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Method of enterprise business processes modeling and analysis

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Enterprise resources planning-systems (ERP-systems) structure, functions, problem, concerning their implementation failures are considered. The problems solution is suggested by designing implemented system according to optimized enterprise business-processes. Enterprise business-processes mathematical models and their optimization algorithms, applying dynamic programming methods, are developed.

Introduction

While industrial companies and organizations structurization, modern automated systems for management activities support become more and more popular. They are Enterprise resources planning-systems [1].

ERP-systems are intended for control of all financial and enterprise economic activities. They provide enterprise managers with the information, necessary for management solutions, and support the infrastructure of electronic data exchange between enterprise, suppliers and customers.

ERP-system is the integrated applications set, allowing to create the integrated informational environment (IIE) for automation of planning, accounting, control and analysis of enterprise all basic business-processes.

ERP-systems should provide modeling of some situations, connected, first of all, with planning and forecasting. They are considered in the paper with the orientation to this requirement performance.

ERP systems advantages are universality and practically unlimited scalability. They can offer adequate models of enterprise corporate resources management for various production processes types.

Despite of ERP-systems advantages, there is a number of problems, appearing while their implementation and maintenance.

One of such problems is implementation inefficiency. This problem is the basic one and testifies that any even advanced technology will be useful only in case of its correct implementation and use. Many enterprises which have spent huge funds for ERP-systems buying and implementation have got only negative outcomes. Foreign analyzers prove that up to 70 % of ERP-systems is implementation projects fails [2].

According to Boston Consulting Group (BCG) [3] analyzers, ERP-systems are required for the enterprises functioning, however the success of their implementation depends on the success of their close adaptation to enterprise business-processes.

The considered problems, revealed as a result of studying ERP-systems construction and functioning principles, are the basic reason for similar systems development and implementation methodology improvement.

Main part

ERP-system is not the shrink-wrapped application, which can be equally efficiently installed on computers of any enterprise. ERP-system efficiency appreciably depends on its adaptation to certain enterprise functions. Only correctly designed and adjusted ERP-system supports planning and forecasting of enterprise business-processes and makes business more manageable and clear for company management.

Quite often designed ERP-system complexity and inadequateness for enterprise problems solution make them completely useless.

The basic reason of implementation failures is usually failure of basic principles of automated control systems (ACS) designs. Usually ERP-systems implementation do not return the expenses because of their design without strategy of business development, failure of "top-down" system design principle; business processes wrong reengineering, their wrong adaptation to ERP-system basic functionality and ERP-system basic functionality total reengineering.

ACS cannot be successfully implemented and function at the enterprise, which business processes performance and their management are not effective.

Basis of system design, being under implementation, is business processes model of effectively functioning enterprise.

It is suggested to implement ERP-systems, applying the approach which consists of the following stages:

1. Enterprise business processes modeling and optimization
2. Transformation of enterprise business processes optimized model to ACS model, removing some parts of the previous model, which can’t be automatