of the management system under consideration, its products, services and technologies are to satisfy a number of criteria which meet the demands of consumers.

The analysis of innovational activity management system of an enterprise is a complex and purposeful process which is directed into the identification of the state and tendencies of the main management system elements, managerial decision making process. According to Melnyk M. [14], an analysis makes up the basis for the evaluation and grounding of basic measures of imperfection and management results rise. It also allows achieving output data to evaluate a real level of management system, finding advanced methods and «weaknesses» in the process of management, also the choice of primary imperfection objects, management system development plans making accounting real system capabilities (financial, technical and resource supply, the staff with appropriate qualifications or the possibility of their hiring); formation of complex programs for management imperfection.

In literary sources [3; 10; 13; 14; 17; 25], a great importance is attached to the indexes which characterize management system. We share the authors' opinion, but we apply only those indexes which characterize the innovational activity managements system to a proper extent (tabl. 1).

Table 1. Indexes which characterize the system of enterprise system of innovation activity management*

№	Indexes names	Symbols
1	The index of ID management system functioning	I_{fe}
2	The index of economic work within the system of ID management	I_{ew}
3	The index of ID management system of the aims realization	I_{ir}
4	The indexes of management reliability within the system of ID	I_{mr}
5	The index of personnel employment in the apparatus of ID management	I_{pi}
6	The index of work efficiency of managerial personnel ID management	I_{mpwe}
7	The index of educational level of the personnel of ID system*	I_{deg}
8	The index of information applied in the ID management system usefulness	I_{iu}
9	The index of offered and realized novelties by the system of ID*	I_{is}
10	The index of franchising efficiency of ID system*	I_{fre}

* – suggested by authors.

The index of qualification degree (I_{deg}).The managers and employees who are in the head of personnel are the main element of innovational activity management system and they give exact tasks for certain periods, provide necessary conditions for their fulfillment. Under the analysis of a qualification degree of innovational activity management system the staff and managers of different level are provided. During this process the necessity of preparation, prequalifying and training are found out within the very system of management. In conclusion, to apply rationally the personnel important enough is the evaluation of their qualification. Under these circumstances, it is first of all possible to find out the relativity of qualification level to the demands suggested by norms. Respectively, to characterize innovational activity management system we suggest defining an index which will characterize the given system's appropriate personnel. To count the given index we take into consideration the educational level of the staff and also the fact of their training:

$$I_{\deg} = \frac{Q_{hed} + Q_{te}}{Q_{gen}}, \tag{1}$$

where: Q_{hed} – the quantity of people having higher and secondary education which corresponds to the profile of innovational activity management system of an enterprise; Q_{te} – the quantity of employees who had their training course throughout the last 3-5 years; Q_{gen} – is a general quantity of employees of innovational activity management system of an enterprise.

The index of a qualification level may be counted separately according to the categories of employees, for instance managers, researchers, workers, supervisors, etc.

The index of the applied information reward within the management system of innovational activity (I_{iu}) characterizes the importance of the information applied for the solution of the tasks aimed. The index of reward is generalized and counted with the following formulae:

$$I_{iu} = I_{iv} \cdot v_{iv} + I_{iru} \cdot v_{iru}, \tag{2}$$

where: I_{iv} – is an index of information value; I_{iru} – is an index of information rational use; v_{iv} and v_{iru} – are the coefficients of validity for value indexes and information rational use respectively.

During accounting of a reward index of the information applied it is advisable to count the coefficients of an index of reward validity and the index of information rational use. According to the research conducted the following condition will be in action:

$$v_{iv} + v_{iru} = 1, \tag{3}$$

The index of information reward (I_{iv}) characterizes the ability of this information to provide the object and subject of management with necessary conditions for their aim achievement. The given index is counted with the following formulae:

$$I_{iv} = \frac{I_v}{I_{tr}}, \tag{4}$$

where: I_v – is the quantity of information messages which turned out to be valuable for managerial decisions making; I_{tr} – the very quantity of informational messages out of general quantity of admission information which turned out to be true as a result of check.

The information rational use index characterizes the degree of fruitful use of information messages which appear in the system of innovational activity management and is counted with the formulae (I_{iru}):

$$I_{iru} = \frac{I_{ru}}{I_{tr}}, \tag{5}$$

where: I_{ru} – is the quantity of cases of informational messages rational use within the system of innovational activity management.

The authors of monographs [13; 14] count the information rational use index on the basis of accounting of general quantity of information messages which have been delivered to innovation activity management system of an enterprise. We consider it a necessity to use those information messages in accounting which have been verified.

During the analysis of innovational activity management system informational supply it is possible to evaluate the full range of informational supply therefore managers and employees' acquiring of the full and sufficient information, reliability of it; timeliness and purposefulness of information supply and its address correctness. Under these circumstances the evaluation of the information flow is also possible to fulfill.

The results of analysis of innovational activity management system information supply will allow concluding about the development of information bulks and the choice of rational forms of informational system organization.

Index of success of innovational activity of the novelties offered and realized by the innovational activity management system (I_{is}). This index characterizes the level of successful novelties out of their general quantity. The index is counted with the following formulae:

$$I_{is} = \frac{I_s}{I_{gen}}, \tag{6}$$

where: I_s – and the quality of novelties which were worked out and successfully realized by the system of innovational activity management system; I_{gen} – general quantity of novelties which were worked out and realized by the system of innovational activity management system of an enterprise.

Coming up with and realizing the useful and creative ideas the system of innovational activity management tries to provide the efficiency of each of them. The more successfully offered and realized creative ideas are there, the more efficient is the work of the system of management under consideration. The correspondence to the condition is the most perfect meaning of the index of success among the ideas offered and realized $I_{is} \approx 1$.

The index of franchising efficiency innovational activity management system of an enterprise is (I_{fre}). This index characterizes the interrelation of innovational activity management system with other enterprises. Such interrelation includes the use of know-hows, commercial secrets and enterprise non-material shares. Apart from that, this index allows other enterprises using non-material shares of an enterprise.

$$I_{fre} = \frac{F_e}{F_{gen}}, \tag{7}$$

where: F_e – are franchising deals which ensured the system of innovational activity an economic profit; F_{gen} – is a general quantity of the deals signed in terms of franchising.

The index of franchising success characterizes the success of innovational activity management system with other companies. The higher the meaning of this index, the greater an economic profit is from management system functioning.

The indexes offered characterize innovational activity management system and enable us to evaluate the given system of management in full range, define its state and development perspectives.

The innovational activity management system can be also characterized according to the parameters peculiar to the management system. As a result of scientific sources review [1; 6; 12; 15; 16; 18; 19; 20; 21; 22; 23; 24; 26], we can define the following innovational activity management system features, which provide innovational enterprise development (fig. 1).

It is worth considering the features of innovational activity management system offered previously. The first feature is integrity. The term ”integrity” presumes that the complex of elements is considered as a system and make up a whole which possesses general features and their own behavior. The deletion or replacement of at least one element may lead to efficiency decrease or even the collapse of innovational activity management system. Innovational activity management system analysis according to the following feature is rather important as all the systems are to operate in concord. The incapability of functioning of at least one element may damage the whole system of innovational activity management.

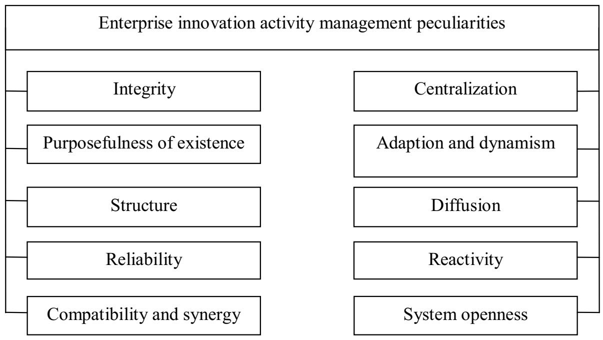

Fig. 1. Enterprise innovation activity management peculiarities*
*compiled by the authors on the basis of sources analysis.

The purposefulness of existing is an exact goal fixing of innovational activity management system which change with the time flow in dependence of the conditions and does not contradict to the general goals of enterprise. The feature under consideration means the concordance of goals of innovational activity management system with the aim of organization and decision making concerning novelties in the view of usefulness of enterprise. The analysis according to the given feature provides a constant correspondence among the goals and tasks of innovational activity management system of enterprise in general.

Structure is a complex of components and their connections within the system of innovational activity, it is to be mobile and able to easily get accustomed to the change of demands and goals of the very management system and enterprise on the whole. Connection trekking within the given system of management allows preventing from elements interaction which is inefficient for the system under consideration.

Innovational activity management system analysis, according to such features as reliability, reaction, adoption and dynamism allow defining the possibility of constant functioning of the given management system under any circumstances. Every enterprise functions under constant changes of outer and inner environment. That is why the ability to quickly react and get accustomed to any changes provides smooth effective functioning of innovational activity management system and enterprise on the whole.

Compatibility and synergy define the interrelation of innovational activity management system, mutual supplement of one another, the ability to get accustomed, not to contradict and provoke conflicts, mutual adapting to achieve the best result with the help of mutual direction of their actions. Innovational activity management system analysis according to the given feature provides an opportunity to find those elements which are inefficient in their work.

The analysis of centralization of the system of innovation activity provides the opportunity to avoid anarchy, irrationality, irresponsibility and impunity within the given management system.

Personnel's skills reconsider the information and define correctly its scope make up the effect of diffusion. Innovational activity management system analysis is rather important for the enterprise as the information received on time provides the efficiency of enterprise functioning. N.Heorhiady in her monograph [3] made a detailed research of informational management system supply. The author claims that «it is necessary to analyze the degree of managerial information security; the documents of informational management security; technological security of management activity; personnel security and the service of informational management system used». Methodological recommendations offered by N.Heorhiady enable us to evaluate actual level of information security of management system of enterprise.

Innovational activity management system analysis of openness is of the urgent importance, as interrelation and interdependence of the given system with other ones and outer environment are analyzed.

The reversibility of connection is a direct or mediate connection with the innovational activity management system and other systems of an enterprise. The connection which is qualitatively established provides innovational activity management system with the opportunity to timely get rid of existing deviations, prevent from new ones or lower their risk to none and also work out efficient measures of the system protection from negative influence of inner and outer environments of indecent competitiveness.

CONCLUSIONS

The analysis of management system by innovational activity enables us to find the drawbacks which were taken during both the formation of the very management system and its functioning. The analysis of innovational activity management system according to such parameters as object and subject of management, admission and output of the system, the mechanism of management and outer environment enable to find out the drawbacks of the system and prevent from negative outcome of their functioning. For instance, through the analysis of innovational activity management system admission a high quality of such resources as information, raw materials, personnel are provided which in its turn provides a high quality of an outcome of innovational activity management system, including novelties, creative ideas and innovational technologies.

The analysis of innovational activity management system according to its features enables us to find out that not the quantity of elements is essential in the system but the interrelation between them, the skills to work efficiently in concordance, interrelate with other systems of an enterprise and outer environment as well. Innovational activity management system inherence of the above mentioned features ensures its effective functioning nevertheless all possible unfavorable conditions in inner and outer environments of an enterprise.

The innovational activity management system analysis fulfillment according to all provided parameters is a background for decision making directed to its functioning.

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The monitoring mechanism of the intellectual technologies commercial potential

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Abstract. The theoretical and methodological foundations of intellectual technologies monitoring that are based on intellectual property are considered in the article. We prove that the evaluation of intellectual technologies market opportunities by the enterprise, the state of their target market, market changes on it to determine the position of the enterprise relatively goods analogs and substitute goods and identification of possible prospects and areas of intellectual development can be done very effectively using the principles and methods of economic monitoring. Methodical provision of monitoring commercial potential of intellectual property using the function of tangential economic effect is elaborated.

Key words: monitoring, commercial potential, smart technology, economic impact, transfer, commercialization.

INTRODUCTION

The monitoring system of production and business activities of industrial enterprises is an effective means to monitor and ensure the proper functioning of various economic objects and processes. This economic category is long enough and widely used in the field of production and business activities of industrial enterprises. Our studies show that the most frequent monitoring concept finds its use in environmental economics [1], in crisis management [2, 3], financial [4] and innovation activities [5, 6], monitoring market conditions [7,8].

Various aspects of research issues are presented in the works of local and foreign scientists: Pererva P.G. [2, 3, 11], Antonyk L. [9], Pervushyn V. [10], Shpak N. and Knyaz S. [12], Chernobay L. [13], Bazylevych V.D. [14], Kendyukhov O. [15], Glukhiv L.J. [16], Androsova O. and Cherep A. [17], Kletkina Y.A. [18], Tihonov N. [19], Kozyrev A.N. [20] and other. However, in our view, the theory and practice of monitoring can be very effectively implemented in other areas of the market of industrial activities, particularly to monitor processes of creation, economic evaluation, modification and management of intellectual activity (intellectual property) of innovation oriented industrial enterprises [8-11]. It should also be noted that the set of tasks related to the monitoring inspection scope of industrial market is not fully developed, methodological basis for monitoring the situation of the commodity market is not enough explored, its place and role in the management of market processes is not determined, there is virtually no organizational and methodological support for monitoring conditions, information links with the external environment are not optimized. The theoretical importance of these problems and their practical importance for the efficient operation of businesses, organizations has led to the choice of the article theme and determining range of issues that it investigates.

MATERIALS AND METHODS

The aim of the paper is to study guidelines for formation and implementation of monitoring of the intellectual property commercial potential in industrial enterprises and development of recommendations for its effective use. Theoretical and methodological basis of research are fundamental tenets of modern economic theory, scientific work and teaching of leading scientists in the field of intellectual property. To solve this problem by forming a mathematical model for monitoring market appeal intelligent technologies used methods of correlation and regression analysis and methods of economic-mathematical modeling.

RESULTS

The process of economic monitoring market opportunities of intellectual technologies (intellectual property) in order to improve the efficiency of its implementation is presented as a series of interrelated stages (*Fig. 1*).

Each of the present process stages (stages) is to some extent independent, but the systematic consideration of other stages (phases) of the monitoring process takes on a very different meaning, which, as it seems, can be called teamwork. This situation, in our opinion, can be explained by presence of the above principles of economic monitoring market prospects of intellectual technologies, in particular, the principles of integration, consistency and efficiency.

Our studies indicate that the accuracy and objectivity of the current state of the intellectual technology commercial potential is largely dependent on the potential economic impact E_{dev} which the technology developer can get at its commercialization and consumer of this technology – when using E_{cons}. Determining values of these effects, in our view, is appropriate during the entire lifecycle of intellectual technology. If there is a need to assess the effect of the annual user and developer, then its value can be calculated taking into account potentially effective lifetime of intellectual technology. It should be noted that these values E_{dev} and E_{cons} and over time change their values since, first, conditions and factors that characterize the developer environment and consumer technology change and, second, the conjunctural characteristics of technological market also change , thirdly, the qualitative characteristics of the technology and its potential opportunities can greatly vary.

Values E_{dev} and E_{cons}, or rather their ratio used are suggested to assess changes in the current market appeal (commercial building). To do this, in our opinion, tangential function F_1 should be used . Formation of this function, as evidenced by the experience of its use in crisis management [3,8,11] and market conditions management [7] should be used in two varieties:

$$\text{Option "A":}\quad F_1 = tg\,[\pi\,(E_{dev} - E_{cons})\,/\,4\,E_{dev}] \quad \text{if}\quad E_{dev} > E_{cons}\,. \tag{1}$$

$$\text{Option "B":}\quad F_1 = tg\,[\pi\,(E_{dev} - E_{cons})\,/\,4\,E_{cons}] \quad \text{if}\quad E_{cons} > E_{dev}\,. \tag{2}$$

Functions (1) and (2) can be considered both for the technological market of a particular company – in this case the overall effectiveness of the developer (firm, company) and the overall efficiency of potential users of the developer intellectual work results and for the company-developer specific intellectual products (technologies) – in this case the level of the market attractiveness of a particular technology is considered .

Certain restrictions for functions (1) and (2) is the fact that their use should be the condition:

$$(E_{dev} + E_{cons}) > 0. \tag{3}$$

The presence of such restriction (3) is explained by the fact that function F_1, which is offered for use both for the option "A" and option "B" provides analysis only of intellectual technologies which would be attractive for the whole business technology market (the developer and the consumer), or at least for one of them: either the developer (in this case, the technology envisages only its own consumption) or the consumer (in this case the technology provides only licensed version of commercialization, as their own consumption is inefficient). If the technology under study is not effective for either the developer or a potential customer, in this case there is no point for consideration and analysis.

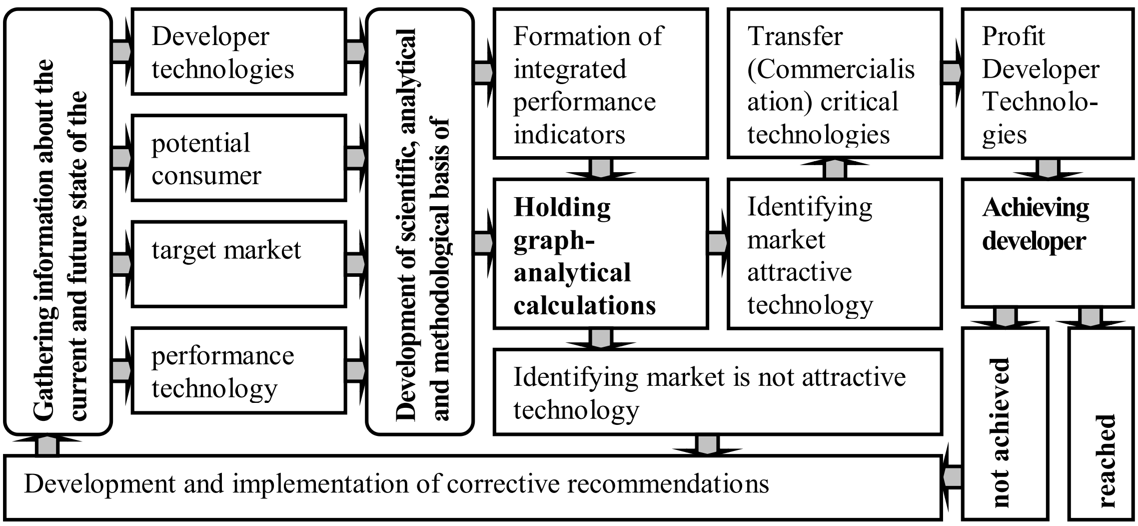

Fig. 1. The sequence of steps of intellectual technologies market appeal (commercial potential) monitoring
Note: developed by the author

Relations (1) and (2) can be presented more clearly using some transformations, then these features become easier for economic interpretation and further use of the form:

Option "A":

$$F_1 = tg\frac{\pi}{4}\left(\frac{E_{dev} - E_{cons}}{E_{dev}}\right) \to E_{dev} > E_{cons}\,, \quad (4)$$

Function F1 "A" is defined in the interval [0, 1].

Option "B":

$$F_1 = tg\frac{\pi}{4}\left(\frac{E_{dev} - E_{cons}}{E_{cons}}\right) \to E_{dev} < \quad E_{cons}\,. \quad (5)$$

Function F1 option "B" is defined in the interval [-1 , 0].

The choice of the functional form of the present model F_1 based on trigonometric tangent function requires some explanation and justification. Mathematical theory suggests that the tangential function, which is represented by functions (1) and (2) is defined in the interval [*-1, +1*]. In our view, the tangential nature of the function F_1 provides the greatest extent possible to restrict (normalize) the field of values in the range [*-1, +1*] and by the nonlinearity function F_1 it is made possible to track changes in the gradient of economic benefit from the development and use of intellectual technology in general and in the market of the technologies enterprise-developer, in particular.

Determining the economic substance of the tangential function F_1, which characterizes the ratio of economic benefit to the consumer and developer of intellectual technology, and economic characteristics of its most important values of reference points allows the researcher to obtain economically important characteristics for the monitoring performance purposes.

When choosing a functional form of model F_1, we proceeded from the premise that the function F_1 should simulate priority use of intellectual technology that reproduces, first, major environmental changes in the technology market, i.e. an increase in demand for technological product (reduced supply) the developer effect increases and vice versa, and second, the technologies developer and consumer effect largely reflects timeliness of sale or consumption of technological products. In the present form (models 1 and 2, 4 and 5) the function F_1 simulates (characterizes) as a positive trend from the developer ($E_{dev} > E_{cons}$) and consumer ($E_{cons} > E_{dev}$) of intellectual technology and possible difficulties both in the economic environment of the technology developer (decrease of E_{dev}) and in the environment of potential technology consumer (decrease of E_{cons}). Although equality between the effects of the developer and the consumer ($E_{dev} = E_{cons}$) is most desirable for any commodity market usually it is not the case and in the technology market we often see permanent tactical variations in one or another way. Taking into account the abovementioned, we can draw the following conclusion: some differences between the economic effects that the technologies developer gets at its commercialization and the technology consumer while using it, can be used for rationing characteristic trends and marketing strategies of the company-developer and the consumer company in determining market appeal of intellectual technology and determining its commercial potential.

The analysis suggests that the range of monitoring function values F_1 includes a number of very interesting reference values, each of them having its own economic foundations and describing certain economic conditions both as technology developer and its consumer environment. Our proposals on this matter can be combined in the following terms and generalizations.

1. State of market appeal and commercial potential of intellectual technology in which the monitoring function $F_1 = (-1)$. Monitoring function F_1 may have this value in an economic situation where there is no effect of the technology developer E_{dev}, but there is the economic effect of a potential consumer E_{cons}. A similar situation arises when F_1 function arguments have the following values: [$E_{dev} = 0;\ E_{cons} > 0$]. Under the analyzed function F_1 argument values the economic situation in intellectual technology developing enterprises environment reflect the situation when the in-house usage is either impossible or doesn't have appropriate areas of consumption, on the contrary, a potential consumer can use it efficiently. Although market prospects of technology in this situation are not satisfactory, because potential consumers are not commercially attractive for the technology developer (owner), and their price offers do not provide the technology developer (owner) a positive economic impact. The economic situation, which corresponds to the monitoring function $F_1 = (-1)$ can be called the "crisis of usage" In general, we can not determine such a monitoring function condition as positive. It appears that this condition reflects to some extent the negative trends in both the developer and the consumer of the intellectual technology, because it does not contain positive aspects of the current state of commercialization.

According to the results of our study, such a monitoring function condition with respect to the current state of the intellectual technology commercial prospects can be explained by the following reasons:

- a principally new technology that has not had broad areas of its practical use yet. This fact affects the current inability to consume the technology directly by the developer (there are neither processes nor installations, where the technology can be used), and potential existing customers (albeit in a small number), are unable to widely use this technology yet, thus offering a low price for it, that does not provide economic benefits to the technology developer. Such a technology commercial future seems to be very promising, but in many cases its arrival may have an extremely distant outlook**,**

– an obsolete technology that has already lost most of its areas of use. In this case, the technology developer (owner) has no way to effectively use it himself/herself (loss-making use), and some potential users still agree to purchase the technology from the developer (owner), but can not offer the developer (owner) a commercially attractive price. The technology is in the final stages of its life cycle and it may have prospects only in case of substituting a technologically advanced segment for a technologically outdated one, where outdated technologies may have commercial prospects,

– the developer (owner) and the potential consumer of intellectual technologies are in technologically opposite segments of the technology market. The developer's high commercial requests are inconsistent with modest financial capabilities of potential consumers. The technology commercial prospects can be increased by enhanced marketing development of more technologically significant technology market segments, consumer search, firstly, with larger financial resources and, secondly, with the possibility of the analyzed intellectual technology more widespread use.

Marketability (commercial potential) of the technology with the monitoring function , which corresponds to the monitoring function value $F_1 = (-1\ )$ – "Crisis of usage", is characterized by high ambiguity. Its current status is low, the prospects of changing it are highly dependent on the reasons that lead to the presence of such a condition. Promising commercial potential may have either a significant value (in case if this technology is principally new) or extremely low (an obsolete technology). It is possible also to change the attractiveness of the market in the nearest future if the technology developer (owner) can find potential customers in less technologically significant segments of the technology market. The transfer prospects of the technology at this stage of monitoring function are low and urgently need to be strengthened and developed, but the options available for this are usually quite small.

2. State of market appeal and commercial potential of intellectual technology in which the monitoring function F1 is in the range [-1 < F_1 < 0]. It is more favorable for the company – the developer (owner) Technology Transfer situation in which both the developer and the consumer process of commercializing technology brings economic benefits. However, the redistribution of this effect is made in favor of the consumer ($E_{cons} > E_{dev}$), due to a number of economic, social, political or environmental circumstances.

The economic situation, which corresponds to the function F_1 in the range from "-1" to "0" we call "dictatorship of the consumer" (options "passive consumer", "passive transfer"). This situation is generally consistent with the laws of development and function of the traditional market situation that economic theory is called "buyer's market" and is made at a time when the supply of certain goods exceeds demand. For technological product such a situation do not occur very often, because of the technological features of commodity market in most cases do not involve mass supply of goods due to its individuality and exclusive offers. To a certain extent we do not exclude the presence of the technology market two or more offers almost similar technology products developed by different teams (firms). Often there are technology – substitutes, which can also affect the tactical value to the technology market.

The situation in the transfer market , which corresponds to the function F_1 in the range from "-1" to "0", requires special attention top management of enterprise engineering and operational response to the changes that take place here. The fact that the company that sells technology there is no strong motivation to sell the technology as a deterrent acts in some way "unfair" redistribution of the commercial potential of the object transfer in favor of the consumer. Having this condition may be due to the following conditions of production and business activities in enterprises producer and consumer:

- main activity of the company is a venture-seller activity is the development and sale of intellectual products. Own use of results of intellectual labor firm has no plans, as wide production of high-tech products is not carried out , except for pilot production. In this case, the proportion in the division of economic benefit for the developer are not critical, more important is simply the sale of technology and provide the necessary scientific return on the size of the company, as some economic benefit the company still receives,

- financial and economic condition of the company, the seller is unstable and requires constant support. The company reserves no time to search for more commercially attractive customers for their technology and agree to deals with the distribution of existing economic effect that plays at this stage monitoring function F_1,

- consumer technology analyzed, with a sufficient number of alternative proposals (technology-analogues or substitutes) that can basically decide their industrial and entrepreneurial issues. Based on the standard laws of the market (supply exceeds demand), retailer of technology (software development firm or company owner) agrees with the distribution of the proportion effect technology for the consumer (buyer's technology).

The marketing activities of the company that owns the technology in the range of values monitoring function F_1, which is analyzed, primarily related to the implementation of the practical ability to find its technology consumer. Technology is a specific product that does not have physical deterioration, obsolescence but can occur very quickly . If in a given period of time technology market has been active from the developer of technology products and certain passivity on the part of consumers, retailers are left with no choice but to agree to the distribution of commercial effect of technology in favor of the consumer, which is the standard for the functioning of the traditional (non-technological) product. Moreover, in our opinion, in favor of the consumer is the conclusion of transfer agreements. If the user can over a period of time to get a better technology, losing some income from non During this period of time the technology, the developer can lose almost everything, because after a certain period of time technology can go a full line of obsolescence and converted into a scientific theory methodological development, practical value and commercial potential which will be close to zero.

3. State of market appeal and commercial potential of intellectual technology in which the monitoring function F_1 = 0. The situation, in which the developer and potential customers are with this value of monitoring function, in our opinion, is rather attractive, as in this case there are no trends toward changing. The practice of technology transfer points that this situation although being favorable (like market equilibrium in the market of traditional products), as a rule, is short-termed.

It reflects the situation when the economic benefits of the developer and consumer technology intellectual match ($E_{dev} = E_{cons}$), i.e. the market situation of this technology is in state of *fair transfer*. Such a condition is usually aspired by all actors (developers and consumers) of technology market, because in this situation the developer of technology of products has no obvious short-term problems and consumer of technology is definitely satisfied with fair distribution of commercial potential. However, a detailed analysis of this situation in the transfer market of certain technology points that in some cases this tranquility there may hide some negative trends. We are going to consider some of them that are, in our view, the most appropriate to of modern technological market.

Firstly, the situation of market equilibrium in the distribution of economic impact of technological development and consumer product ($E_{dev} = E_{cons}$) often corresponds to the central stages of the life cycle of intellectual technology (the period of commercial success of technology in the transfer market when the product technology is in the zenith of its fame) which will inevitably be followed by the declining interest among potential customers to this technology. It is extremely important for the developer (owner, seller) of technology not to miss the moment of transfer and be ready for it. If the transfer agreement isn't signed at that moment, the following situations can lead to a redistribution of economic benefits in favor of the consumer of technology (a situation in which the monitoring function F_1 is within the limits of [$-1 < F_1 < 0$]), or the developer would get no profit from this technology (a situation in which the monitoring function $F_1 = 0$) or even lead to financial losses (the cost of financing the development of intellectual technology will not be reimbursed).

Secondly, in case of transfer failure, the developer is recommended to prepare an updated version of the technology that would be more responsive to the demands and needs of potential consumers whose attitude to the existing technology has definitely changed. Studies in this area show that it is quite difficult scientific, engineering, technological, production and market work and shortcomings in this area can significantly affect the future success of innovative companies.

Thirdly, we should clearly understand whether the present state of technological product matches the situation described by the monitoring function, whether unused marketing and unrealized market opportunities are not hidden behind this seemingly prosperous state ($E_{dev} = E_{cons}$). As matching of the state argument $E_{dev} = E_{cons}$ can occur, for example, because of bad-quality conducting of a marketing campaign, the results of which do not completely reflect the real situation, i.e. ratios of trends in the economic conditions of the company-developer and company-user that have developed lately are not clearly reflected.

Depending on the type of the actual situation (options which we have considered above), the developer (owner, seller) of technological product can make appropriate decisions. If the current state of the economic environment of developer and potential customers is valued correctly, marketing program is developed and conducted at an acceptable level, without errors and ungrounded decisions, the transfer situation could be considered as quite acceptable and can be completely implemented.

4. State of market appeal and commercial potential of intellectual technology in which the monitoring function F1 is within the limits of [$1 < F_1 < 0$].

This value of monitoring function F_1 concerning technological product, the analysis of which is held, can take reallocate total economic impact of the development and use of technology for the benefit of its developer ($E_{dev} > E_{cons}$). This transfer situation in the technology market can occur quite frequently under different (not necessarily economic) conditions. The considered transfer situation with intellectual technology we propose to call "*active transfer*" and it can include both positive and negative in some way points which are worth analyzing in detail and considering when transfer operations take place.

The transfer situation, considering a particular technology product, inherently meets the laws of development and functioning of traditional market conditions that are called "seller's market" in economic theory when the supply of certain goods exceeds demand. As we have noted above, situations for this type of technology product do not appear very often, because market features of technology goods in most cases do not involve mass demand for technology goods in connection with its individuality and exclusive offers. If the availability in the technology market of two or more offers of almost similar technology products developed by different teams (firms) is quite rare, the presence of two or more firms wishing to acquire the same technology is a phenomenon quite common even on a specific technology market.

Therefore, in our opinion, the monitoring function F_1, which is within the limits of [$1 < F_1 < 0$], reflects one or more of the following conditions of the economic environment of developer and potential consumer of technology products:

- situation that takes place in the distribution of economic benefit in favor of the developer of technological product ($E_{dev} > E_{cons}$), often corresponding to the initial stages of the life cycle of intellectual technology, the risk of successful completion is quite high. About considerable commercial advantages of using this technology potential consumers know not enough yet, and marketing service of the developer can, to some extent, overrate certain production effects related to practical use of intellectual technology;
- potential consumers are sufficiently aware of the potentially important advantages of this production technology, recognize and accept them, and expressed willingness to transfer transaction on terms attractive enough for the developer of technological product. This situation, in our opinion, is the most attractive to the developer and it is recommended immediately to use fully, i.e. to complete the transfer operation;
- dynamics of short-term relationships in the technology market is in enhancing stage (demand for technology exceeds the relevant proposals raised by the market equilibrium, some technological demand remains unsatisfied by developers), unsatisfactory for consumers technology product price situation is formed in the market, which market has been investigated, manufacturers (distributors, resellers) sell their products at higher prices, i.e. the situation is in favor of the developer (owner, seller) of technology products.

Along with above-mentioned positive trends that characterize the transfer situation in the technology market, which we propose to call "active transfer", there may take place a situation when this technology is at the final stages of its life cycle, the majority of potential users of this technology product (especially with large volumes of production using intellectual technologies) have left this market and switched to more advanced and more modern technology in terms of science and technology. However, the consumer needs to have this technology, and the proposals for the implementation of transfer transactions are taking place. The volume of these requests currently has significant value which exceeds the capabilities of developers. On these assumptions, even at the final stages of the product lifecycle process we could have up-conjuncture situation that is in favor of the seller (developer, owner, licensor) of Intellectual technology.

The value of the commercial potential of Intellectual technology in the analyzed condition of monitoring function F_1 allows the company-developer to pursue active transfer policy, to achieve pre-set business objectives of the activities associated with this technology product. In this limit of values of monitoring function the developer is recommended to perform the following marketing activities:

– conduct an active market search of potential users of the technology product,

– assess the maximum possible values of economic effect E_{dev} for each possible consumer, while the consumer would agree to transfer Intellectual technology,

– perform a transfer operation that will ensure that criteria conditions of technology transfer for the developer (owner , seller, licensor) of technology:

$$(E_{dev} - E_{cons}) \rightarrow max$$

or

$$E_{dev} \rightarrow max.$$

In our opinion, criteria condition $E_{dev} \rightarrow max$ is more acceptable in comparison with the condition $(E_{dev} - E_{cons}) \rightarrow max$. We have come to this conclusion because the two criteria conditions are equival if the overall effect E_{com} (commercial technological potential) is constant, i.e. E_{com} $(E_{dev} + E_{cons})$ = const. But there may also be other conditions:

a) the value of the commercial technological potential E_{com} tends to increase. In this case market situation may change in favor of the developer, if a potential customer will be satisfied with the absolute value of its economic effect E_{cons}, and in favour of consumers – if the developer agrees to continue to implement technology transfer on terms of the initial value E_{dev}. This market situation in general is positive and the implementation of transfer operations is quite probable,

b) the value of the commercial technological potential E_{com} tends to decrease. This is a less favorable situation, as in this case the developer or potential consumer (or both of them at the same time) for the transfer operation must agree with some decrease in the value of economic effect, which was planned before. This is not a straightforward market situation, which carries a significant market and economic risks and requires further detailed analysis and studies, the probability of realization of transfer transactions of this technological product under these conditions tends to downsize and the developer should become more active to achieve the desired result.

It is also very important that with this approach, commercial interests of the developer are on the first place in the transfer process and the commercial interests of the consumer are on the last place. Therefore, developers should take into account the fragility of the state of the consumer, when it is possible to make transfer in favorable for developer way, and make this technology transfer operation as soon as possible. This conclusion is proved by the fact that the conjunctural situation of the technological market, which corresponds to the limit of value of monitoring function F_1 [$1 < F_1 < 0$], can change dramatically, because there are a lot of reasons that are market attractive for developers of new technology products, increased competition, changes in short-term expectations and, consequently, the changing relationship between economic effects of developer E_{dev} and consumer E_{cons} of this technological product in favor of potential customers.

5. State of market appeal and commercial potential of intellectual technology in which the monitoring function $F_1 = (+1)$. To achieve this state of monitoring field the arguments of tangential monitoring function F_1 should be in the following states: economic benefit which the potential consumer of the intellectual technology has E_{cons} is almost entirely absent, but for the developer (selelr, owner) the value of this indicator (economic benefit of the developer) is positive, i.e. [$E_{cons} = 0$, $E_{dev} > 0$].

The current transfer situation in the technological market, rather frequently occurs in the practice of not only research-oriented enterprises, but also in the practice of industrial and business activities of most industrial firms. In this case, we mean scientific researches and developments of scientific, engineering and technological organisation units for their own use or for internal transfer (if it is a production firm of several relatively independent companies). Accordingly, the monitoring situation in the transfer market, which is analyzed, is proposed to be called “internal transfer”. This state of a technological product can be in these market-production situations.

1. To some extent a company holds a monopoly of intended end-use products production, with no competitors or explicit substitutes. In this case, intellectual technologies related to improving the quality of the product or its production process, generate no interest for external users because of the lack of technological interest for them. The company uses scientific researches only to meet its own needs, as an attempt to conduct a technological transfer (if a company has such a desire) is almost impossible because of the complete lack of demand for scientific development. The only way to conduct an effective transfer to the consumer in this case is possible only when the company sells its business with its scientific and technological support.

2. The company does not hold a monopoly of production, in the market there are competitors that produce similar goods as well as goods-substitutes. The level of competition is significant and the company has to make considerable efforts to maintain its market position (market share) under such conditions. In this case, the company considers a new technological development as a competitive advantage that enables it to strengthen its competitive position. External transfer of the technology is not considered by the management, as in this case, positions of competitors can be enhanced, and the market position of the company can deteriorate. The real demand for this technological product is missing (although the potential demand and the potential consumer effect in case of its satisfaction can take place) because of the lack of real demand.

3. For the practical use of this technological product it is necessary to have a unique equipment, certain economic output, special knowledge and specially trained personnel and basic maintenance staff, etc. All these additional conditions make transfer offers of an enterprise-developer unattractive to a potential consumer, who has no indicated conditions of efficient Intellectual technology use or has them in part. In this case, all current transfer prospects of intellectual technology today is almost impossible, their appeal may arise only in a long-term prospect.

4. The company produces an outdated products that are in the final stages of their life cycle and are already taken out of the production by the main producers. However, in the market there is still a demand of retrograde people (conservatives), who provide the company with effective production of obsolete products. According to these theses, scientific researches of companies that directly relate to improving the quality of old products or their production process, are not of a lively interest any more for those producers who are still in this goods market, and especially for those producers who have already taken these products out of production.

5. The company production is currently the world's scientific and technological leader. Its production currently is hardly accessible for other competing

producers, strong enough though they may be in scientific and technological sense. Therefore, researches and developments concerned with the production and use of these products do not constitute an urgent need to obtain certain competitive advantages and effects of production or consumption in this stage of development of scientific and technological progress. For an effective use of these developments appropriate conditions and circumstances have not been created yet. However, it should be noted that this situation can be changed dramatically very soon, as the main competitors of the company (the technological leader of the leader) are actively working on technological improvement of both the products and processes of production .

As we have already stated, the transfer situation with a specific intellectual technology, which corresponds to the monitoring function $F_1 = (1)$ is rather common. Moreover, it can occur even in cases when the technology can be much in demand, when there are prerequisites for its effective use in other businesses (not necessarily competing), but the company-developer does not even consider the possibility of transfer, focusing all attention on its own (in terms of the most effective enterprise) consumption of this technological development.

According to the analysis of the set of possible monitoring function F_1 values final conclusions and generalizations should be made.

First, in the present state offered for the use a tangential function F_1 allows scientific and innovative enterprises to monitor permanently the current state of the market-transfer prospects of intellectual technologies (intellectual property, results of innovation).

Second, the results of this analysis form the science-based foundation for the development of transfer prospects of technological products, which is extremely important in the preparation of perspective plans of scientific and business activity of the intellectual products enterprise-developer.

Third, the set of monitoring function F_1 values allows to detect and identify many important intervals, each of which may find its interpretation from an economic point of view. Each of these intervals can be defined as a kind of a current and future plan of the intellectual technologies enterprise-developer in terms of their transfer prospects.

According to the conclusions and generalizations the following theses in the activity of the company-developer of intellectual products can be asserted. If the set of calculated monitoring function F_1 values is close to (-1), it can be concluded that the developer makes insufficient efforts to intensify transfer operations. Approximation of the function F_1 to zero reflects stability in the enterprise developer currently and its fairly stable market positions in future. Disturbing moments can take place in the enterprise-developer water when the value of the tangential monitoring function F_1 tends to (1).

The main values of the tangential monitoring function F_1 in terms of evaluation of the market prospects (commercial building) of intellectual technologies which in many aspects determine the transfer policy of the enterprise-developer of technologies and have been analyzed in detail above, are presented in Table 1.

Table 1. Economic characteristics of the set of tangential monitoring function F_1 values

Transfer technology trends Calculated	Calculated value of the function *F1*	Current status of the arguments of F_1		Expanded description of market attractiveness (commercial potential) of intellectual technology
		E_{dev}	E_{cons}	
Nonprofit transfer	$F_1 = 1$	$E_{dev} = 0$	$E_{cons} > 0$	Intelligent technology currently can perform social and ecological functions. The developer does not receive direct financial benefits staying satisfied with Promo achievements.
Passive transfer	$1 < F_1 < 0$	$E_{dev} < E_{cons}$	$E_{cons} > E_{dev}$	Transfer positions of the technology development are not active, the developer does not hurry to perform the transfer operation, trying to persuade consumers of more attractive prices for Developers
Just transfer	$F_1 = 0$	$E_{dev} = E_{cons}$	$E_{cons} = E_{dev}$	The equally advantageous transfer operation for the consumer and developer. Transfer realization promotes further commercial relationship between consumers and developers of technology.
Active transfer	$(-1) < F_1 < 0$	$E_{dev} > E_{cons}$	$E_{cons} < E_{dev}$	The situation is in favor of the developer of technological product that will make the maximum effort to use it as regards the implementation of transfer operations
Internal transfer	$F_1 = (-1)$	$E_{dev} > 0$	$E_{cons} = 0$	External customers are not interested in the technology. Effective use of technology product is possible only through internal transfer

CONCLUSIONS AND PROSPECTS OF FUTURE RESEARCH

1.Using tangential monitoring function F_1 for the purposes of analysis and assessment of market attractiveness (commercial building) of intellectual technologies, we believe, can provide sufficiently objective data to form an idea about the market state of each process product developed in the company, which has the potential for the practical use to improve the products produced by this or other companies, or processes of production.

2. The results of the monitoring process of the product allow developers to create its transfer program, taking into account both current, and prospect transfer opportunities as well as possibilities for their further improvement.

3. The proposed concept of monitoring significantly expands the company on the effective use of existing intellectual potential.

4. Propositions were successfully introduced by the author in the practice of Ukrainian scientific and industrial enterprises.

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Specifics of self-commercialization of innovative products by machine-building companies

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Abstract. Scientific literature considering modes and methods of enterprises innovative products commercialization was analyzed in the article. Also authors' opinions about commercialization of innovative products by manufacturing companies through using the products for own needs were described. Based on the information from the studied literature and statistical data was concluded that the most appropriate and most popular method of commercializing innovative products by machine-building companies is using the products for the needs of the company (for internal needs or for product sales). However, this method has significant advantages as well as partial disadvantages expressed in certain risks occurring during commercialization process implementation. To provide clearer understanding of these issues the article describes the special features of the aforementioned method in accordance with business objectives and conditions of use in the enterprise.

Key words: commercialization, innovative products, modes and methods of commercialization, self-commercialization, machine-building companies

INTRODUCTION

Commercialization of innovative products is one of the key stages in the innovation process as it delivers competitive advantages to a company. Commercialization of innovative products allows for the product market launch aiming at economic benefits.

Commercialization of innovative products manufactured by machine-building companies can be implemented in following modes: independently by a company manufacturing innovative products; jointly with the commercialization company (engaging outsourcing company (or several companies) that will be responsible for commercialization process (certain stages of the process); and in a mixed mode (combining the two previous modes). Whereas, the relevant methods for self-commercialization of innovative products include: the use of products for the company's needs (for internal needs; for product sales); establishing a subsidiary and the sale of patent rights. These methods are most suitable for that particular mode as it is appropriate and practicable for a company to undertake them alone.

The most suitable method of commercialization of innovative products by manufacturing companies is using them for the company's needs (for internal needs or for product sales). This statement is supported by statistics and scientific sources. The method is aimed at maximizing profits and keeping all information related to innovation within the company. But the unassisted sale of innovative products is a quite risky method of commercialization, as it requires full support with the company resources at all stages of the process. In case of incompetent commercialization, the company may incur significant losses. A clear knowledge and understanding of the positive and negative aspects of the above method may help the company to assess benefits and predict possible risks of commercialization of innovative products.

MATERIALS AND METHODS

Commercialization of innovation, in particular its modes and methods, is an urgent problem which is actively studied in contemporary scientific literature. The scientists studying the modes and methods of commercialization include [2, 4, 6, 11, 12, 19, 20, 21, 22,] et al.

Bliznichenko M.O. and Marchenko Z. I. [2] claim that the use of innovative products for own business brings an owner maximum profit resulting from the products sale and monopolistic ownership. At the same time the authors note that while using this commercialization method the company may incur substantial costs associated with the arranging of manufacturing process, marketing, sales, etc. [11] support the statement that the use of innovative products for own business is the most profitable option. The authors, however, note that while using innovative products for own business, added value will consist of two components: a portion of the value that is part of the intellectual capital obtained in pure form, and the rest of the surplus value derived from sales of innovative products together with using intellectual capital in pure form.

This statement is also supported by [19]. The author notes that in terms of profitability, commercialization through the use of innovation for own business is the most effective method. He asserts that this commercialization method is accompanied by significant risks and is quite costly. It is difficult to quarrel with this statement while a company practicing self-commercialization remains fully responsible for result as it administers the entire process without any assistance.

So, the cited authors' opinion confirms that the most profitable and effective method is self-commercialization of innovative products by manufacturing companies through using the products for own needs. This fact is also confirmed by the relevant statistics. The analysis of the distribution of innovation funding in industry (Table 1) allows the statement that the main source of innovation funding are own funds, which share significantly increased in 2013 and accounted for 72.9% of total costs (63.9% in 2012).

10 companies received state financial support from national budget and 24 companies from local budgets, totaling 1.9% (2.2% in 2012 respectively). However, state involvement in the innovative development of the country should be much higher as the public sector is also interested to improve the state position on the world stage. 12 companies received funds from domestic investors and 12 from foreign, which consisted 1.3% and 13.1% (1.3% and 8.7% in 2012 respectively). The poor investment in innovation process can be explained by various factors, including the deteriorating economic and political situation in the country, increasing distrust of foreign investors to the Ukrainian market, etc. 55 companies took advantage of credit facilities in 2013 which accounted for 6.6% (21.0% in 2012 respectively). According to statistics data [10, 13, 14, 17] the main source of innovation financing are own funds, which indicates that companies practice self-commercialization of innovation.

Besides, [21] in his book The introduction of scientific and technological results into commerce provides the following interesting information on innovation commercialization by different means (Table 2). As the table shows, the least effective way of commercialization is to sell information about the development. This can be explained by the fact that the result that innovation can bring will be much more valuable collectively than just the information about the relevant idea. Also, while selling the information a company loses rights to the innovation.

Table 1. Breakdown for innovation funding by sources, %

Funding sources	Year		
	2011	2012	2013
Own funds	52.9	63.9	72.9
Credits	38.3	21	6.6
Home and foreign investors' funds	0.7	10	14.4
Funds from state and local budgets	1.1	2.2	1.9
Other sources	7	3.1	4.2

* Source [10]

Table 2. Economic efficiency of different methods of commercialization

#	Commercialization method	Economic efficiency, USD
1	Selling information relating to the development	5,000 – 20,000
2	Assignment of rights to use intellectual property	15,000 – 50,000
3	Using innovation in own company	All profits remain within the company
4	Growing business for sale to other corporations	500,000 – 2,000,000
5	Growing businesses for sale on the stock exchange	Over 10,000,000

* Source: [21]

In turn, assignment of rights to use intellectual property is more cost-effective, nevertheless it is not the most efficient way as the information about innovation becomes disclosed and the company loses privacy. The author also highlights such commercialization methods as “growing business for sale” to a big company and for sale on the stock exchange. These methods are the most profitable. However, the use of intellectual property rights for own business allows all profits from innovation remain within the organization, which in turn can be more cost-effective than the sale of the business. If necessary, the company may sell it at any time.

Based on the information from the scientific literature [2, 6, 7, 11, 19, 21] and statistical data [10, 13, 14] it can be concluded that the commercialization of innovative products by machine-building companies through the use of the products for their own needs (for internal needs or for product sales) is the most appropriate method of commercialization. However, this method has significant advantages as well as partial disadvantages expressed in certain risks occurring during commercialization.

RESULTS AND DISCUSSION

Based on the information from the studied literature and statistical data it can be argued that the most appropriate and most popular method of commercializing innovative products by machine-building companies is using the products for the needs of the company (for internal needs or for product sales) (see Fig. 1).

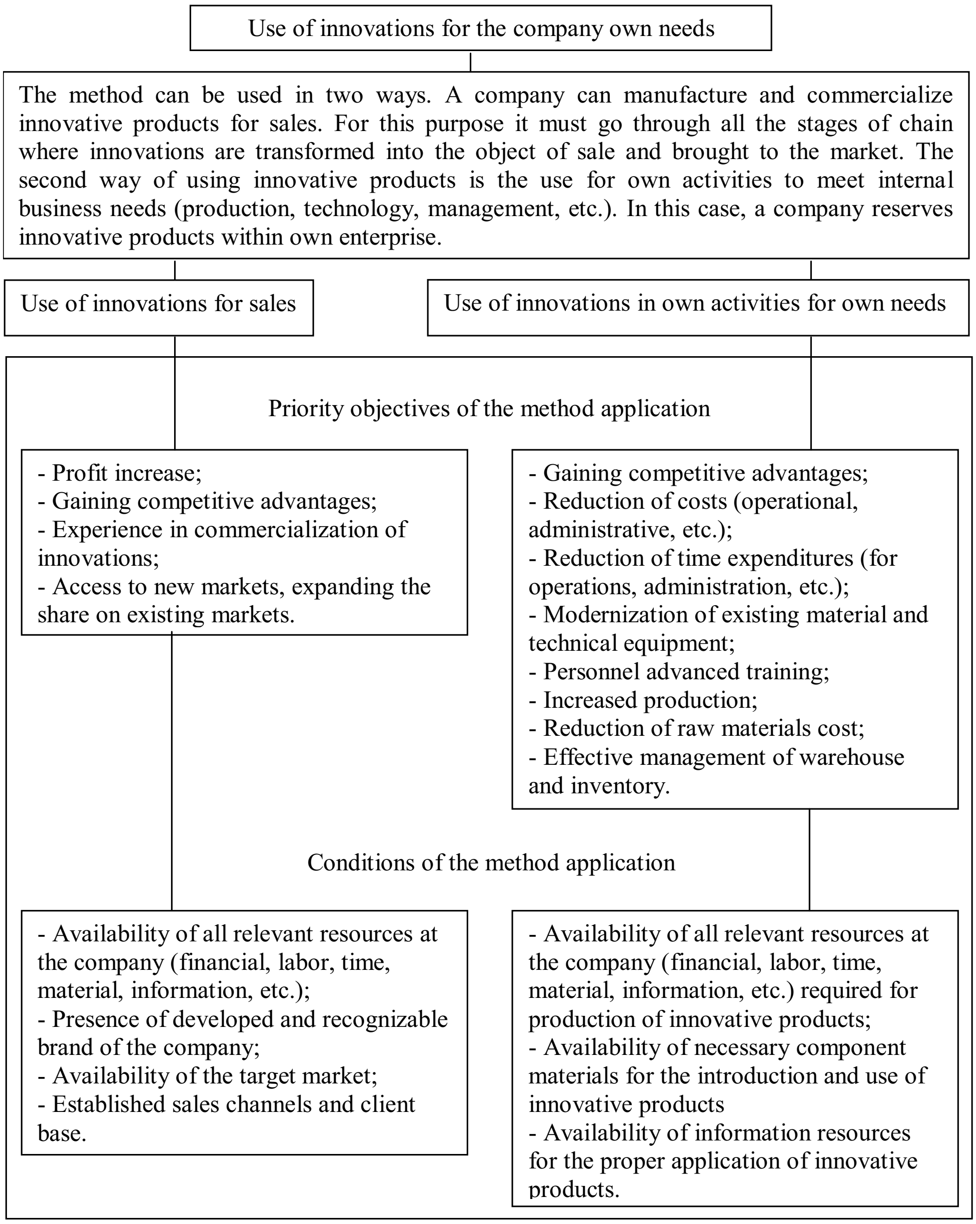

Fig. 1. Commercialization of innovative products by machine-building companies through using the products for company own needs

Table 3. Stages of innovative products sales by machine-building companies

Stages of innovative products sales by machine-building companies	Description of stages of innovative products sales by machine-building companies
1. Gathering information on relevant products market	– Identifying the needs of the market; – Determining the market capacity; – Detecting products similar to innovative products by their functional properties; – Identifying the domestic market potential; – Identifying opportunities for entering foreign markets.
2. Assessment of company resource capabilities for self-commercialization	– Availability of financial resources (available funds for commercialization, ability to obtain a loan, availability of liquid assets); – Availability of labor resources (qualified staff experienced in commercialization of innovation (marketing specialists, etc.), lawyers knowledgeable about intellectual property issues; – Availability of material resources (raw materials and equipment for the manufacture of innovative products, software for commercialization, etc.); – Availability of information resources (information on market needs and the relevance of innovation, information required for legal registration of patent, information for marketing promotion of innovation, information required for the marketing of innovative products, etc.) – Timing constraints.
3. Justification of economic feasibility of innovative products self-commercialization	– Calculating all potential costs associated with the commercialization of innovative products (resource support, legal registration, marketing promotion, etc.); – Justification of sales prices for innovative products; – Forecasting revenues from sales of innovative products; – Budgeting commercialization of products; – Determination of break-even point.
4. Preparation of necessary documents for legal registration of property rights	– Gathering information on the required documentation; – Proper preparation of required documents
5. Registration of legal status (acquisition of title)	– Filing all documents to the intellectual property registration authority; – Obtaining title to innovative products; – Certification
6. Develop and launch a marketing program (advertising, PR, other marketing events for sales promotion)	– Optimization of product lines; – Development of communication policy (advertising, PR, sales promotion activities, etc.).
7. Formation of client base, making agreements with buyers and establishing sales channels	– Search for potential buyers; – Negotiations with potential end customers and intermediaries; – Stipulating all conditions of the agreement, preparation of agreement; – Forming and signing agreements.
8. Products sale and servicing	– Sales of innovative products to end customers and intermediaries; – Warranty service and after sales service
9. Testing effectiveness of innovative products commercialization	– Calculating all actual costs associated with the commercialization of innovative products (resource support, legal registration, marketing promotion, etc.); – Analysis of revenue from sales of innovative products; – Comparison of planned and actual costs and revenues; – Analyzing the profitability of innovative products commercializing and achieving break-even point.

*Resource: made by the author analyzing research material [1, 3, 5, 8, 9, 15, 16]

To select the optimal method of innovative products commercialization it is advisable to consider – in addition to business opportunities – the objectives and conditions of the method application. With the sale of innovative products a developer is mainly focused on entering new markets or expanding existing markets and, consequently, increasing its profits. Since products are innovative a company gains competitive advantages over other market insiders. Due to the fact that the company carries out the process of commercialization alone, it gains experience in this area and can commercialize its further products with less effort. This objective of the commercialization method is typical and most reasonable for companies where innovation activities dominate the business.

However, depending on available resources a company may face certain restrictions on the use of a particular method. Regarding the launch of innovative products on the market a company should, in the first place, have all the necessary resources (financial, labor, time, material, information, etc.). As the method is mainly focused on profit a company should have a target market for products with established distribution channels and potential client base. Also, for more active sales a company should have a developed and recognizable brand.

As can be seen from Table 3, at the first stage of innovative products sales a machine-building company has to collect information on relevant products market. At this stage it is necessary to undertake some actions aimed at identifying the target market.

The next stage of the innovative products sales is the assessment of company resource capabilities for self-commercialization. Based on the information received regarding the resource capabilities of the company, it is necessary to calculate accurately the economic feasibility of commercialization of innovative products carried out by the company alone. The next step in the innovative products sales is pricing for products.

Further the possible revenue from sales of innovative products should be predicted. The next step is budgeting for commercialization of innovative products. That is a combination of the two previous stages.

Having analyzed revenues and costs relating to the commercialization, and having completed budgeting process, it is necessary to determine a break-even point, i.e. the sales of products, where total revenue equals total costs. Whereas, revenue and costs from sales of innovative products are calculated as follows:

$$R = Pq*Q + \sum_{1}^{i} Pk, \tag{1}$$

where: R – revenue from sales of innovative products, UAH; Pq – the price per unit of innovative products sold, UAH; Q – the number of units of innovative products sold, units; Pk – the price of advice on the use of innovative products, UAH; *i* – the amount of advice provided, units:

$$C = C1 + C2 + C3 + C4 + C5 + C6 + C7 + \\ +C8 + C9 + C10 + C11 + C12 + C13 + C14, \tag{2}$$

where: C – costs for innovative products sales, UAH; C1 – the payment for advisory and information services, associated with the support of legal registration of title to the products, UAH; C_2 – the payment for patenting of title to the products and their manufacture, UAH; C_3 – the payment for products certification (if applicable) , UAH; C_4 – the payment for licenses and other government approvals for conducting business (if applicable) , UAH; C_5 – the advertising costs, UAH; C_6 – the cost of packaging and packing materials (if applicable) , UAH; C_7 – the cost of paying interest on financial loans obtained for replenishment of working capital (if applicable), UAH; C_8 – the tax costs, UAH; C_9 – the cost of compensation for storage, handling, transshipment, packaging, transport and insurance costs incurred by a provider included in the price of products on the basis of deliveries under the agreement of the parties, UAH; C_{10} – the cost of services rendered by freight forwarding, insurance and intermediary organizations (including commissions), the cost of which is included in the price of products on the basis of deliveries under the agreement of the parties, UAH; C_{11} – the payment of export duties and customs fees (if applicable) , UAH; C_{12} – the warranty and maintenance costs, if it is stipulated by sales terms, UAH; C_{13} – the wages of employees involved in the commercialization process, UAH; C_{14} – the benefits-related deduction, UAH.

Further stage of innovative products sales is to prepare the necessary documentation for the legal registration of property rights and registration of legal status (acquisition of title). Having received legal title to innovative products, the company is able to further promote the products with no risk of losing the title to such products. However, depending on the type of product, the company may be required to obtain appropriate certifications to further activities.

The next step in the innovative products sales is to develop and launch a marketing program for products promotion and marketing. Upon determining the range and modification options of innovative products marketing communication policy for promotion of innovative products should be developed and implemented. The next step in the innovative products sales is to develop a client base, reach agreements with buyers, and create sales channels.

A further step is the sale of products to resellers and end customers. At this stage of commercialization, based on feedback, the company gets the first results regarding the demand for innovation, and it can assess all advantages and disadvantages of using the products. In case of defects in products use, the company needs to fix them through warranty service. Also if the putting the product into service is a complex process or in case of any failure the manufacturer shall carry out after-sale maintenance service, if it is stipulated in the agreement.

The final stage in the innovative products sales is testing the effectiveness of the completed commercialization. This stage is designed to carry out a mandatory study of results received from the completed actions. The main indicator of successful commercialization is profit ratio of innovative products sales (3):

$$P_R = P_n / R_n., \tag{3}$$

where: P_R – the profit ratio of innovative products sales; P_n – the net profit from sales of innovative products, UAH; R_n – the net revenues from sales of innovative products, UAH.

Concerning the use of innovative products in company business to satisfy own business needs, it should be noted that it brings many benefits to a company during its internal activities and thus gives it competitive advantages in the market in comparison with other companies. Innovative products can be used both in production (innovative equipment, new production technology, etc.), and for other economic and administrative processes. In particular, the use of innovative products can help reduce both material costs and time in different organizational processes. Also innovative products help to modernize the existing logistics equipment, which in turn can result in increased production. Another main objective of applying this method is professional development of the staff, effective management of warehouses and inventory and so on. Thus, on the basis of the above it can be concluded that the use of innovative products in own business activity to meet the in-house needs will result in significant competitive advantage.

However, in order to apply this commercialization method, as well as in case of innovative products sale, one must have all the appropriate resources for manufacturing these products at the company. It is also necessary to have information to be able to properly use innovative products and have the necessary completion materials to introduce and use innovative products at the company.

CONCLUSIONS

Based on the above it can be argued that the commercialization of innovative products by machine-building companies through the use of the products for the company's needs (for internal needs or for product sales) is the best method of self-commercialization. However, it should be noted that this is a rather complicated process. Also, this method has both advantages and some risks for the company business. To provide clearer understanding the article describes the special features of the aforementioned method in accordance with business objectives and conditions of use.

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Software of geoinformation system for spatial inventory of greenhouse gas emissions

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Abstract. In this paper, the advantages and disadvantages of existing software for inventory of greenhouse gas emissions have been analyzed. Necessity of creation the new specialized software for spatial inventory of greenhouse gas emissions has been proved, and the requirements for such software have been specified. A flexible architecture of specialized geographic information system (GIS), the structure and main modules of the software have been presented. The mathematical model of greenhouse gas emissions caused by using various types of fossil fuels in the residential sector has been described. Using developed specialized GIS, a case study for Zhytomyr region in Ukraine has been conducted.
Key words: software, geoinformation technology, architecture, GHG inventory, spatial analysis.

1. INTRODUCTION

The industrial revolution of the late eighteenth and early nineteenth centuries transformed most of the countries from a primarily agricultural society into one based on the manufacturing of goods and services. Therefore demand for energy resources, especially fossil fuels, is sharply increasing. This has led to emission of anthropogenic additional greenhouse gases, which cause global warming. The main chemicals that cause the greenhouse effect are carbon dioxide (accounts for 50% of the greenhouse effect); chlorofluorocarbons (25%); methane (10%); nitric oxide (8%); surface ozone levels (7%). Therefore searching for way of reducing the GHG emissions is a burning issue. In order to solve the problem of GHG emission reduction the effective inventory tools in all sectors of human activity are needed.

2. MATERIALS AND METHODS

Nowadays different software is developed for inventory of greenhouse gas emissions in various sectors that take into account specific of regions [1-6]. Software that is used for inventory of greenhouse gas emissions can be divided into two types: specialized and non-specialized GIS [7-11]. The non-specialized GIS include software MapInfo and ArcGIS; specialized GIS include TEISS, EMIT2, Copert, e3CAT, webEI, etc.

Tribal Emissions Inventory Software Solution (TEISS) [10] is software with a user-friendly interface for greenhouse gas emission inventory. The system contains an integrated GIS platform that includes all necessary tools for inventory of greenhouse gas emissions and visualization of the results. TEISS contains a description of used methodologies for spatial inventory of greenhouse gas emissions as well as models which are combined into a single user interface. Input data and results of the inventory are stored in SQL database. The system is independent of the provider and allows user to store data in such databases: Oracle, MS-SQL Server, MySQL, and Interbase. The system estimates emissions using AP-42, NEI, and EIIP methodologies. It allows conducting numerical experiments for more than 200 emission sources and provides detailed information on every source. The software is flexible to modifications in calculations of any emission process without adverse impact on system.

Software EMIT [11] was designed for conducting greenhouse gas emission inventory. It was developed by a group of scientists from CERC (Cambridge Environmental Research Consultants) in 1985 using the latest technology in the field of environmental studies. The developers provided the ability to store, process and analyze data about the greenhouse gas emissions taking into information about emission sources. EMIT is particularly useful for testing different scenarios of emission reductions.

Most of GISes are commercial software. They are not fully adapted for spatial inventory of greenhouse gas emissions or cover only certain sectors of the inventory (ADMS-Airport, SELMA). In contrast to these commercial products, the specialized GIS, which is presented in this article, is based entirely on the modules that are freely available.

3. RESULTS AND DISCUSSION

3.1. Generalized approach to architecture construction of geoinformation system

Approximately 80-90% of all information may be considered as spatial data. Operations with such data are seen as a central task for geo-information systems. Geoinformation technology is a multifunctional analysis tool that consolidates tabular, text and cartographic data from various areas: demography, statistics, land management and other information. Geographic information systems are becoming more widely used not only in the traditional areas of application, such as natural resource management, agriculture, environment, urban planning, but also in business, e.g. in telecommunication industry and retail trades. GIS supports business or organizational decision-making activities, hence helps to improve customer service, maintain a high level of competitiveness, and increases profitability of commercial organizations. GIS is an effective tool for selecting sites and determining the areas of trade, outdoor advertising and production facilities, scheduling and routing of delivery vehicles, informational real estate activity.

Input data for GIS are digital maps, plans, space multispectral and radar satellite images. The data contained in the digital map is divided into spatial (geographic, geometric, vector) and attribute (tabular). All GIS operate with the following spatial data objects:

- point objects which are showing location of discrete objects (size of the objects is not significant);
- linear objects, which consist of the nodes that are linked with arcs (one dimension linear data that does not have thickness);
- polygon, which consist of a number of arcs that form a close loop without crossing over one another (indicates area occupied by a particular object);
- text labels on the map.

3.2. Specification of requirements for software architecture

The geoinformation systems are the main instrument for creating an effective software tool for spatial inventory of greenhouse gas emissions. Such tool can provide the opportunity not only to assess the amount of greenhouse gas emissions, but also geographically locate all sources [7-11]. As emission sources are located very unevenly, in order to take decisions about greenhouse gas emission reduction the authorities require information not only about the amount of emissions, but also about localization of emission sources. As national inventory is conducted according to IPCC methodology [12], it does not include the spatial analysis of obtained results. Therefore development of effective software tool for spatial inventory of greenhouse gas emissions is the burning issue.

Software for spatial inventory of greenhouse gas emissions must satisfy a number of requirements on the input data and provide necessary tools for operation with spatial data. As input data we use:

- digital maps of the investigated area (administrative regions, forests, land use, road or railways, etc.); these digital maps should contain neccesary data for conduction greenhouse gas emission inventories (settlement boundaries, population density, forest types, capacity of roads, etc.),
- georefferenced statistical data about results of economic activities; main focus is on data which leads to greenhouse gas emission or absorption in investigated area; such data are usually available only on regional or distric level and include:

(a) information about fossil fuel consumption (coal, natural gas, oil, etc.) in different categories of the energy sector [13-15] (electricity and heat production [6], residential sector, industry and construction, mining and processing of fuels, transport [1, 3], etc.),

(b) production volumes (cement, lime, meat products, bakery, alcohol, etc.) [2],

(c) number of livestock (dairy and non-dairy cattles, pigs, horses, sheep and poultry),

(d) amount of chemical fertilizers used in agriculture [16],

(e) volume of forest plantations and industrial timber harvesting in forestry,

- emission factors and net calorific values (IPCC methodology [12]) or country-specific values (if available),
- set of geographical elementary objects of spatial cadastre of greenhouse gas emissions, which are obtained using disaggregation grid.

The software of specialized GIS for spatial inventory of greenhouse gas emissions and analysis of obtained results should provide the following functions:

- creation new digital maps of the region/area,
- formation of the set of elementary objects (point-, line-, and area-type objects),
- development of program modules for spatial disaggregation of statistical data about fossil fuels consumption or other activities from regional level to the level of elementary objects,
- calculation of greenhouse gas emissions and stock from main sectors (Energy, Industry, Agriculture, Waste, Land use, land-use change and forestry) and for all types of economic activities (electricity and heat production, residential sector, transport, etc.),
- calculation of emissions of carbon dioxide, methane, nitrous oxide, non-methane carbon compounds for every elementary object using mathematical models,
- visualization of the obtained results of spatial inventory (thematic maps of specific greenhouse gas emissions or absorptions – tons per unit of area),
- summation of obtained results to the level of administrative units (usually – administrative districts) and summarising in form of diagrams and graphs.

3.3. Characteristics of the main modules

Software architecture enables processing geoinformation in various vector and raster formats using library GDAL/OGR [17]. Each map is a set of spatial data which describe certain two-dimensional region with a given coordinate system. A map consists of one or more layers. Each layer contains an attribute table and the associated geographic objects, such as polygons, points, lines, and text (labels). Each graphical object is specified by its coordinates. In addition, the layer contains information about visual style and scale of the map window.

Architecture of geographic information system involves: (1) organization of interaction of geocoded data from external data sources, (2) work with a variety of specialized modules, (3) and using them in mathematical methods for solving a wide range of modeling tasks. Software modules for working with GIS can be also used to solve many scientific problems related to the processing of geoinformation. Development of specialized software is fully justified and economically feasible as it allows not only to replace the expensive GIS by alternative free software, but also to implement individual requirements of a user.

Any specialized applied software should be designed to fulfill specific needs taking into account functional requirements and the concept of scalability. This enables a developer to build the optimal configuration of GIS to solve a particular problem. The software should be able to interact and share different types of integrated data with other existing GIS.

Main modules in a structure of the cross-functional geographic information system are modules which work with the data of vector and raster formats. We used free library for working with vector and bitmap formats GDAL/OGR for building software architecture. Core modules of geographic information system are presented in Fig. 1. Connections between system modules are weakened by using of architectural decisions such as design patterns, which provide the use of modules in other systems.

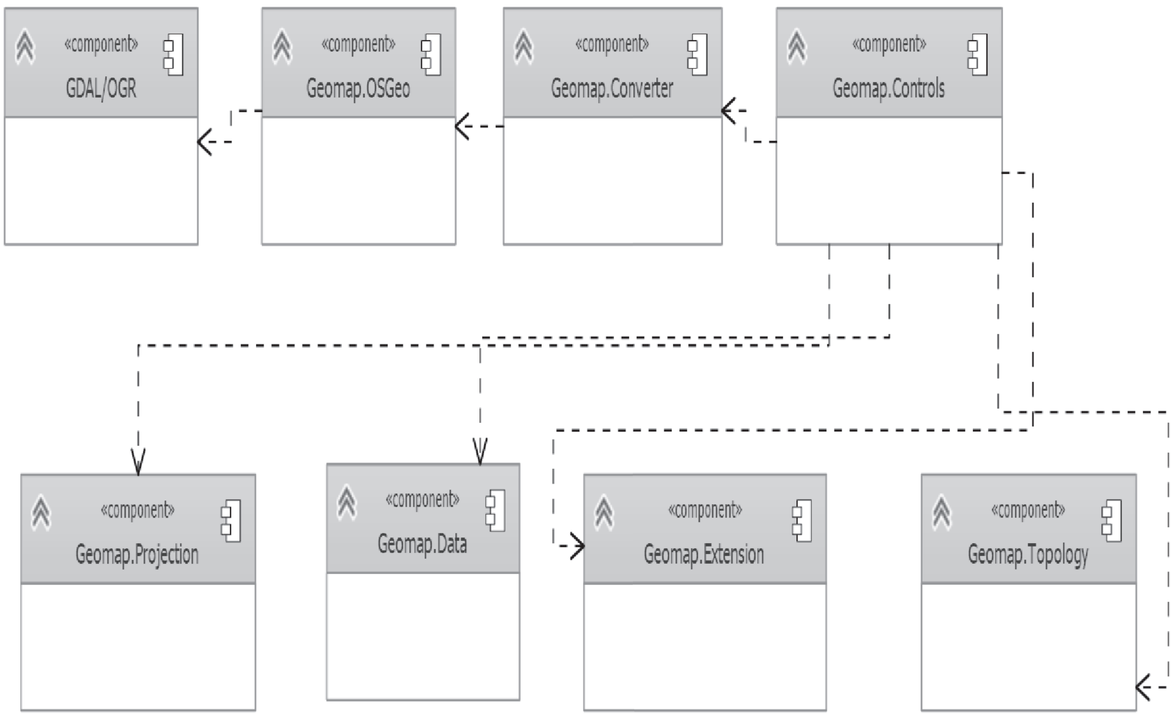

Fig. 1. Components of the specialized software

Spatial data is displayed as digital maps using module Geomap.Controls. This module contains the basic functionality to build custom GUI. Class Map is essential part of this module and contains all necessary functionality for working with spatial data in various formats. The range of operations includes adding and removing layers of maps, scaling, data visualization, etc. The module design enables visualization to be independent from the libraries, which are responsible for representing graphical objects (GDI + +, DirectX, OpenGL).

The input data of geographic information system are the maps commonly recorded in either a vector or raster format. Vector-formatted data are given in WKB and WKT formats. WKT is a text markup language for representing vector objects on a map. WKB is a binary equivalent, which is used to transfer and store the same information in databases (Microsoft SQL Server, PostGIS and DB2). Module Geomap.Converters converts binary and text data to the appropriate geometric shapes. The module reads data from the stream and creates the geometric primitives, which are later displayed on the map. In this module we implemented a set of classes for working with WKB and WKT formats. The exchange of geometric data as binary streams is represented as BLOB, which contains geometric WKB-information.

Functions for data manipulation and setting different styles are implemented in Geomap.Data module. Map formats contain a set of graphical primitives (line, point, polygon, etc.) and associated attribute data (types of roads, population, etc.). DataSet class provides storage of attribute data of geometric primitives. In class VectorStyle a set of basic styles and instruments to display geometric shapes of vector formats is implemented. Class OGRProvider works with data in OGR formats, implements reading of attribute and graphic information for further analysis and calculations using SQL queries.

Geomap.Extension is a module of additional extensions. It provides classes and libraries which enable user to calculate the area and perimeter of planar objects, the length of linear objects as well as obtain other additional information (location, object type, etc.). In these classes we implemented functional approach, therefore the necessary geoinformation can be retrieved from the database using query ‘select’.

Geomap.Symbology module is built for working with styles for displaying maps using GDI++. It is designed to draw graphical objects and shade them with gradient. Geomap.Topology module contains a set of basic geometric shapes and additional classes. Geomap.OSGeo is module from SWIG package that enables to use library GDAL/OGR in high-level programming language C#. Geomap.Projection is a module of map projections. This module is needed to transform point coordinates from one geographic coordinate system to another. The core of this library is a port of the Proj4J library.

3.4. Additional modules for spatial inventory

Specialized geoinformation system includes not only modules for mapping, analysis and storage of data, but also a new module for mapping in vector format. Some maps are created in raster format. Any raster map can be converted to vector format using specialized software [7,8].

The digital map can be created using the following algorithm:

- use a physical or any other map of analyzed area,
- digitize map in order to obtain the raster map,
- open raster map, set a percentage of transparency for stroking contours on the map,
- create vector map using boundary points and contours of raster map (using the corresponding module).

The construction of vector map is conducted in the current or a new layer in edit mode. If a map is multi-layered, the objects will be created on the upper active layer (as active we consider visible layer). The size of created file changes automatically depending on the amount of added layers.

The module for construction of vector maps has the following features:

1) creation of the following objects of a map:
– lines, polylines,
– polygon,
– point,
– rectangle,
– ellipse,
– text,

2) setting:
- shape fill of planar objects (polygon, ellipse or rectangle),
- thikness and type of shape outline,
- colour filling area-type objects and their outlines,

3) cancelation or reversing the last operation or more another commands executed during the process of map creation,

4) deleting objects,

5) selecting objects while drawing and synchronization with corresponding database.

A simplified diagram of classes of the module for mapping in vector format is presented in Fig. 2.

Spatial inventory of greenhouse gas emissions is conducted at the level of elementary objects. Within one sector of human activity emission sources can be presented as point, line or polygon objects. In order to summarize inventory result, we need universal map of investigated area. For this purpose was created tool “Grid”, which splits the investigated area maps with grid (spatial resolution $n\times m$ km). This tool has the following features:

- this function is applied to layers which contain polygons, lines and points,
- data from attribute table for polygons and lines are copied and attached to each created object in resulting map; points are copied to new map together with related data from attribute table,
- the result is presented as a new layer with all new geographical objects created by splitting input map with a grid.

The algorithm of the module "Grid" is presented in Fig. 3.

Visualization of the results of spatial inventory is an essential component of the emission analysis. A module for spatial visualization uses tool „Grid” that disaggregate tabular and spatial data to the level of elementary object. The algorithm of the module consists of the next steps:

- selected layers of the map are splitted using tool "Grid" into set of elementary objects (developed disaggregation algorithm is implemented),
- new layers, which contain the geoinformation about greenhouse gas emissions, are created,
- the inventory results are visualized.

The algorithm of visualization module is presented in Fig. 4. The results of applying this module to Zhytomyr region is shown in Fig. 5 (specific N_2O emissions from burning fossil fuels in transport sector in Zhytomyr region of Ukraine).

3.5. Spatial inventory of greenhouse gas emissions using specialized software

An integral part of greenhouse gas emission inventory is development of an approach and mathematical models that describe a particular kind of human activity, performing numerical experiments and analysis of the results. As an example of such inventory, we perform greenhouse gas emission inventory in the residential sector of Zhytomyr region in Ukraine. The emissions in this sector are caused by burning fossil fuels and wood by households in order to meet their energy needs for space and water heating, cooking, including cooking and water heating for sanitary needs for livestock.

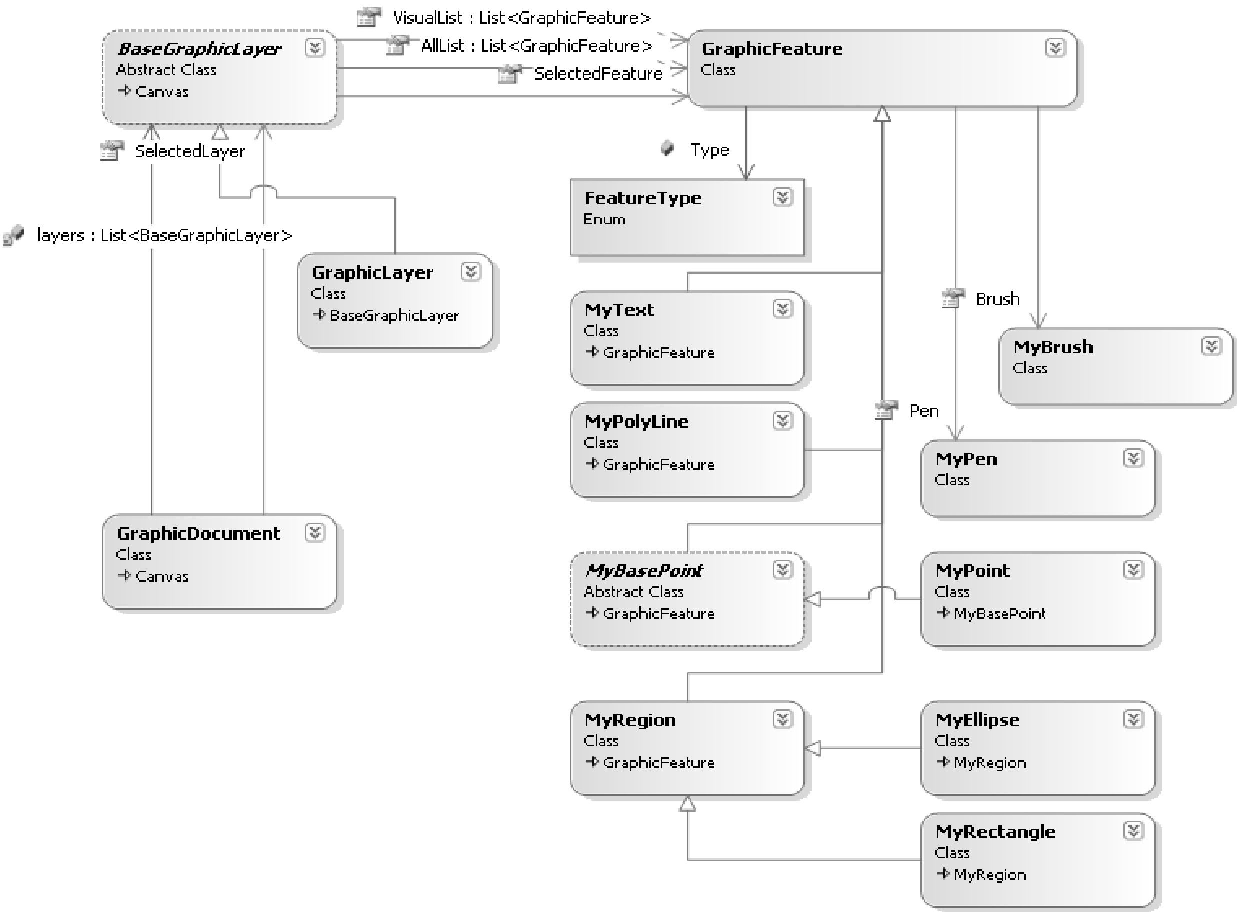

Fig. 2. Simplified diagram of classes of the module for mapping in vector format

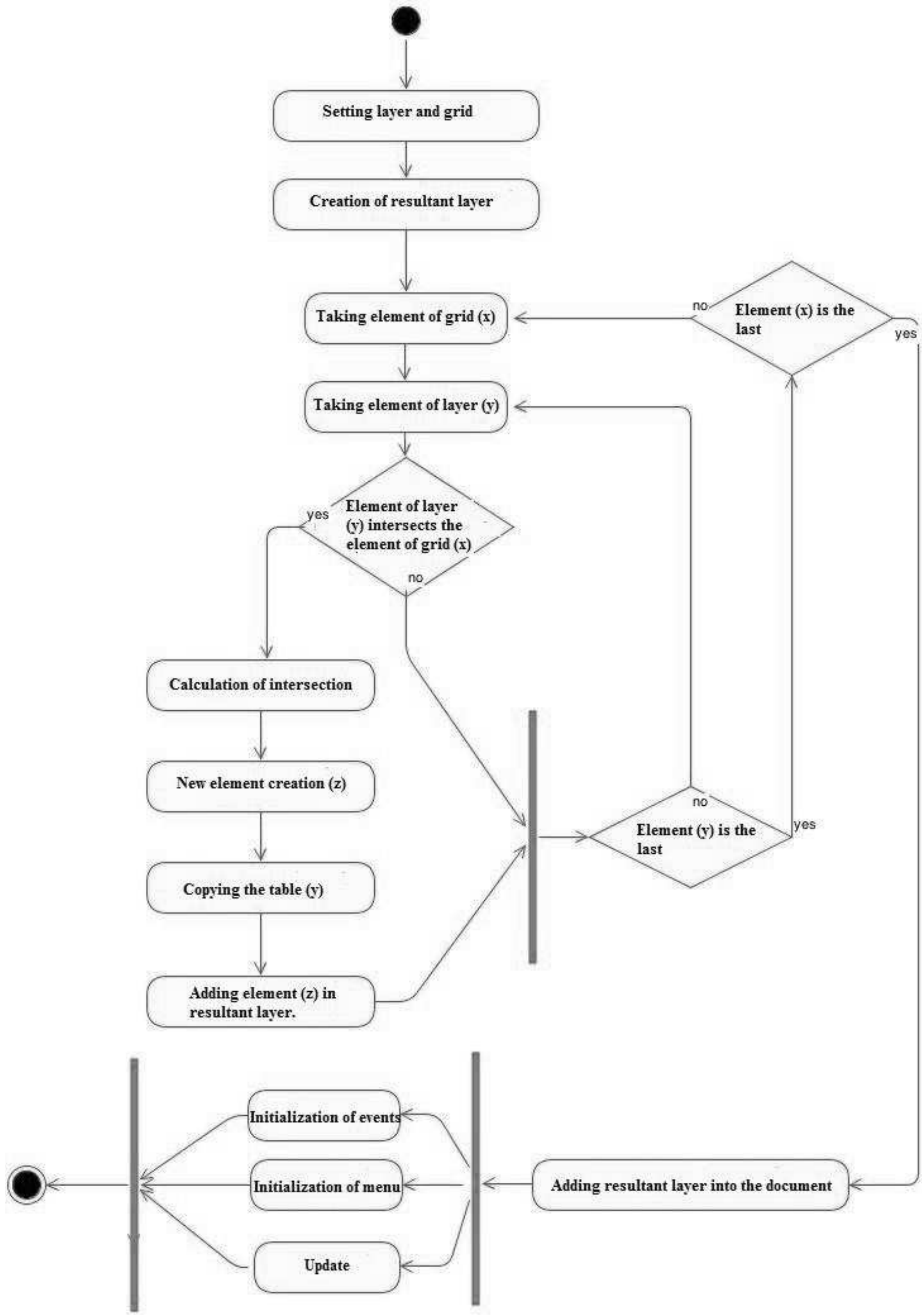

Fig. 3. The algorithm of the module "Grid"

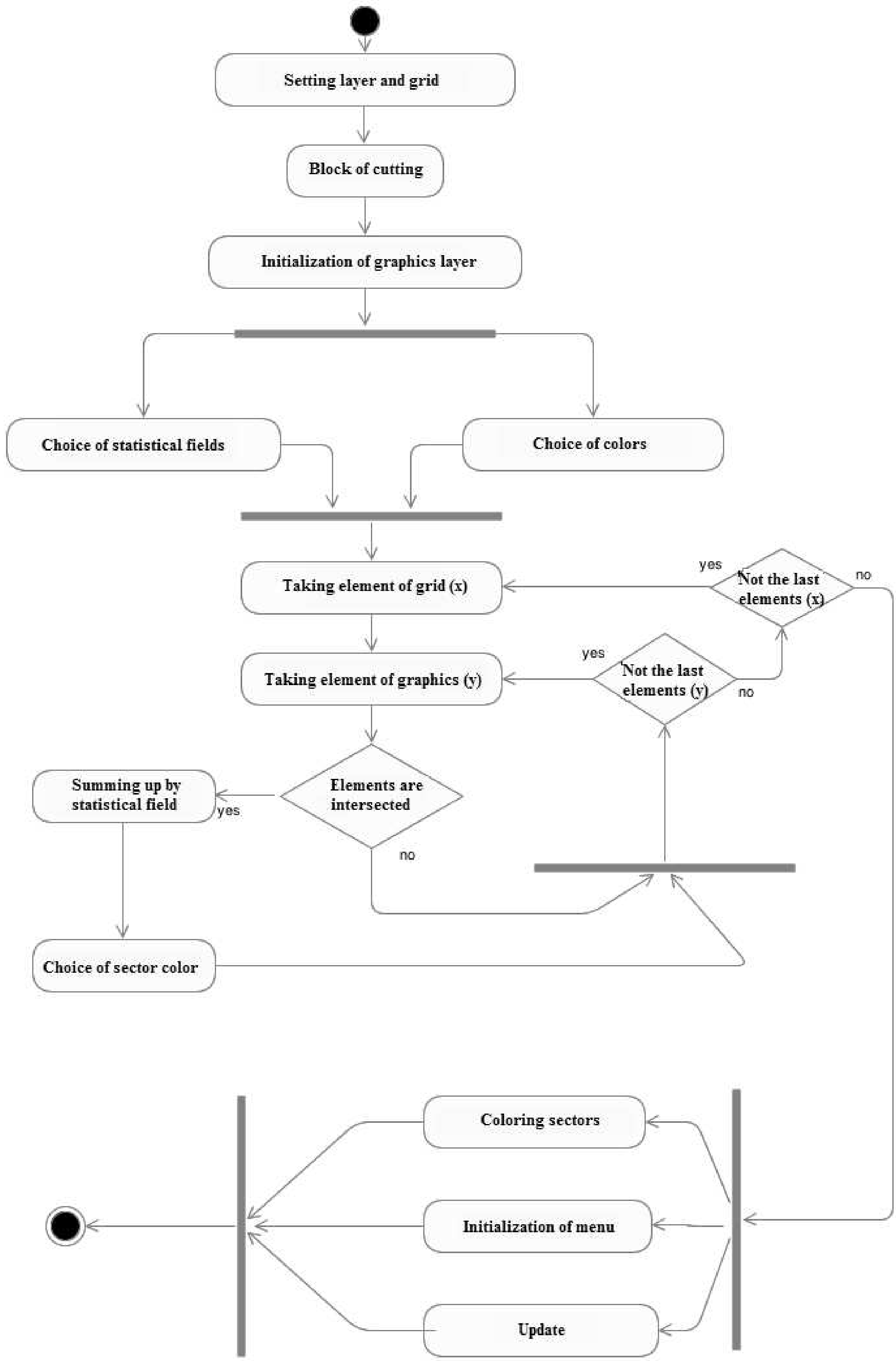

Fig. **4**. The algorithm of visualization module

The main energy sources for space heating and cooking in rural areas are natural and liquefied gas, coal and wood. As input data we used official statistical data about amount of fossil fuels that was burned in this region. However, such information is available only on regional level, in some case on district level. Therefore we need to disaggregate statistical data to the level of elementary objects (e.g. settlements). The amount of carbon dioxide emissions from stationary fuel combustion in the residential sector can be estimated by a model:

$$E = \sum_{g \in G} \sum_{\delta \in \Delta} \sum_{i \in I} M_{i,\delta} * A^g_{i,\delta}, \qquad (1)$$

where: $I = \{i_1, i_2, ...\}$ – set of fuels (coal, natural gas, liquefied petroleum gas, firewood) used in the residential sector; $\Delta = \{\delta_1, ..., \delta_n\}$ – set of elementary objects (settlements); $G = \{g_1, ..., g_n\}$ – set of greenhouse gases (carbon dioxide, methane, nitrous oxide); $M_{i,\delta}$ – amount of the *i*-th type fuel consumed in the elementary object δ; $A^g_{i,\delta}$ – emission factor for the *g*-th greenhouse gas from burning the *i*-th type fossil fuel.

The amount of coal and wood that was burned in elementary object δ is calculated using the next formula:

$$M_{i,\delta} = (M_i * F^R_{i,\delta} + M_i * F^U_{i,\delta}) * \frac{P_\delta}{P_w}, \qquad (2)$$

where: i – index that indicates type of fuel (coal or wood); M_i – statistical data about amount of consumed fuel of the i-th type on regional level; P_δ – population in a settlement (elementary object δ); P_w – population in administrative unit (district); $F^R_{i,\delta}, F^U_{i,\delta}$ – indicators that allocate share of the *i*-th type fuel from total volume used in urban and rural areas respectively.

The amount of natural and liquid gas that was burned in elementary object δ is calculated using the formula:

$$M_{i,\delta} = (Q^R_{i,\delta} * F^R_{i,\delta} + Q^U_{i,\delta} * F^U_{i,\delta}) * \frac{P_\delta}{P_w}, \qquad (3)$$

where: i – index that indicates type of fuel (natural or liquid gas); $Q^R_{i,\delta}, Q^U_{i,\delta}$ – numbers of households with access to centralized gas supply in urban and rural areas respectively within an elementary object δ; $F^R_{i,\delta}, F^U_{i,\delta}$ – indicators that allocate share of the *i*-th type fuel from total volume used in urban and rural areas respectively, and are calculated according to the next formulas:

$$F^U_{i,\delta} = M^i{}_{\mathrm{Region}} / Q^{region}_{urb}, \; F^R_{i,\delta} = M^i{}_{\mathrm{Region}} / Q^{region}_{Rur}, \qquad (4)$$

where: Q^{region}_{urb}, Q^{region}_{Rur} – numbers of households with access to centralized gas supply in the administrative region (district) in urban or rural area respectively; $M^i{}_{\mathrm{Region}}$ – amount of consumed fossil fuel of the i-th type (natural or liquid gas) in the region.

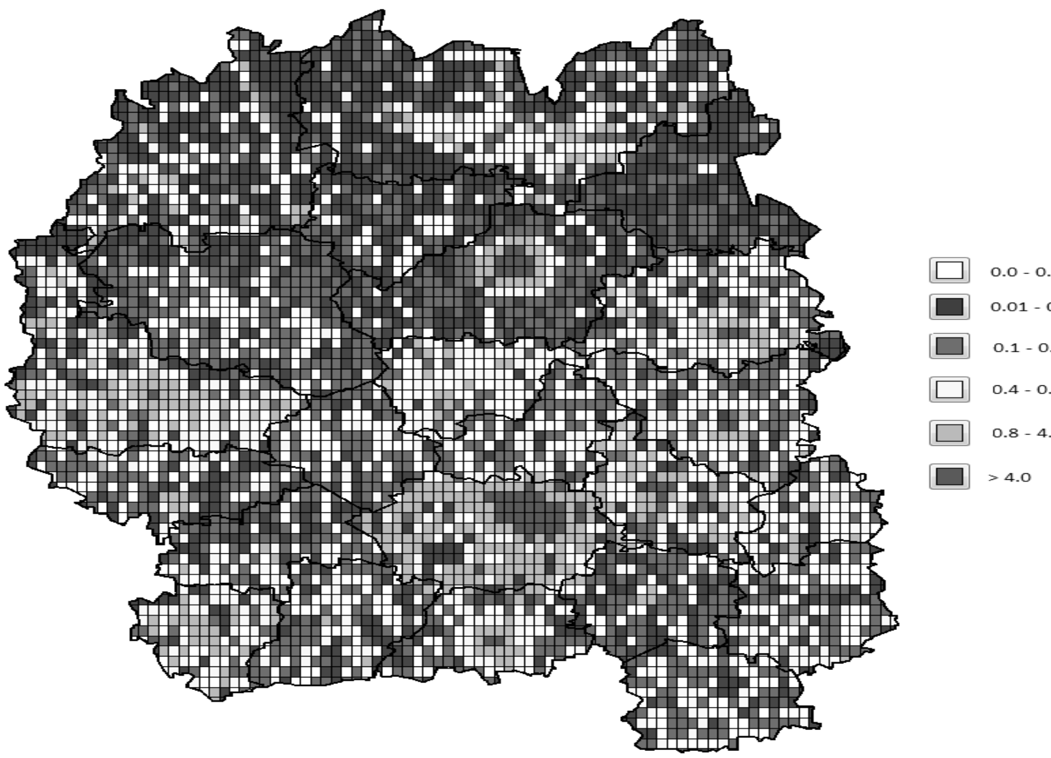

Fig. 5. Specific N_2O emissions from burning fossil fuels in transport sector in Zhytomyr region of Ukraine (kg/km^2, 2 km × 2 km grid, 2011)

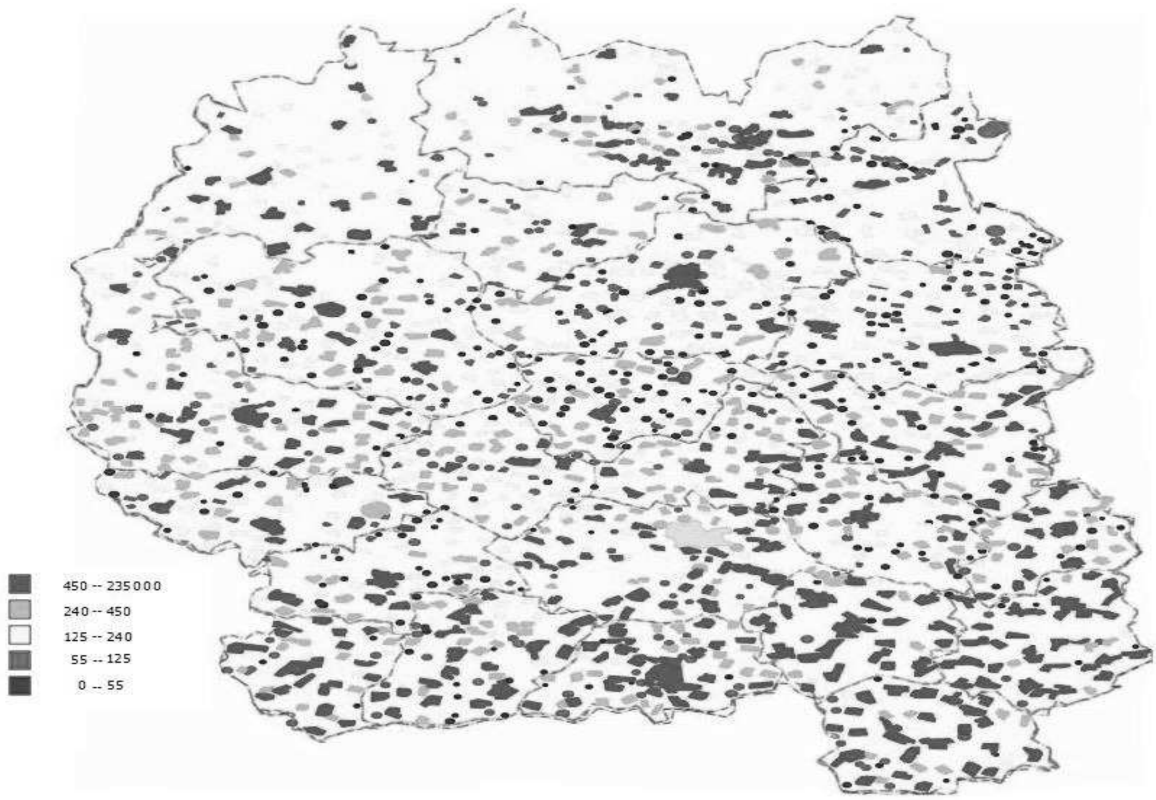

Fig. 6. Total specific greenhouse gas emissions from burning fuels in the residential sector in Zhytomyr region (CO_2 -equivalent, tons/km^2, 2011)

4. CONCLUSIONS

As an example, we conduct numerical experiments for the residential sector in Zhytomyr region in Ukraine in order to obtain the geo-referenced database with the results of greenhouse gas emission inventory. As input information we used statistical data about fossil fuels consumption in the households for districts and cities of regional subordination for 2011. As the base for the creation of geo-referenced database we used digital map of Zhytomyr region.

We made the review of existing software for greenhouse gas emissions inventory and justified the importance of development of specialized geographic information system that fully takes into account specific procedures for constructing spatial cadastres of emissions. According to specified requirements we construct the architecture of the specialized software for greenhouse gas emissions inventory, using the library GDAL/OGR. We implemented modules which enable to work with vector and raster data formats: to present maps in different projections; to work with different layers; to add new object to the map; to create new layers; to operate with attribute map and image data with the possibility of further analysis. We also developed additional modules for disaggregation of statistical data and visualization of results. Spatial inventory of greenhouse gas emissions is conducted for the residential sector of Zhytomyr region in Ukraine for 2011 using developed specialized GIS software.

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Mesoscale Modeling of Complex Microfluidic Flows

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Abstract. The mesoscale description of multiphase flow in a typical Lab-chip diagnostic device is presented in actual article. The mesoscopic lattice Boltzmann method, which involve evolution equations for the single particle distribution function, was applied for the modeling of complex microfluidic flows. The general D2Q9 lattice Boltzmann formulation, considered multiphase flows, was developed. Three types of boundary conditions were used for the mesoscopic modeling: "ghost-fluid", "bounce-back" and "periodic boundaries". Traditional Dirichlet and Neumann macroscopic boundary conditions were transformed into mesoscopic lattice formulations. Algorithm of fluid flow solution, based on BGK single-relaxation-time scheme was proposed and implemented. The scaling procedure was used for physical parameters convertion into non-dimensional units. Simulation procedure was tested on a fluid flow with single solid particle. The final results showed good consistence with fundamental flow phenomena.

Key words: multiphase, microfluidics, flow, mesoscale, modeling.

INTRODUCTION

A variety of miniaturized microfluidic devices for point-of-care diagnostic, biofluidic assays, biochemical synthesis and single cells analysis have been widely investigated and developed over the last two decades. These devices, called Lab-on-Chips, usually process multicomponent multiphase fluid mixtures, which flows under the hydrodynamic or electrokinetic forces in complex microchannels or microchambers [2, 6, 24]. The precise modeling of microfluidic Lab-chip flows requires an accurate description of multiphase and multicomponent interactions. Well developed classical Navier-Stoks flow models, which are based on the continuum theory, unfortunately can't be applied for simulating Lab-chip devices [9]. Microfluidic flow models should consider various atomistic effects due to the presence of macroscopic time, length and energy scales in phases and components interactions. It is known, that in general applications atomistic models, based on quantum-mechanics and molecular dynamics, are not usable due to its extremely high computational costs. Thus, the majority of recent research activities in the field of microfluidic flows modeling was devoted to the new numerical techniques.

The motion of a fluid mixtures can be described on three different levels (scales) – microscopic, mesoscopic and macroscopic [7, 14, 21]. At macroscopic scale – a Navier-Stokes partial differential equations are used. These equations can be solved by various numerical schemes like finite element method (FEM), finite volume method (FVM), etc. At microscale – on the contrary, a small particles movement simulate by molecular dynamics models. The governing is the Hamilton's equation, where we have to identify the location and velocity of the each involved particle. At mesoscopic scale – which fills the gap between macro– and micro– scales, fluid is considers as a collection of pseudo-particles. There are two main approaches for fluidic flow modeling at mesoscale level [15]: 1) hybrid approach, which combine molecular and continuum models; and 2) simplified approach, which directly formulates mesoscale model from molecular by some transformations. One of the main mathematical methods for mesoscale models is lattice Boltzmann method, which united microscopic models and mesoscopic kinetic equations [5]. This method uses the modified version of Boltzmann equation, which describes the meso-particles interactions on fixed lattices and directly simulates the fluids movement. The lattice Boltzmann method (LBM) was used here for the modeling a simulating of multiphase and multicomponent microfluidic flow mixtures.

The difficulties associated with Lab-chips microfluidic flows modeling are related to a principal contradiction: the flow equations directed to the macroscopic variables – fluid density (ρ), pressure (p), temperature (T), velocity (u), while the fundamental mechanisms of the basic phenomena are related to the microscopic level. It is well known, that any continuum liquid is an ensemble of particles – molecules, ions and electrons with different positions (r_i) and velocities (v_i), which move under the influence of external forces (electromagnetic fields, pressure, gravity) and internal collision processes (brownian, ionization, charge exchange etc.). Unfortunately, "averaged" macroscopic parameters, which we observe at macroscale level, are averages over the distribution of particle velocities and/or positions. Thus, instead of hydrodynamic equations, more natural fluid flow description might involve evolution equations for the particle distribution function. Applying pseudo-particles instead of real molecules, one can create an alternative mesoscopic description of fluid flows, intermediate between microscopic and macroscopic worlds.

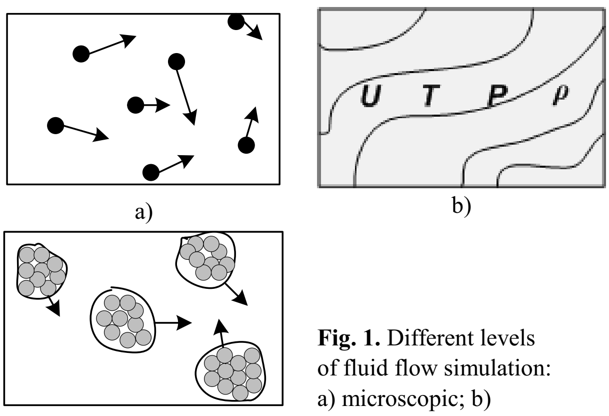


Fig. 1. Different levels of fluid flow simulation: a) microscopic; b) mesoscopic; c) macroscopic

As it is shown, lattice Boltzmann approach describe fluids as substance, consisted of fictive particles. Such particles perform consecutive propagation and collision processes like separate discreet molecules. Due to such particulate nature and local dynamics, mesoscale approach has plenty advantages over classical continuum models, especially in case of complex boundaries, multiphase interactions and in modern tendencies of the parallel calculations. The physics of microfluidics flow and fluid properties can be accurately incorporated into the LBE method, even more accurate than in Navier-Stokes equations [22]. Typical macroscopic parameters, like density ρ and velocity u can be easily calculated as soon as LBE solution will be obtained. Besides, it is particularly suitable for modeling various surface and interfacial phenomena, multiphase bio-flows and porous media flows, typical in microfluidics [1, 8].

MATERIALS AND METHODS

The kinetic Boltzmann equation was used to describe the temporal and spatial variation (evolution) of the particle probability distribution function. It represents the expected mass density of particles located at position r, moving with average velocity v at time t [4, 22]:

$$\frac{\partial f}{\partial t}+v_k\frac{\partial f}{\partial r_k}+\frac{F_k}{m}\frac{\partial f}{\partial v_k}=\Omega(f), \qquad (1)$$

where: $f(\vec{r},\vec{v},t)$ – the distribution function of single-particle position and momentum; F – external bulk force giving rise to the acceleration $a = F/m$; m – the mass of a particle.

Here, at the left-hand side: the first term represents the explicit velocity of the function f variation in time, the second – gives the spatial variation of function f according to particles movement, and the third – describes the effect of any force, acting on the particles. The right-hand side characterize the changes in distribution function, related to particles collisions. This part is highly non-linear, as it depends on actual value of distribution function and on inter-particle forces. Original Boltzmann collision operator $\Omega(f)$ is extremely complex, and usually replaced by a simpler model for computational work [3].

In the Boltzmann , see Eq. (1), the main unknown is mass density distribution function f. In 3D space it depends on seven independent variables: three coordinates, three micro velocity components and time. By using discrete working space into regular lattice, where the particles may have only certain number of allowed velocities q, the number of independent variables can be reduced to four. As a result of such reduction, at any given time each particle may have a discrete velocity from the set $\{v_0, v_1, \ldots, v_{q-1}\}$. Then the Boltzmann equation can be rewritten:

$$\frac{\partial f_i}{\partial t}+v_i\cdot\frac{\partial f_i}{\partial r}+\frac{F_i}{m}\cdot\frac{\partial f_i}{\partial v_i}=\Omega_i(\vec{f}), \qquad i=0,1,\ldots,q-1, \qquad (2)$$

where: i – node index in discrete cell, $f_i \equiv f(\boldsymbol{r},\boldsymbol{v}_i,t)$, and $\tilde{f}$ is a shorthand for the vector $(f_0, f_1, \ldots, f_{q-1})^T$. The continuous operator $\Omega(f)$ is replaced by its discrete analog $\Omega_i(\tilde{f})$, which includes summations.

The solution of the Boltzmann equation defines the macroscopical fluid variables through the velocity moments of f. The Boltzmann equation has very high mathematical complexity and need to be linearized and simplified. Besides, instead of direct numerical solution, it was proposed to imitate the evolution of particle distribution function $f(r,\vec{v},t)$ over the discretized lattice space. So, in an elementary volume *dr* pseudo-particles move chaotically or under some external forces, collide with each other and change its original speed. Applying basic conservation laws and Chapman-Enskog expansion for the elementary volume *dr*, the change in the distribution function was written [25]:

$$f\left(r+vdt,v+\frac{F}{m}dt,t+dt\right)d^3rd^3v=$$
$$=f(r,v,t)d^3rd^3v+dJ_{coll}, \quad (3)$$

where: F – external body force, m – particle mass, dJ_{coll} – change in the number of particles due to collisions.

According to the Le Chatelier – Brown principle, in a slight deviation of the physical system f from the stable equilibrium f_0 ($|f-f_0|<<f_0$), appear internal forces that are trying to return the system to equilibrium. In a simplest approximation, these forces are proportional to the deviation:

$$\frac{df}{dt}=-\frac{1}{\tau}(f-f_0), \quad (4)$$

where: $\boldsymbol{\tau}$ – relaxation time or the rate at which f approaches its equilibrium state. The minus indicates that the response of the system on perturbations lead it to equilibrium. In this expression, as an equilibrium function, can be used local Maxwellian $f^{eq}=f^M$, which equals:

$$f^{(M)}=\rho\left(\frac{m}{2\pi k_BT}\right)^{D/2}e^{\left(-\frac{m}{2\pi k_BT}(v-u)^2\right)}, \quad (5)$$

where: ρ – particles density, m – particle mass, D – space dimension, v – particle microscopic speed, u – macroscopic fluid velocity, k_B Boltzmann constant.

By merging Eq. (3-5), and applying standard Bathar-Gross-Krook (BGK) collision approximation, where the collisions are considered as a linear process with single relaxation time model (SRT), the final lattice Boltzmann equation was obtained [3]:

$$f\left(r+vdt,v+\frac{F}{m}dt,t+dt\right)-f(r,v,t)=-\frac{\left(f-f^{eq}\right)}{\tau}dt. \quad (6)$$

Rewriting this equation in discrete mode, the evolution of the distribution function, which includes external body force, was obtained:

$$f_i\left(\overline{r}+\overline{v}_i\Delta t,t+\Delta t\right)-f_i\left(\overline{r},t\right)=$$
$$=-\frac{\Delta t}{\tau}\left[f_i\left(\overline{r},t\right)-f_i^{eq}\left(\rho,\overline{u}\right)\right]-\Delta t\frac{F}{m}\cdot\nabla_v f_i\left(\overline{r},t\right), \quad (7)$$

where: f_i – related to the mass of particles, that moves from actual position in the direction i in one time step. The left-hand-side described a streaming step, and the right-hand-side – a collision step, which relaxes to its equilibrium value $f_i^{eq}(\rho,u)$ with relaxation time τ. Here f_i^{eq} depends on the macroscopic density and velocity at local domain coordinates and time. This equation don't define which state should be used for simulation: f_i^{eq} – in the point $(r+v_i\Delta t)$ at the time $(t+\Delta t)$ or in the point (r) at the time (t). According to classical computational fluid dynamics experience, it's better to use the up-wind calculation scheme, means: position $(r+v_i)$ at time $(t+\Delta t)$ [10].

As far as the collision process involves calculation of body forces F or other non-linear values, an intermediate step between streaming and collision should be inserted. Thus, the evolution equation (7) is decomposed in two steps: collision and streaming steps [19]:

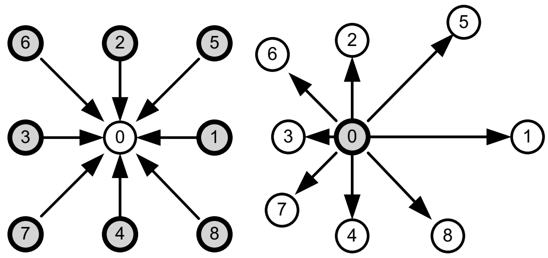
- collision:

$$f_i^t\left(\overline{r},t\right)=f_i\left(\overline{r},t\right)-\frac{\Delta t}{\tau}\left[f_i\left(\overline{r},t\right)-f_i^{eq}\left(\rho,\overline{u}\right)\right], \quad (8)$$

- streaming:

$$f_i\left(\overline{r}+v_i\Delta t,t+\Delta t\right)=f_i^t\left(\overline{r},t\right). \quad (9)$$

were: f_i^t depicts function value in moment t, when particles that came to the node in the direction i, but has not yet collide with other arrived particles, f_i is labeled a post-propagation or pre-collision population, and $f_i^t(r,t)$ – a post-collision or pre-propagation population. Both steps can be schematically presented as following:



a) b)

Fig. 2. Schematic representation of the a) streaming step, b) collision step

It can be seen, that in Boltzmann's elementary node there can be either 0 or 1 pseudo-particle, moving at a given speed. After a time interval Δt, each particle will move in the direction of a nearby node (streaming step). If several particles from different directions come into one node, they collide and change their speed according to collision rules (collision step). The collision step is completely local – it involves only the nearest neighbor nodes: the post-collision particles f_i^t move to the next node according to their discrete velocity set. As to the streaming step – it affects neighbor nodes, but it is uniform and requires regular computational efforts.

By calculating local equilibrium distribution and body forces, the collision step executes and new set of f_i components at each lattice node. Then, particles with f_i components stream into next neighboring lattices. Both – streaming and collision steps sequentially alternates. Appropriate collision rules provides conservation for number/mass, momentum and energy, and the results satisfy continuous Navier-Stokes macroscopic equations.

In case of multiphase fluid flow, Shan and Chen have been formulated original algorithm, where a set of n-discretized LBE should be solved, where each fluid is represented by own equation [1, 20]. Thus, discretized Eq. (7) for the n-th fluid components looks like:

$$f_i^{(n)}\left(\bar{r}+\bar{v}_i\Delta t, t+\Delta t\right)-f_i^{(n)}\left(\bar{r},t\right)=-\frac{\Delta t}{\tau^{(n)}}\Big[f_i^{n}\left(\bar{r},t\right)- \\ -f_i^{(n)eq}\left(\rho,\bar{u}\right)\Big]-\Delta t\frac{F}{m}\cdot\nabla_v f_i^{(n)}\left(\bar{r},t\right), \tag{10}$$

where: $f_i^{(n)}$, $\tau^{(n)}$ – are traditional single particle distribution function and single relaxation time for n-th fluid component.

The LBM simulation of multi-phase and multi-component transformations can be implemented through calculation of phase boundaries, emerging in the bulk microfluidic mixture. To describe the equation of state, which allows such transitions, it is necessary to introduce forces acted on the mixture components in the neighboring nodes. These forces can also provide the surface tension at the interface between different phases. As far as several fluids/phases may constitute the node component, this ambiguity will be solved according to the measurable dynamics – the node belongs to the fluid, which has the largest mass contribution.

General representative of microfluidic Lab-chip usually contain: injectors, junctions, microchannels, mixers, reactors, separators, filters, etc. Typical principal scheme of such device for diagnostic purposes is shown on Fig. 3 [18]. Mesoscale flow model can be applied in all important regions of Lab-chip device, where complex physical and chemical effects appear. Here, let's consider Ψ-junction (mixer) at the entrance region, where each microchannel input brings different components for multiphase fluid mixture.

The size of this device is 65x35 mm. The typical size for input microchannels can vary within 50..500 microns, depending on the size of bio-particles and contaminants. The length of input Ψ-mixer is up to 2..5 mm. The cross-sections of microchannels usually have rectangular (square) or semicircular shape. Each type of channel has appropriate resistivity parameter, which influence on calculation domain:

$$R_{rect}=\frac{12\mu L}{H^3 B};\; R_{circ}=\frac{128\mu L}{\pi D}, \tag{11}$$

where: R_{rect} , R_{circ} – microfluidic resistance for rectangular and semicircular shapes, μ – dynamic viscosity of fluid mixture; L, H, B, D – length, height, width and diameter of the microchannel.

In order to simulate flow effects in a fluid mixture by LBM, a special discretization procedure for selected calculation domain should be conducted. Let's consider, that fluid processes and transformations at income microchannels before Ψ-mixer are less important. Also, 2D domain was chosen for test calculations. These simplifications allow to take only rectangular-body part for simulation microchannel Ψ-mixer. The LBM workspace discretization is executed by creating uniformly located spatial nodes and a set of allowed velocity vectors. Each velocity vector points on possible propagation directions, arises after particles collision. Besides, it contains a zero vector, which describes particles that do not stream and remains in a node. The set of nodes, which outlines the allowed velocity vectors, created an elementary Boltzmann lattice. By applying parallel transformations on the base of Galilean invariance principle, this lattice can be extended on the whole workspace and form required computational grid. That's why, the corresponding equilibrium distribution function and the related coefficients could be derived only after a specific lattice scheme is choose. Here, the D2Q9 lattice scheme was selected for 2D fluid flow in the ψ-junction. Nine discrete velocity vectors for the D2Q9 lattice Boltzmann scheme is shown below in Fig. 4, and the values of corresponding weight factors for calculating equilibrium distribution function are given in the Table 1.

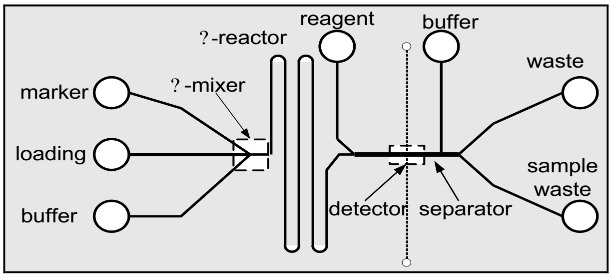


Fig. 3. Principal scheme of Lab-chip diagnostic device [18]

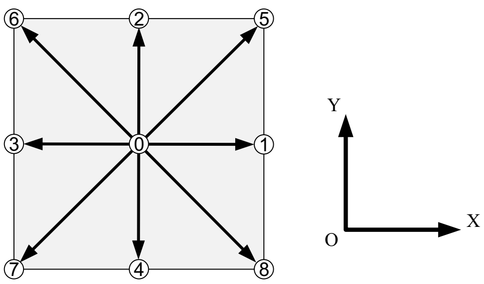


Fig. 4. D2Q9 lattice Boltzmann scheme with discretized velocity vectors

Table 1. Velocity and weight parameters for D2Q9 scheme.

Directions	Elementary vectors (e_i)	Lattice velocities (c_i)	Lattice weights (w_i)
i=0	(0,0)	$c_i = 0$	4/9
i=1,2,3,4	(1,0), (0,1), (-1,0), (0,-1)	$c_i = c_r$	1/9
i=5,6,7,8	(1,1), (-1,1), (-1,-1), (1,-1)	$c_i = c_r\sqrt{2}$	1/36

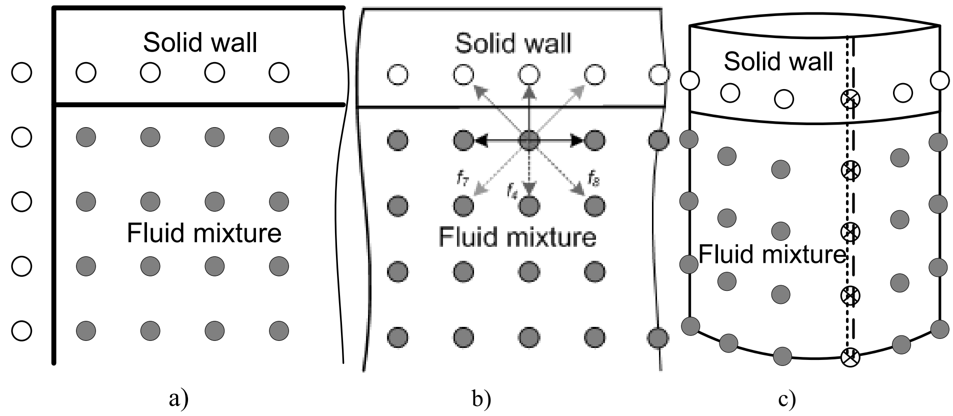


Fig. 5. LBM boundary types for mesoscopic fluid flow implementation:
a) ghost fluid nodes; b) bounce-back scheme; c) periodic boundary

The value of nonzero velocity components is equal to the distance traveled by a mesoparticle along a certain elementary axis during one time step. In general, the velocities c_i are equal to the relation of lattice size δr_i to the time step δt: $c_i = \Delta r_i / \Delta t$. From other side, the speeds in lattice Boltzmann simulation are related to the speed of sound. Theoretically, the discrete time unit can be calculated as $\Delta t = \Delta r/c_s$, where c_s is the speed of sound in the fluid. Besides, the choice of lattice velocity should keep the restriction between the macroscopic velocity u and the sound speed c_s: $u << c_s$ – in most calculations this relation fits $0.01 \leq c_s/u \leq 0.1$. In case, when $c_s/u \approx 0.1$, the time step Δt is equal: $\Delta t = 0{,}1\Delta r/|u|$.

The next stage in LBM is to define initial and boundary conditions in ψ-junction domain. Discussions of various boundary types can be found in the literature [13, 26]. Three types of boundary schemes were used in actual mesoscopic modeling – “ghost-fluid”, “bounce-back” and “periodic boundaries”, see Fig. 5. These types were chosen for their simplicity and satisfying accuracy.

In the “ghost-fluid” scheme two types of nodes are defined: interior fluid points are inside a solution domain, and ghost-fluid points are outside the solution domain, mainly inside solid microchannel walls or inside solid particles, which moves in a fluid. Thus, the microchannel solid boundaries lays in the middle between fluid interior nodes and ghost exterior nodes. The ghost nodes are also used in bounce-back boundary scheme for creating distribution functions at solid boundaries. According to the “bounce back” scheme, pseudo-particles comes towards the solid boundary and bounce back along incoming direction – definitely to the node from which they went out, but with opposite directions. The advantages of bounce-back condition is the fact, that it provides mass conservation in the simulation, and ensures no-slip and no-penetration up to 2nd-order of accuracy. The last scheme – periodic boundary condition is used to close the system within the two opposite edges – like input and output are connected to each other. This allows to obtain seamless connection and provides global conservation of mass in the calculation area.

Next, traditional Dirichlet and Neumann macroscopic boundary conditions should be transformed into mesoscopic conditions for LBM grid. As far as LB model deal with the velocity of fluid particles, main boundary conditions should be related to macroscopic velocity u. Once the local velocity values are computed, the single particle distribution function at each point, which streams according to chosen schemes, can be calculated. Generally, the Dirichlet condition postulates no-slip and no-penetration boundary. At first approximation, when boundaries lays between the fluid and ghost nodes, and assuming that velocity varies linearly from one node to another, the relation between adjacent node velocity u_i, macroscopic wall velocity u_w and ghost node velocity u_g can be represented by arithmetic mean:

$$u_g = 2u_w - u_i\,. \tag{11}$$

As to inlet particle distribution function $f_i(0,0)$ – it can be simply calculated from known distribution functions within the flow domain, based on imposed macroscopic parameters for fluid flow velocity and density:

$$f_i\left(r=0,t=0\right) = f_i^{eq}\left(r=0,t=0\right) = f_i^{eq}\left(\rho_0,u_0\right). \tag{12}$$

This equilibrium distribution function f_i^{eq} can be calculated through [11, 12]:

$$f_i^{eq} = \rho w_i \left[1 + \frac{u \cdot c_i}{c_s^2} + \frac{1}{2}\left(\frac{u \cdot c_i}{c_s^2} \right)^2 - \frac{1}{2}\left(\frac{u \cdot u}{c_s^2} \right) \right], \quad (13)$$

where: c_s – lattice sound velocity.

For Neumann condition, one could use a classical central-difference scheme:

$$\left. \frac{\partial u}{\partial y} \right|_{y=y_w} \approx \frac{u_i - u_g}{2\Delta y} = 0 \quad means \quad u_g = u_i . \quad (14)$$

To implement the boundary condition at the outlet (where neither velocity nor density is imposed), one can use the extrapolation of known distribution functions:

$$f_i(r,t) = \frac{1}{2}\left[f_i(r - c_{-i}\Delta t, t) + f_i(r - 2c_{-i}\Delta t, t) \right], \quad (15)$$

where: r – appropriate particle's coordinate.

All macroscopic hydrodynamic boundary conditions, which describes pressure, density, temperature and concentration parameters should be converted into appropriate expressions for the mesoscopic distribution functions.

A schematic LBM grid of a rectangular microchannel (mixer) with appropriate boundary conditions for velocity variable is shown on Fig. 6(a). In case of the presence of multiphase inclusions (gas bubbles, immiscible liquid drops, solid particles or soft agglomerates) in a fluid mixture, the moving boundary condition should be described on the edge of inclusions, see Fig. 6(b).

There are several schemes for reflecting moving boundaries among components in multi-component fluid mixture [17, 23]. The most popular are: classical non-slip bounce-back scheme (for solid particles), slip bounce-back scheme (for two immiscible liquids), bounce-back with modified collision operator (for fluid mixtures), bounce-back operation with non-equilibrium part of distribution function (for complex mixtures), bounce-back operation with Galilean transformation (for universal approach), and others. In this research the modified collision operator, which fits the microfluidic Lab-chip environment most of all. For this reason, the LBM equation for agglomerates is modified by the "solid" area fraction γ in each nodal cell [16, 17].

Single particle distribution function in these nodes becomes:

$$f_i^{(n)}(r + c_i\Delta t, t + \Delta t) = f_i^{(n)}(r,t) -$$

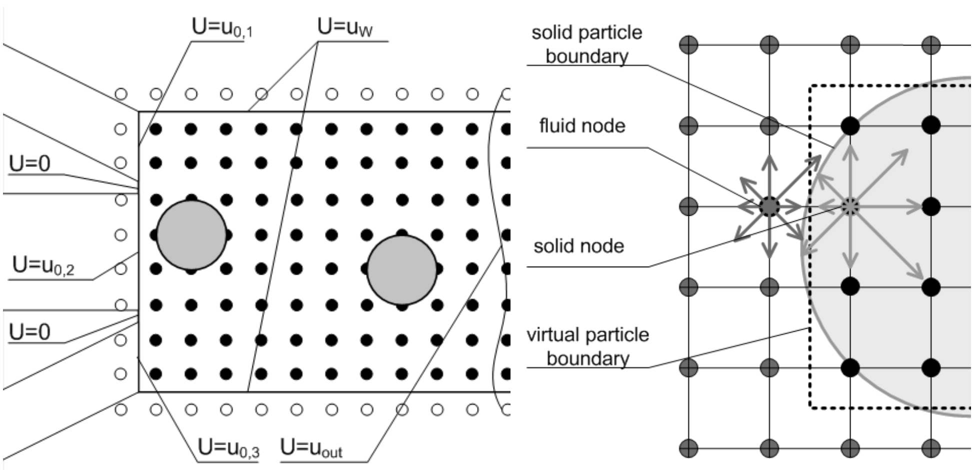
$$\frac{\Delta t}{\tau^{(n)}}(1-\beta)\left[f_i(r,t) - f_i^{(n)eq}(r,t) \right] + \beta \cdot f_i^{(n)}, \quad (16)$$

where: β – is coefficient, that depends on the "solid" area fraction (γ_s) in each lattice node:

$$\beta = \frac{\gamma\left(\tau^{(n)} - 1/2\right)}{(1-\gamma) + \left(\tau^{(n)} - 1/2\right)}. \quad (17)$$

All boundary expressions should be formulated and applied in such way, that the relevant hydrodynamic moments recalculated from the distribution functions are consistent with the primary macroscopic hydrodynamic parameters. Thus, in LBM algorithm the macroscopic parameters should be recalculated and harmonized at grid nodes before each collision step.

The major limitation of this LBM algorithm is the requirement of grid discretizing, which should comply to uniform square lattices. Several modifications were proposed in literature, like rectangular or stretched grids, multi-block grid, they do not receive extended application and most of LBM software tools works with regular square lattices. Besides, LBM simulation should be conducted entirely in lattice units, where time step, lattice step are of unit length. So, in order to guarantee the simulation consistent, all physical parameters need to be rescaled to non-dimensional form and then converted to LBM units, (Fig. 7).



a) b)

Fig. 6. LBM discretizion grid of microfluidic microchannel domain:
a) black dots – fluid domain; white dots – ghost fluid;
b) fluid and solid LBM nodes in multiphase flow

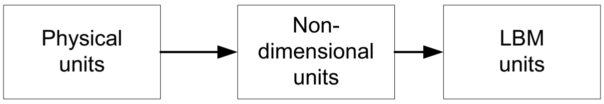


Fig. 7. LBM scaling procedure

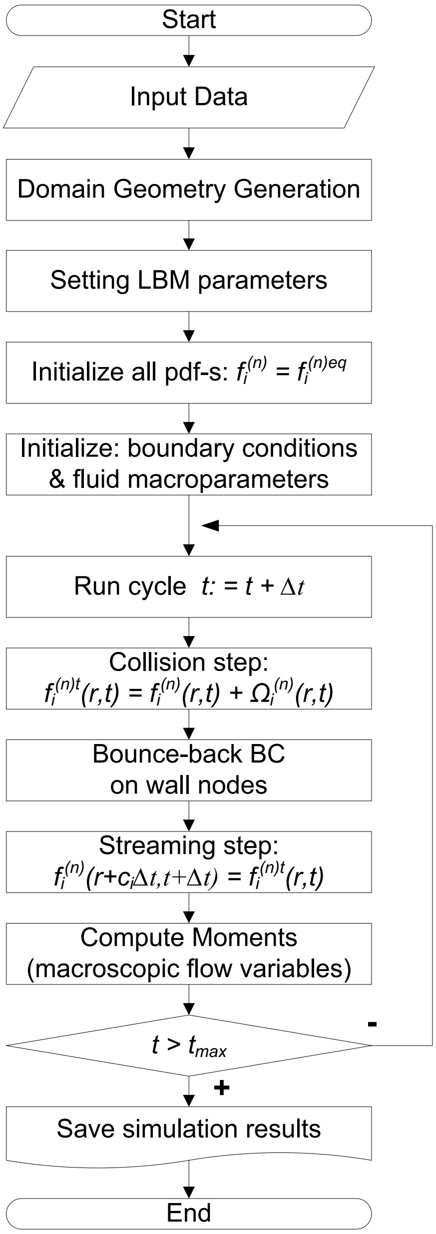


Fig. 8. LBM computational algorithm

The overall solution procedure, allows the LBM fluid flow simulation, can be described by the following collide&stream algorithm, (Fig. 8).

At first, the geometry of computational domain should be defined, and discretized grid (spatial step) according to selected lattice type (velocity scheme) must be formed. Next, appropriate time step, related to the incorporated fluid flow physics (number of fluid components and distribution functions) need to be calculated and verified according to $\Delta t = \Delta r/c$. As far as grid nodes and required distribution functions are known, an initialization procedure should set values for each $f_i^{(n)}$ in all lattice directions at each grid node. Initial boundary conditions should be included into initialization procedure as well according to Eq. (11-15). On this stage "collision step" should be executed and temporary (ready to stream) versions of n distribution functions at each node point for each lattice direction have to be calculated according to Eq. (8). Nodes, which are in touch with various boundaries, should correct their temporary distribution functions by applying appropriate bounce-back and/or periodic conditions, see Eq. (16). Next is "streaming step", where the particle population advects in the direction of corresponding lattice velocity to the neighboring lattice node, see Eq. (9). After that, macroscopic flow variables (u, ρ) can be updated in each grid node by calculating distribution function moments. At last, time step need to be incremented and checked if it reached maximum value.

Usually, the isothermal fluid flow can be characterized by Reynolds number:

$$\mathrm{Re} = \frac{u \cdot L_D}{\nu}, \tag{18}$$

where: L_D – equivalent hydrodynamic diameter, $L_D = a$ – for microchannel with typical square cross-section (a – appropriate side). In LBM simulation procedure, the mesoscopic and macroscopic Re numbers should be equal [12]. This requirement allows to calculate the number of LBM nodes, and the appropriate size of LBM lattice.

RESULTS AND DISCUSSION

A numerical simulation of two-component fluid flow, which consists of liquid phase (water) and single solid particle was conducted in actual research (see Fig. 9). The microchannel dimensions were chosen as *1.0x1.0x10.0* (*mm*). Reynolds number was estimated in a range $Re = 0.1\text{-}10$. At this research stage, solid particle was represented as a sphere with the radius $r = 10^{-4}\,m$ and density $\rho = 2.59x10^3 kg/m^3$. Viscosity of the fluid μ was set to 10^{-3}Pa s.

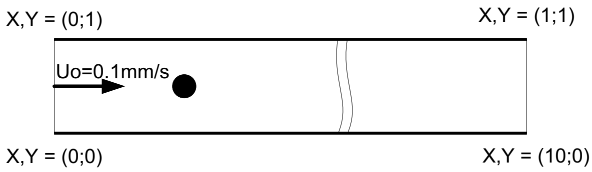


Fig. 9. LBM calculation domain

Flow enters from the left boundary with a prescribed parabolic velocity and exits out the right boundary with a constant pressure $P_{out} = 1{,}0\ atm$. The top and bottom boundary are modeled as no-slip walls. In order to reduce calculation costs, the LMB domain was truncated to 500x100 lattices. The carrier fluid enters the domain with a Poiseuille velocity profile.

LBM calculations were conducted to obtain the fluid velocity profile around solid particle and its position. The colorbar legend with appropriate velocity scale is shown at the right. The diameter of particle is much smaller than the domain size and, at the beginning, solid particle moves slower then surrounded fluid.

The development of velocity profile can be presented by graphical screenshots, which were taken in different timestamps (see Fig. 11).

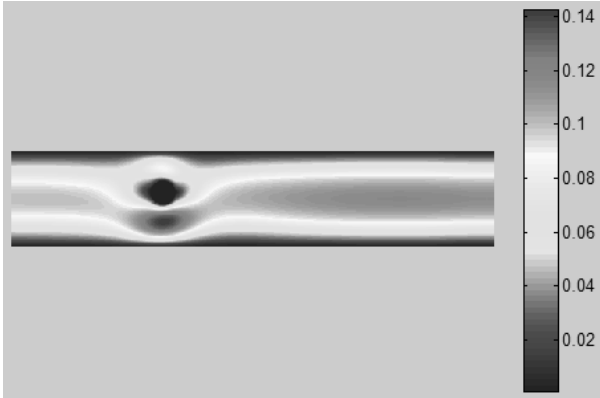
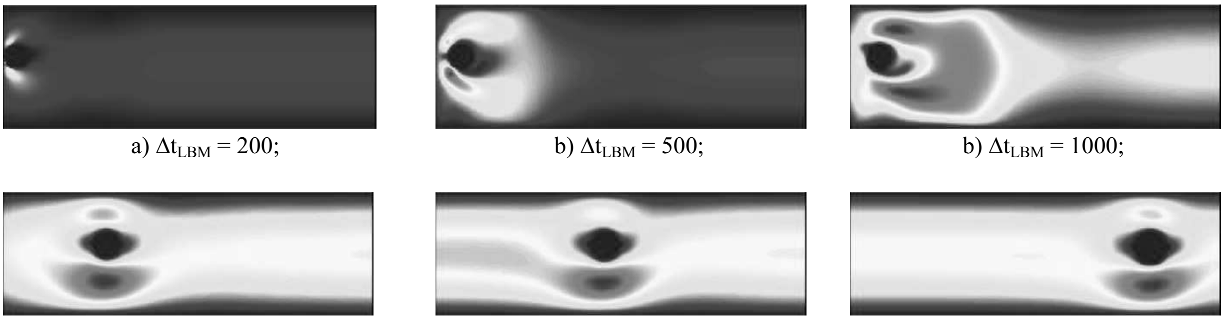


Fig. 10. Fluid velocity profile around particle



a) $\Delta t_{LBM} = 200$; b) $\Delta t_{LBM} = 500$; b) $\Delta t_{LBM} = 1000$;

b) $\Delta t_{LBM} = 3000$; b) $\Delta t_{LBM} = 5000$; b) $\Delta t_{LBM} = 10000$;

Fig. 11. Screenshots of simulated fluid velocity profile

The velocity profile around particle is going to stabilized at Δt_{LBM} approach to 40000 LBM time steps. In areas, remote from particle, velocity profile returns back to initial Poiseuille flow.

CONCLUSIONS

In actual research the mesoscale lattice Boltzmann model of fluid flow was developed and simple numerical simulation experiment with single solid particle was implemented. No-slip, no-penetration and bounce-back boundary conditions were prescribed at each wall using the Ghost-fluid method. Although, mesoscopic LBM gives a remarkable possibility to simulate a broad variety of complex fluid phenomena within single computational procedure. Just small change in the original computational procedure allows significant changes in physics of domain. In further research solid particle will be replaced by immiscible fluid drop, like oil. Next, multiple particles with different sizes may be added and simulated fluid flow behavior. Different obstacles, external forces and non-slip boundary conditions may be included to analyze mixing/separating possibilities.

The most valuable advantages of LBM calculation procedure are: 1) Intrinsic linear scalability in parallel computing that can be efficiently solved, because the collision are calculated locally; 2) Easy dealing with arbitrarily complex geometries: geometric complexity of microfluidic channels is not a challenge, because of the simple solid moving and domain deformation; 3) Efficient inter-phase interaction handling for multiphase flow because phase interaction is inherently included in the particle collisions.

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Dataspace architecture and manage its components class projection

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Abstract. Big Data technology is described. Big data is a popular term used to describe the exponential growth and availability of data, both structured and unstructured.
There is constructed dataspace architecture. Dataspace has focused solely – and passionately – on providing unparalleled expertise in business intelligence and data warehousing strategy and implementation. Dataspaces are an abstraction in data management that aims to overcome some of the problems encountered in data integration system. In our case it is block vector for heterogeneous data representation.
Traditionally, data integration and data exchange systems have aimed to offer many of the purported services of dataspace systems. Dataspaces can be viewed as a next step in the evolution of data integration architectures, but are distinct from current data integration systems in the following way. Data integration systems require semantic integration before any services can be provided. Hence, although there is not a single schema to which all the data conforms and the data resides in a multitude of host systems, the data integration system knows the precise relationships between the terms used in each schema. As a result, significant up-front effort is required in order to set up a data integration system.
For realization of data integration from different sources we used SQL Server Integration Services, SSIS.
For developing the portal as an architectural pattern there is used pattern Model-View-Controller (MVC).
There is specifics debug operation data space as a complex system. The query translator in Backus/Naur Form is give.
Key words: Big data, dataspace, translator requests metalanguage, architecture, formal language

INTRODUCTION

Information boom led to an increase in the amount of data accumulated in many subject areas thousands of times. Number of information gathered grows exponentially. Thus, according to research IDC Digital Universe Study, conducted and commissioned by EMC, the total amount of global data in 2005 was 130 Exabyte, by 2011 it increased to 1227 EB, and over the last year doubled again, reaching 3 ZB. Weather by that same survey shows that by 2015 the volume of digital data will grow to 7.9 ZB. The size of individual databases is growing very fast and overcame barrier in PB. Most of the data collected are not currently analyzed, or is only superficial analysis [15].

The main problems that arise in the data processing is the lack of analytical methods suitable for use because of their diverse nature the need for human resources to support the process of data analysis, high computational complexity of existing algorithms for analysis and rapid growth of data collected [21]. They lead to a permanent increase in analysis time, even with regular updating of hardware servers and also arise need to work with distributed database capabilities which most of the existing methods of data analysis is not used effectively. Thus, the challenge is the development of effective data analysis methods that can be applied to distributed databases in different domains. It is therefore advisable to develop methods and tools for data consolidation and use them for analysis.

Big Data information technology is the set of methods and means of processing different types of structured and unstructured dynamic large amounts of data for their analysis and use for decision support [7 - 11]. There is an alternative to traditional database management systems and solutions class Business Intelligence. This class attribute of parallel data processing (NoSQL, algorithms MapReduce, Hadoop) [1, 2, 15, 16].

Defining characteristic for big data is the amount (volume, in terms of value of the physical volume), speed (velocity in terms of both growth rate and need high-speed processing and the results), diversity (variety, in terms of the possibility of simultaneous processing of different types of structured and semi-structured data) [12 -14].

Data space is a block vector comprising a plurality of information products subject divided into three categories: structured data (databases, datawarehouses), semi-structured data (XML, spreadsheets) and unstructured data (text). It consists of the set of information products of subject area [1]. Above this vector and its individual elements defined operations and predicates that provide: converting various elements of the vector at each other; association of one type; Search items by keyword.

In thesis there is projected dataspace architecture as information technologies for working with big data.

MATERIALS AND METHODS
DATA SPACE ARCHITECTURE

Dataspace architecture consists of several levels and has such levels as data level, manage level and metadescribe level (Fig . 1).

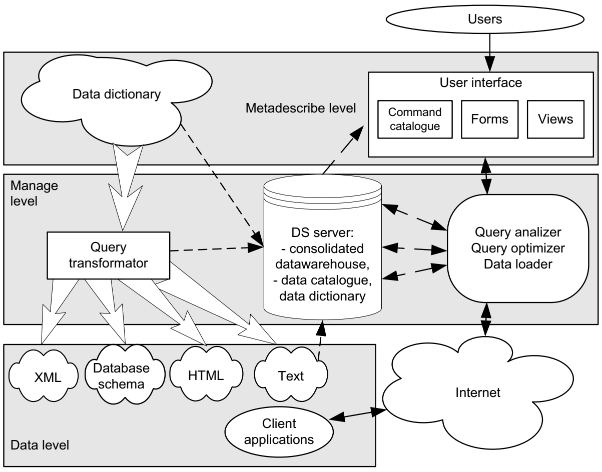

Fig. 1. Dataspace architecture

The modules structure of dataspace is described on Fig. 2.

Data level consists of information products of dataspace. Data level on Fig. 2 described as cloud.

Manage level consists of modules for dataspace organization and manage [1,2]:

– Module for user permission determination (by user authorized procedure).

– Query transformation module (by interpretation method).

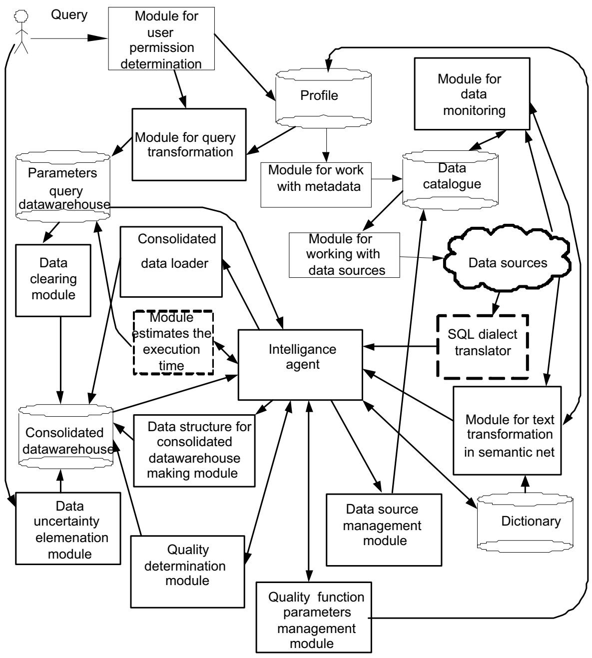

Fig. 2. Dataspace structure

– Module for working with metadata (by find operation as query to metadata).

– Sources access by type module (by standard data exchange protocols usage).

– Module for text transformation in semantic net (by the semi-structured data analysis method).

– Intelligent agent (based on the formal description of intelligent agent determine the structure of the data source, the algorithm of the intelligent agent).

– Data structure for consolidated datawarehouse making module (based on the method of construction of consolidated data repository schemes and work smart agent determine the structure of the data source).

– Consolidated data loader (based operations consolidation, data consolidation method).

– Module purification data (based on advanced operators cut, coagulation operator, method of forming a system of norms and criteria, method of analysis, filtering and converting input data).

– Data uncertainty elimination module (based on the method of application of classification rules and modified operator eliminate uncertainty in the network structure of the consolidated data. The method of construction schemes consolidated data repository and work smart agent determine the structure of the data source).

– Quality determination module.

– Quality function parameters management module (based methods control elements data space based on the function of the quality and levels of trust).

– Data source management module.

– Module for data monitoring.

– Module estimates the execution time (based on the standard of fixing runtime)SQL dialect translator (by the SQL description).

Level control models of platform is maintenance DS.

The meta descriptions level containing all the basic information about the data sources and methods to access them. Also there are defined methods of data processing: for structured sources - selection, grouping, etc., for semi-structured and unstructured - definition of structure or search by keyword.

In addition, the dataspace also provides data storage for storing user profiles and temporary storage request parameters.

TECHNOLOGICAL ASPECTS

For realization of data integration from different sources we used SQL Server Integration Services, SSIS. SSIS has a flexible and scalable architecture that provides effective data integration in today's business environment.

SSIS consists of the support tasks thread kernel and kernel support for the data stream. The support tasks thread kernel is oriented on operations. The flow of data exists in the context of the total flow problems (fig. 3).

The core of SSIS is the pipeline data conversion. The architecture of the pipeline supports buffering, that allowing the conveyor to quickly work with the manipulation of the data sets once they are loaded into memory. The approach is to perform all phases of ETL-process of converting data in one operation without intermediate storage. Although the specific requirements for the conversion of operations or conservation are can be an obstacle in the implementation of this approach.

SSIS if possible even avoid copying data in memory. This is fundamentally different from traditional ETL-tools that often require intermediate storage at almost every stage of processing and data integration. SSIS transforms all data types (structured, unstructured, XML, etc.) before loading into their buffers into a relational structure.

Service Integration SQL Server 2012 is optimized for connections via ADO.NET (previous versions were optimized for OLE DB or ODBC). ADO.NET using simplifies system integration and support of third parties. Integration Services SQL Server 2005 used OLE DB to perform important tasks such as search operations (lookups), but now for all tasks associated with data access, you can use ADO NET.

As the scale of integration solutions often productivity increases only to a certain limit, and then goes to a level that is very difficult to overcome. Integration Services SQL Server 2012 removes this limitation by sharing streams (threads) set of components, which increases the degree of concurrency and reduces the frequency lock, it enhances productivity in large-scale systems with a high degree of parallelization based on multiprocessor and multicore hardware platforms.

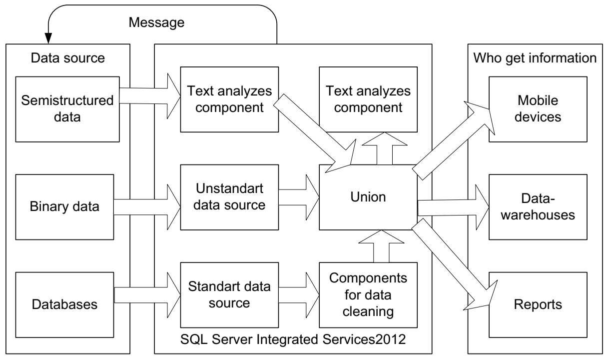

Fig. 3. SSIS integration schema

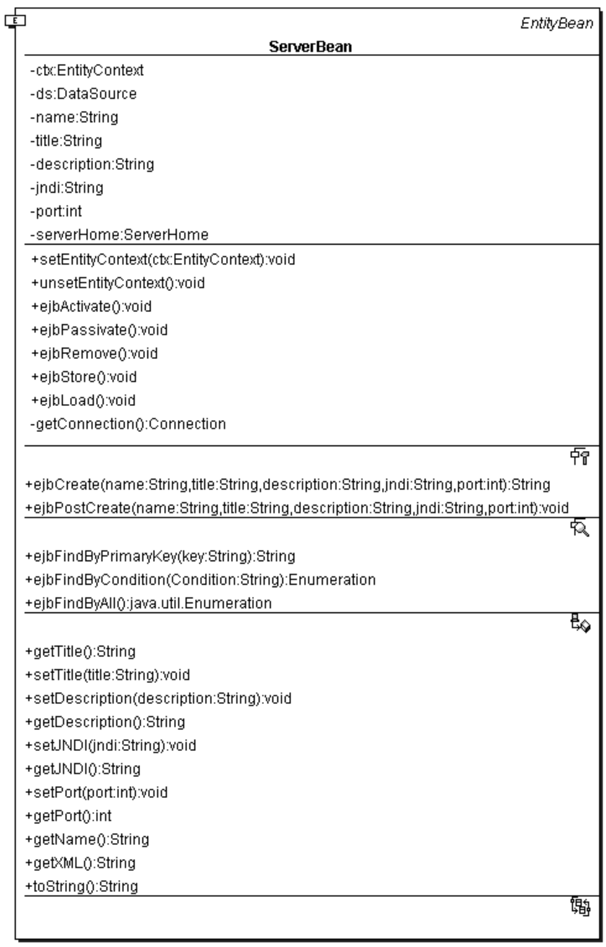

Fig . 4. DS components manage class structure

Search is one of the most common operations in the integration solution. Integration Services SQL Server 2008 accelerates the search operation and effectively implement them in large tables. There is loading full cache from any source, cache size can not exceed 4GB, even in 32-bit operating system. Using partial cache service integration SQL Server 2012 pre-load data required for the search. Partial cache supports OLEDB, ADO.NET and ODBC for database search, and tracks hit and miss in the search process [17–18].

SSIS can extract (and unload) data from various sources, including OLEDB, controlled sources (ADO.NET), ODBC, flat files, Excel and XML, with a special set of components called adapters. SSIS can also be used for custom adapters. It means that they are created by yourself or other manufacturers for their needs. This can include inherited logic upload data directly to the data source, which, in turn, without additional steps can be implemented in a data stream SSIS. SSIS includes a set of data conversion, with which you can do with all the data manipulations that are needed to build consolidated data repository.

THE MANAGEMENT CLASS OF DATASPACE COMPONENT STRUCTURE

Let us describe the structure of class management components of PD (Fig. 4):

– ctx – a reference to the object that allows a component to obtain proprietary information about users and transaction data that a user works with the component,

– ds – reference to the pool of database connections,

– name, title, description, jndi, port – component parameters accessible via Remote-interface methods,

– serverHome – link to Home-interface component Server,

– setEntityContext / unsetEntityContext - methods which establish ctx.– Invoked only container,

– ejbActivate / ejbPassivate – methods that control life cycle component.– Invoked only container,

– ejbRemove – a method that is called before the destruction of the component on the server side (implementing a database query to remove this component from the base),

– getConnection – a method that cause for connection pool connections.– Its more as a convenience, and the EJB specification does not in any way,

– ejbCreate – a method that implements a create-methods with Home-interface.– It implement database queries to create the component and set the parameters component,

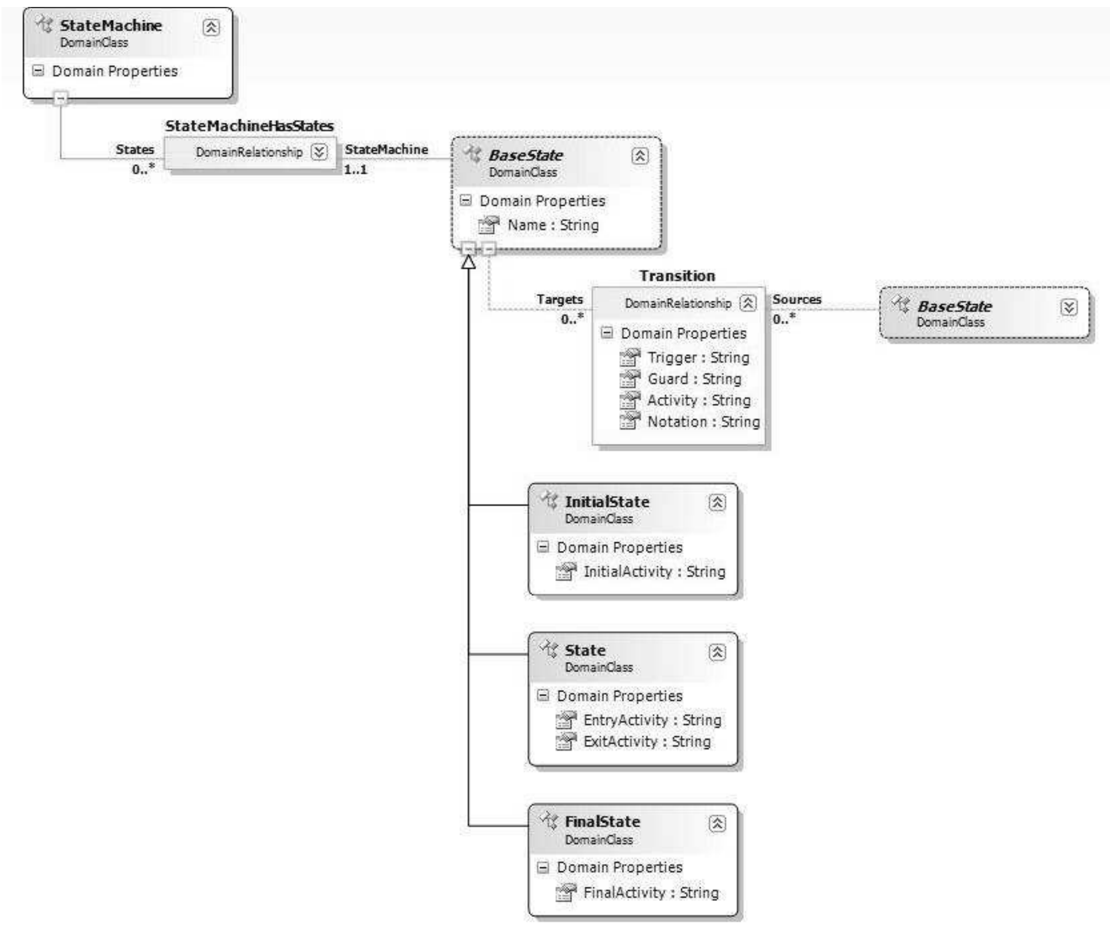

Fig. 6. Intelligence agent metamodel diagram

– ejbPostCreate – methods are called after ejbCreate,

– ejbFind – implement method of search techniques is searched components in the database,

– get / set – methods of implementing get / set methods defined in the Remote-interface,

– toString – defined for greater compatibility with infrastructure JAVA.

Intelligence agent metamodel is described on Fig. 5.

The root element of the metamodel is itself diagram intelligent agent [1] StateMachine. StateMachineHasStates ratio means that the agent is in the states. BaseState - base type for the state. The chart can accommodate three types of states: initial state InitialState, State intermediate state and final state FinalState. Any intermediate state can have two actions: EntryAction - action to be executed immediately at the entrance to this state, ExitAction - action to be executed upon exit from the state. The initial and final states have the single action. For the initial state of this action InitialActivity. It will be executed when you run the agent. To the end of this action FinalActivity. It will be performed at the end of intelligent agent.

Attitude Transition means a transition from one state to another.

Each transition has an event name Trigger, while the emergence of which is next. Tape Guard delivers a covenant enforcement is necessary to complete the transition. In the case of the availability and performance of necessary conditions, the proposed operation will Activity. Notation-tape, which automatically generates and submits a complete description of the transition in a format Trigger [Guard] / Action.

The main class for working with data sources is the class Model (specification is shown in Figure 7). It designed for requirements [4].

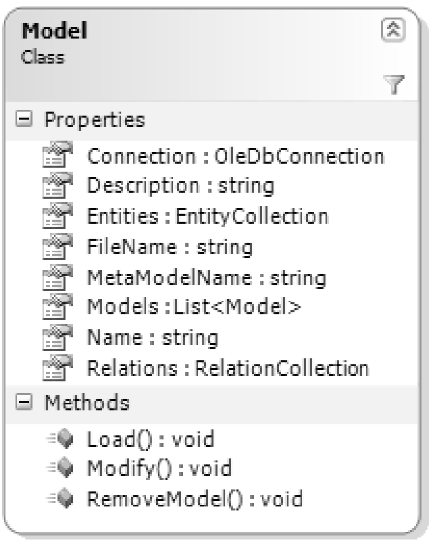

Fig. 7. Class Model specification

This class has such methods and properties as:

– Connection – link on data source connection.

– Description.

– FileName.

– MetaModelName – data source type.

– Models – list of linked sources.

– Name – source name.

– Entities.

– Relations.

– Load – the method for data structure load in data catalogue and data dictionary.

– Modify – the method for modify of elements in catalogue and dictionary.

– RemoveModel – the method for removing information about data source from catalogue.

EntityCollection class is presented on Fig. 8.

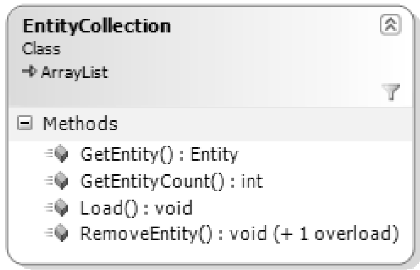

Fig. 8. Class EntityCollection specification

Class EntityCollection has such methods as:

– GetEntity – result of this method is element from entity collection by name.

– GetEntityCount – method for entities count in current model.

– Load – method for entity collection load from current database model.

– RemoveEntity – method for entity removing from collection.

Fig. 9. represents the class Entity.

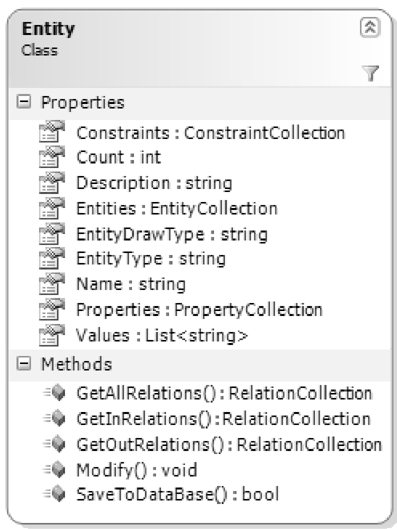

Fig. 9. Class Entity representation

Class Entity consists of following methods and properties:

– Attributes.

– Constraints.

– Count – count of entity elements created in model;.

– Description.

– Name.

– EntityDrawType – pictogram for entity representation.

– Entities – the model's entities collection, which consists of current entity.

– EntityType.

– Operations – list of operation about entity.

– Values – list of attribute values of entity.

– GetAllRelations – the method, result which is the list of all entity relations.

– GetInRelations – the method, result which is the list of all entity get in relations.

– GetOutRelations – the method, result which is the list of all entity get out relations.

– Modify – the method for entity changing in database.

– SaveToDataBase – the method for entity saving in database.

Class Relation is given on Fig. 10. It consists of following properties:

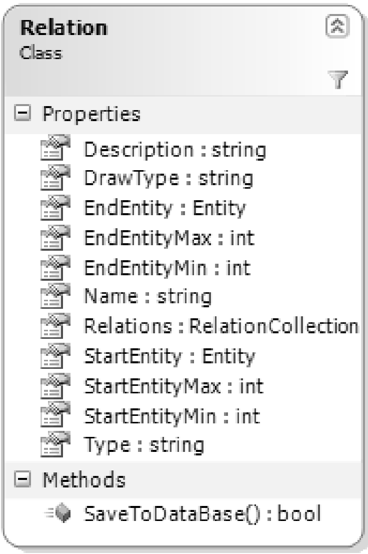

Fig. 10. Class Relation specification

– Constraints.

– Description.

– EndEntity – link on end entity.

– EndEntityMax – the maximum count of end entity examples.

– EndEntitytMin – the minimum count of end entity examples.

– Name.

– Relations – relations collection of current entity.

– StartEntity – link on start entity.

– StartEntityMax – the maximum count of start entity examples.

– StartEntityMin – the minimum count of start entity examples.

– Type – relation type.

The method *SaveToDataBase* saves the relation in data catalogue.

The class RelationCollection describes the entities collection (Fig.11).

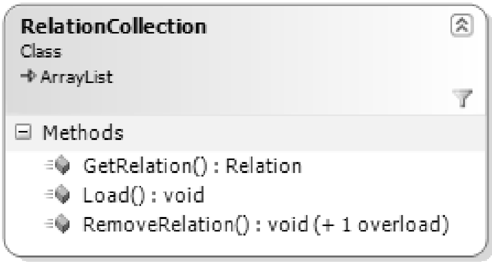

Fig. 11. Class RelationCollection specification

Class RelationCollection has following methods:

– GetRelation – result of this method is element of entity collection by name.

– Load – the method for entity load from current data source.

– RemoveRelation – the method for entity removing from collection and data catalogue.

The concept of "Attribute" describes a class Attribute. Specifications class is shown in Fig. 12 properties and methods of the class are:

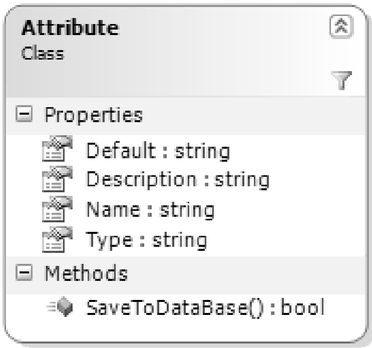

Fig. 12. Class Attribute specification

– Default – default value.

– Description – the attribute description.

– Name – the attribute name.

– Type – the attribute type. It may be referring to the domain of valid values, or a link to some substance.

– SaveToDataBase – the method, that is responsible for maintaining the attribute in the data directory.

A collection of attributes defined entity class AttributeCollection. Description of the class is represented in Figure 13.

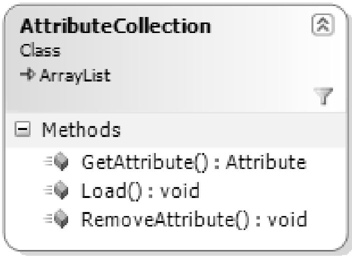

Fig. 13. AttributeCollection Class specification

Class AttributeCollection given by the following methods:

– GetAttribute -– a method that returns the collection of attributes to its name.

– Load -– method responsible for loading collection attributes the current nature of the source.

– RemoveAttribute -– method responsible for removing the attribute from the collection and data directory.

Class specification is shown in Fig. 14, describes the concept of "limit".

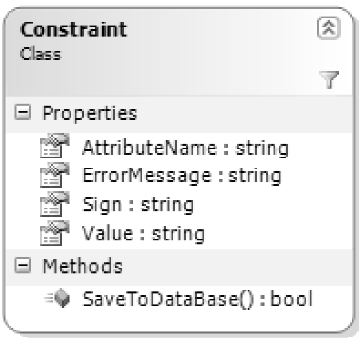

Fig. 14. Class Constraint specification

This class has following properties:

– ErrorMessage – error message on constraint.
– AttributeName – name of attribute.
– Sign – constraint signature.
– Value – value in right part of constraint.

The *SaveToDataBase* method saves information about constraint in database (data catalogue).

Constraint collection for entities and relations is presented by ConstraintCollection class. This class description is presented on Fig. 15.

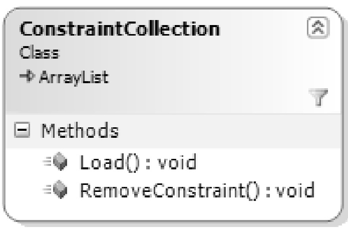

Fig. 15. Class ConstraintCollection specification

The methods of ConstraintCollection class are:

– Load – the method for constraint loading from collection.

– RemoveConstraint – the method for constraint removing from collection and dataspace.

LANGUAGE ELEMENTS DESCRIPTION

For translator building we must describe elements of query language to dataspace. We used Backus/Naur Form, BNF [19 – 20].

<letter>::=a|b|c|d|e|f|g|h|i|j|k|l|n|m|o|p|q|r|s|t|u|v|w|x|y|z|A|B|C|D|E|F|G|H|I|J|K|L|N|M|O|P|Q|R|S|T|U|V|W|X|Y|Z
<keyword> ::= (<keyword>) |<letter> | < keyword>
<number> ::= 0|1|2|3|4|5|6|7|8|9
<object> ::= <data catalogue element>
<par> ::= <the synonym of data catalogue element >
<param> ::= <keyword>[{<keyword>|<number>}]
<num> ::= <number>[{<number>}]
<expr> ::= <operand> [{<op> <operand>}]
<operand> ::=» («<expr>»)» | <num> | <param> [«[«<expr>»]»]
<op> ::= <grteq>
<inv> ::= <logicalop> | «*» | «/»
<type> ::= «SUM» | «COUNT» | «AVG»
<logicalop>::= «<» | «>» | «>=» | «<=» | «=» | «<>» | [<op>]
<whereop> ::= «where» «(» <object> [«:» <par>] {«,»<object> [«:» <par>] }«)»
<whoop> ::= «who» «(» <object> [«:» <par>] {«,»<object> [«:» <par>] } «)»
<howop> ::= «how» «(» <object> [«:» <par>] {«,»<object> [«:» <par>] } «)»
<Seop> ::= «Se» «(»<object>[«:»<par>] [«Agg»<type>] {«,» <object> [«:» <par>] [«Agg» <type>] }«)»
<whatop> ::= «what» «(» <object> [«:» <par>] [«,»<object> [«:» <par>]]«)»
<whichop>::= «which» «(» <object> [«:» <par>] [«,»<object> [«:» <par>]]«)»
<Semantop>::= «Semant» «(» <object> [«,» <object>]«)»
<Consop> ::= «Cons» «(»<object> [«:» { <par> <operator> <param>}] «)»
<profileop> ::= «where» «(» <object> [«:» <num>] {«,»<object> [«:» <num>] }«)»
<Unionop> ::= «Union» «(» <object> [«:» <par>] {«,»<object> [«:» <par>] } «)»
<Unionop> ::= «Union» «(» <object> [«:» <par>] {«,»<object> [«:» <par>] } «)»
<Intersop> ::= «Inters» «(» <object> [«:» <par>] {«,»<object> [«:» <par>] } «)»
< Differop> ::= «Differ» «(» <object> [«:» <par>] {«,»<object> [«:» <par>] } «)»

INTERFACE REALIZATION

Let us project interface metamodel for user query interpretation (Fig. 16). Entities InterfaceHasMethods, InterfaceHasProperties, InterfaceHasEvents meen, that interface has Methods, Properties and Events.

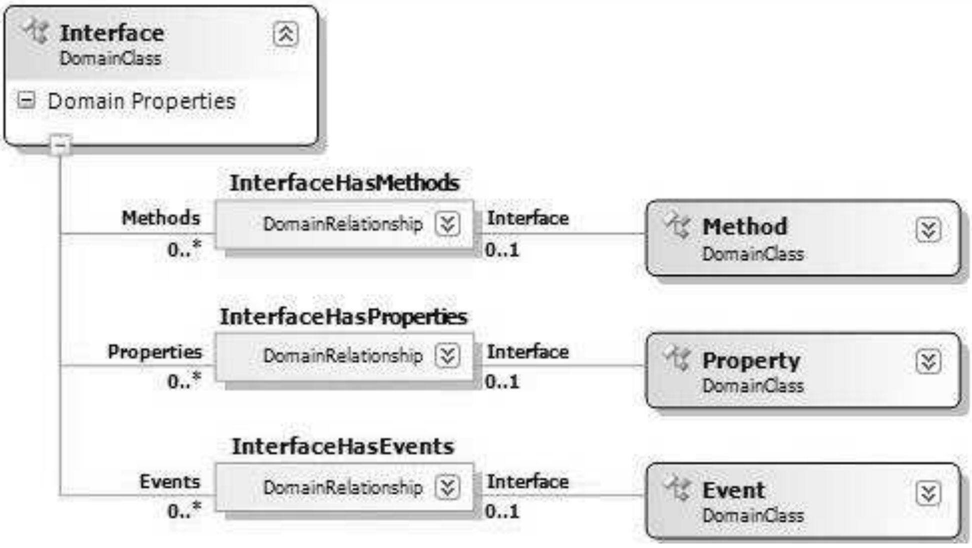

Fig. 16. Interface metamodel for user query interpretation

For developing the portal as an architectural pattern there is used pattern Model-View-Controller (MVC).

Model-View-Controller (Model-View-Controller, MVC) is architectural pattern, which is used in the design and development of software. Splits system into three parts: data model and data view. It is used to separate data (model) from the user interface (view) so that the user interface changes minimally affect the operation of the data, and changes in the data model could be conducted without changing the user interface.

The purpose of the template is flexible design software, which should facilitate further changes or expansion programs, and provide an opportunity for reuse of individual components of the program. Also use this template in large systems leads them in a certain order and makes clearer by reducing their complexity.

The architectural pattern Model-View-Controller (MVC) divides the program into three parts. In the triad of responsibilities Component Model (Model) is a data storage and software interface to them. View (View) is responsible for the presentation of these data to the user. Controller (Controller) manages components, receiving signals as a response to user actions, and reporting changes-component model.

Model encapsulates core data and basic functionality of their treatment. Also component model does not depend on the process input or output. Component output view can have several interconnected domains, such as various tables and form fields, in which information is displayed. The functions of the controller is monitoring the developments resulting from user actions (change of the mouse, pressing buttons or entering data in a text field).

Registered events are shown in different requests that are sent to the component models or objects responsible for displaying data. Separation of models from data presentation allows independent use different components to display. Thus, if the user through controller makes a change in the data model, the information provided by one or more visual components will be automatically corrected according to the changes that have occurred.

At the level Model used ORM (Object-relational mapping), including technology Entity Framework. At this level creates a database model that allows you to work with it as with a set of entities, as well as avoiding explicit use of SQL. All these things will perform ORM.

Controller is a class that contains event handlers and other business logic.

CONCLUSIONS

1. In this paper there is projected dataspace architecture and instrumentation tools for practical realization.
2. There are chased program tools for variant data integration realization.
3. The main classes' specification is described.
4. There are described language tools and user interface realization.

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The conceptual model of essential expression of innovative activity adaptive planning mechanism at the mechanical engineering enterprises

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Abstract. In this article we analyzed the recent state and the perspectives of the Ukrainian mechanical engineering complex, characterized main ways to improve the efficiency of this economy sector. Here are determined new quality characteristics of the mechanical engineering enterprise's operational environment. We proposed the classification of existing methods that explain the phenomenon of adaptation and opened their gist. We pointed out the main groups of factors which activate the adaptive planning mechanisms of the innovative activity at the mechanical engineering enterprises. We proposed the definition of "adaptive planning mechanisms of the innovative activity". Here are characterized the components of the adaptive planning mechanisms of the innovative activity at the mechanical engineering enterprises and their influence on its development. We also made prognosis on how enterprises can alternatively demonstrate their adaptive properties, characterized the main phases of mechanical engineering enterprise's development. In this paper we proposed conceptual model of essential expression of innovative activity adaptive planning mechanism at the mechanical engineering enterprises depending on factors which influence it.

Key words: mechanical engineering, innovative activity, adaptive planning, factors which activate adaptive mechanisms, phases of innovative development.

INTRODUCTION

Today the mechanical engineering complex is the strategic sector of Ukraine's economy, that significantly affects the state competitiveness, because it produces substantive proportion of the gross domestic product. Ukrainian economy is composed in such a way that mechanical engineering became "one of the priority branches of industry" [16], "it determines economical, industrial and scientific level of the state, its positions in exports" [19] and "provides transition of society from traditionally industrial to post industrial development phase" [10]. In addition, mechanical engineering is the main, most complex and knowledge-intensive branch of industry which determines the level of sci-tech progress and the growth of labor efficiency in the entire economy, because it provides economy with machinery, equipment, appliances and other technics [8].

Despite of mechanical engineering complex's strategic priority, today scientists ascertain negative tendencies in its development, emphasizing on "the disparity to the world technological requirements, what causes the absence of potentiality to compete the american-euro-asian market leaders" [5] and on "industry structure letdown, as a result of siderurgy and fuel and energy sector product's proportional growth, along with the downfall of mechanical engineering particle [22], in addition with "the absence of clearly defined perspectives, largest disadvantage of what we can assume to be the inefficient company management" [18].

Considering existing difficult conditions, the innovative activity acquires special significance as a potential possibility to get stable competitive benefits on market for boosting overall state competitiveness.

Innovative activity allows the enterprise to get a number of competitive benefits in the conditions of market relations, because new goods and services or new approaches to business management bring economical advantages and a significant enlargement of client base. In analised literature [23] innovative activity is considered to be the foundation of knowledge based economy.

The necessity to activate the innovative processes at the national industrial enterprises requires the creation of such fundamentally new administrative conception as the adaptive planning of innovative activity, which is formed and functions on absolutely new theoretical and methodological approaches and principals.

MATERIALS AND METHODS

Although adaptive management is a quite new kind of administration in scientific sphere, nonetheless theoretical and practical principles of its realization were described by a cohort of national and foreign scientists`, namely: [5, 7, 9, 11, 13, 14, 15, 17, 24] and others.

Analysis of scientific literature done by author indicates that on the modern stage of management's theory and practice development problems of adaptive planning are not enough researched, scientific and methodological principles of its organisation are not developed. We should note that only some of the aspects of the specified problem are researched in a few articles and scientific economic profile publications, among which are: theoretical meaning of "adaptation" concept, causal relationships of necessity to build adaptive mechanisms of management, theoretical and methodological foundations of adaptive management's realizaion, peculiar properties of its informational providing. Fragmentary character and existing differences in scientist's proceedings largely obstruct adaptive management to develop in entrepreneurial environment.

The purpose of the article is to elucidate the conceptual model of essential expression of adaptive planning's mechanism in innovative activity at mechanical engineering enterprises, depending on factors which influence it.

RESULTS AND DISCUSSION

According to the results of "The Global Competitiveness Report" we must ascertain a considerable drop of Ukraine's production potential and competitiveness on world market (Ukraine lost 9 positions in a scale of 130 positions in the last 4 years) [6]. Such rating was formed considering different factors, such as state's resource base, the quantity of working population, infrastructure development, size of the markets, technological level of manufacture, level of business culture and many others. Many Ukrainian and foreign scientists note that the innovative activity is the competitiveness driving factor, because innovations give the companies stable competitive advantages.

However innovations are not self-contained, that's why the expected positive result can be reached only with complex changes on which scientists make emphasis.

[12] focuses on necessity to make a revision of the whole system of mechanical engineering enterprises functioning, starting from its basic principles with the aim to adapt it to the market environment and national conditions of economic development. In author's opinion, the functioning of mechanical engineering enterprise in conditions of market relations puts new requirements to organization of managing process, which on the way of transformation should comply with the market's principles and the principles of sustainable development.

The variability and dynamic of environment in which domestic mechanical engineering enterprises are functioning, risks which became an integral part of a modern economy, are the main prerequisites to use adaptive mechanisms which are based on a diverse and usually dissimilar forms of the phenomenon of adaptation. As scientists claim, successful functioning and development of the modern industrial enterprises are determined by their possibilities to adapt to the changes in the external environment. The effective management is possible only if it is provided by focused and timely adaptation to changing market's conditions of economy [15].

[1] are making a stress upon the phenomenon of adaptation manifestation as the enterprise's capability to react on changes in markets conditions with the purpose to get favorable consequences for its activity.

[5] explains adaptation as a process of systems adjustment to external environment's changes, what will grant the system the most effective regime of its functioning. Similar points of view have other authors [2; 3; 4], they consider adaptation to be a process of economical system's accommodation to external environment's changing conditions. [7] interprets adaptation as a process of purposeful changing of object's settings, structure and properties as a respond to changes that are taking place.

[21] are understanding adaptation as a resource because they see enterprise's adaptive properties first of all as the reserve of firmness, ability to keep relative integrity during periods of company's unstable functioning without essential structure changes in it or without its destruction.

[11] claim that adaptation is a result, or if more specifically, a new state of company which was obtained after a complex of measures had been realized under the influence of inner or outer environment to reconfigure company's internal processes.

All of the above explanations of the phenomenon of adaptation (fig. 1) are logical and correct, but variability of their manifestation foremost depends on factors which influence the management process.

As well, adaptation is interpreted in two actually opposite aspects. In particular, when it is seen as system's adjustment to condition's changes, it will act as absolutely passive property. On the other hand, a system can affect the changes which influence it from the outside. In this case it will act like active property.

There is a classification of complex adaptive system's development variants, which depends on what factors the system is influenced by [20]. This classification can also be used for subjects of the real sector of economy as an instrument to determine mechanical engineering enterprise's phase of development. The classification demonstrates a character of three main influencing features changes which are activating system's adaptive properties (table 1): duration (time) of adaptation process (T), adaptation's activity (A) and the quality of adaptation (Q).

In our opinion, it is advisable to allocate four main groups of factors which influence the system and are activating the mechanism of innovative activity's adaptive planning at mechanical engineering enterprises:

- variability of the environment,
- risks of the activity,
- external threats,
- untapped potential.

In a process of their functioning national mechanical engineering enterprises constantly are being affected by the variability of the environment, what became an inherent property of the modern conditions of management. To main factors of variability belong constant changes in exchange rates, which significantly influences the cost of imported raw materials, export prices and prices of imported products which are competing on market. As well, changing conditions of supply and marketing are forcing mechanical engineering enterprises to adapt their production and sales processes. Inconsistency of global demand caused by change of purchasing power also stimulates enterprise's adaptive mechanisms.

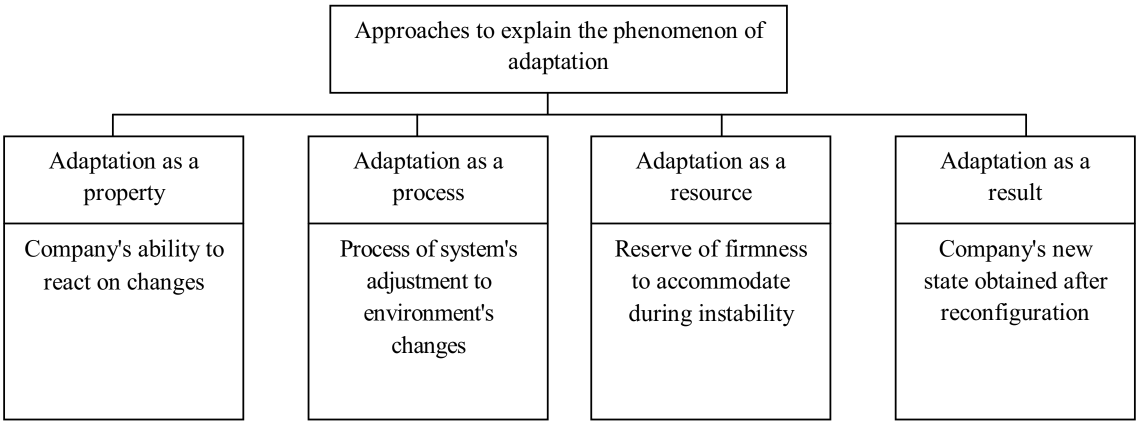

Fig. 1. Approaches to explain the phenomenon of the real economy subjects adaptation*
Source: author's own development

Table 1. Alternative ways of innovative development's adaptive properties manifestation at mechanical engineering enterprises*

№	Factors that stimulate adaptive planning innovative activities	The essence of the adaptation	Adaptation's activity level	The duration of the adaptation process	The quality of the adaptive process	Innovati develop-ment's phaseve
1	Variability of the environment	Adaptation as a property	Passively-active adaptation	Short-term adaptation	Inefficient adaptation	Decline
2	Risks of activity	Adaptation as a resource	Actively-passive adaptation	Short-term adaptation	Effective adaptation	Development
3	External threats	Adaptation as a process	Passive adaptation	Long-term adaptation	Inefficient adaptation	Depression
4	Untapped potential	Adaptation as a result	Active adaptation	Long-term adaptation	Effective adaptation	Prosperity

* Source: author's own development.

Constant accommodation to unpredictability and variability of external environment forms adaptive properties of a modern company, however adapting is not fully passive. Partial adjustment of company's production and management activities cause the emersion of short-term actively-passive adaptation to partial oscillations in the activity environment. This indicates a company's transition to the phase of decline (table 2), because the company must constantly accommodate without affecting the environment.

Another ponderable set of factors, which influences company's innovative activity by stimulating its adaptive mechanisms, are risks. The examples of national mechanical engineering enterprise's risks are the opportunity to change principles of taxation, interest rates and customs regulations. Political circumstances in country are another equally important risk, they also can considerably influence company's activity.

A danger that such risks can occur during realization of innovative projects is predicted yet on a planning stage by laying a margin of resource changes for adapting. In such situation adapting is a resource which was initially laid. In short-terms companies are dynamically changing with the aim of further adjustment to identified threats. Such adaptation is considered to be effective, what gives a signal of company's transition to a development phase (table 2).

Sometimes poorly predicted or not fully foreseen risks of environment become threats for enterprises and further are restricting its functioning possibilities and prevent the achieving of the innovative development's goal. If such threats appear, mechanical engineering enterprises must activate the process of adaptation, which provides long-term accommodation to environment for maximum neutralization of possible negative effects. Such adaption is a fully passive process, because company is in no way trying to influence the environment in which it is functioning and is only adjusting to its conditions, what is considered to be inefficient phenomenon and bring company to a phase of depression (table 2).

In the phase of depression mechanical engineering enterprises have absolutely no effect on market in which they are functioning. All economic conditions are being dictated by competitors, consumers, suppliers, state or other subjects of the external environment. Getting out of that phase is extremely difficult as company is constantly working over accommodation to the conditions, which have already appeared without having possibility to start own development scenarios.

However, there always is untapped potential on the market which can be both internal and external. The example of mechanical engineering enterprise's internal innovative potential are unrealized innovative projects, which will give the manufacturer's sustainable competitive advantages, unrealized management innovation projects which will improve producing and administrative activity, or marketing innovative products which will help to raise demand for the products. In addition, there can be external unrealized potential such as new markets, unmet needs of consumers or access to cheap outer financial resources. If the company managed to catch out that resource on time and used it, it will make possible the getting of great competitive advantages in the market. Long-term effective change of an enterprise leads to a new qualitative state when the adaption manifests itself as a result, which brings the mechanical engineering enterprise to the prosperity phase (table 2).

Characterized factors are activating mechanical engineering enterprise's adaptive planning mechanisms of innovative activity. We offer to look at adaptive planning mechanisms of innovative activity as a relationship of elements, tools, technologies and leverages which enable the creation of adaptive planning system of innovative activity and its successful functioning at the enterprise.

None of the economic mechanisms can't function without interim components, which contribute to the goals of the innovative active enterprise, namely: legal, information, resources and organizational and methodological support.

Company's innovative activity among other kinds of activity is perhaps the most regulated and controlled by Ukrainian legislation, because it provides strategic development of the state. Legal basis of adaptive planning mechanism of innovative activity includes laws of Ukraine, Decrees of the President of Ukraine, Regulations and Decrees of the Cabinet of Ministers, orders, Regulations and Orders of Ministries and Departments, etc. All of the above instruments of legal basis are to create institutional frameworks, which will stimulate innovative processes at the enterprise, support innovative development and promote innovative projects at the enterprise.

Modern company functions in a changing and unpredictable competitive environment, that is why on time and relevant informational flows significantly increase the effectiveness of innovative solutions. Informational flows can be both inner (related to enterprise's strengths and weaknesses, available resources, level of the inner potential), and outer (related opportunities and threats of the environment, demand on market, activities of competitors, the price level and the purchasing power of consumers).

Resources support is a material basis of adaptive planning mechanism's of innovative activity as a set of financial, material, nonmaterial, labor, technical and other resources of the enterprise. The financial resources are of particular importance, as innovative projects require significant investment which are accompanied by time lag after which company begins to receive early cash flow. Equally important are labor resources, because innovative activity needs the appropriate skills and abilities of the staff, and also their desire and a good morale in the team which should not resist the change. The introduction of radical and improving product innovations is not possible without appropriate technical and technological resources, which enable technological development of the enterprise.

Under organizational and methodological support of adaptive planning mechanism of innovative activity we should understand the selection of the optimal organizational structure to maximize the level of adaptability, form associated set of obligations and authorities, internal services and departments that adopt innovative solutions and are responsible for them. Also organizational and methodological support includes complex of administrative and technical measures (rules, procedures, job descriptions, rules and regulations) regulating innovatively active enterprise work.

The influence of interim components of adaptive planning mechanism on mechanical engineering enterprise's activity is displayed in table 3.

Alternative options for manifestation of mechanical engineering enterprise's adaptive properties are underlying the conceptual model of essential expression of adaptive planning's mechanism according to influencing factors (fig. 2).

The proposed model shows that the accretion of adaptive properties should be the priority for every modern mechanical engineering enterprise, which will greatly facilitate its operation in the dynamic, competitive and risky market. The greater are adaptive properties of the company, the more effectively it will be functioning.

CONCLUSIONS

1. The strategic priority of Ukrainian mechanical engineering formed the need for continuous evaluation and analysis of trends in its development. Significant deterioration of its dynamics main indicator's, annual imports growth and decrease in industry exports become the root cause for the unconditional affirmation of the need to review the basic principles of mechanical engineering enterprise's operation. Overcoming of existing problems at the mechanical engineering enterprises, stabilization of their performance and increase of profitability is only possible through the use of effective management.

2. A significant drop in industrial competitiveness requires immediate activation of enterprise's innovative activity. However, the impact of uncertainty, variability and risk on the activities of domestic enterprises necessitates the use of innovative activities adaptive planning in enterprises, which is activated in enterprises as an adaptive mechanism.

Table 2. Innovative development's phases of a mechanical engineering enterprises*

Innovative development's phase	Prosperity	Development	Decline	Depression
Kind of development	Long-term effective progress	Short-term effective progress	Short-term inefficient progress	Long-term inefficient progress
Quality of development	Outstripping development	Moderate growth	Partial decline	Total decline
Competitive position on market	Strong	Strong	Week	Week
Quality of innovative development management	High	High	Low	Low
Need for the introduction and improvement of adaptive mechanisms	Moderate	Moderate	High	High

* Source: author's own development.

Table 3. The influence of interim components of adaptive planning mechanism on enterprise's innovative activity *

Interim components	The influence on enterprise's innovative activity
Legal support	The set of legal acts regulating innovative activity creates favorable conditions for its development, stimulates innovation processes, facilitates the implementation of innovative projects.
Information support	The set of information resources provides information support for making effective management decisions in conditions of adaptation.
Resources support	The set of financial, material, nonmaterial, labor, technical and other resources forms the material basis for the realization of adaptive plans for innovation.
Organizational and methodological support	Complex of administrative and technical measures combined with the organizational elements improve the efficiency of innovative activities adaptive planning, promote transparency of innovative solutions, and provide the highest level of innovation project's adaptability.

* Source: author's own development.

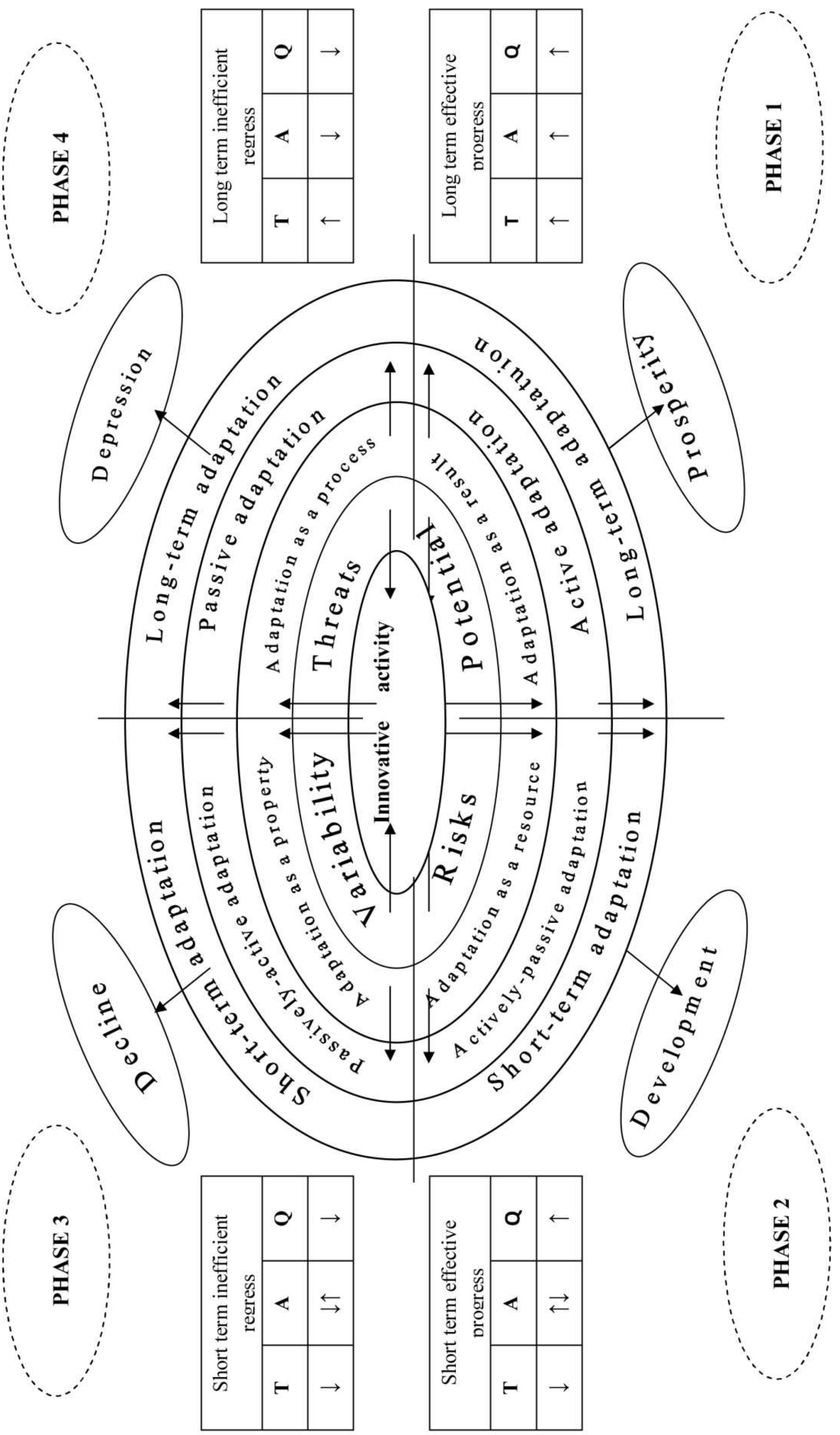

Fig. 2. The conceptual model of essential expression of adaptive mechanism at mechanical engineering enterprises according to influencing factors*
* Source: author's own development.

3. The adaptive planning mechanism of the innovative activity contributes to the steady state of the innovation-active enterprises, enables the formation of innovative activity adaptive plans, and hence the creation and commercialization of new competitive products to increase the market value of the company, capture new and retain existing market segments, meet social needs and accelerate the pace of scientific progress.

4. Depending on what factors trigger the adaptive mechanisms (volatility, risks, threats or untapped potential) adaptation will take place in one of the four options, namely: as a process, as a property, as a result or as a resource, what indicates a phase of innovative development, which is inherent in mechanical engineering enterprise.

5. The phase of innovative development allows not only to evaluate the position of the company on the market, but also give some recommendations for its further operation.

6. Implementation of adaptive mechanisms for planning the innovative activities on the domestic mechanical engineering enterprises will enhance the effectiveness of innovative projects in particular, and innovative activity of the enterprise as a whole, because they enable the quickest method to identify and adapt to the variability of the external and internal environment of enterprise's functioning, which, in turn, enables enterprises to get the most desired results, new competitive advantages, consumer likes and new market segments.

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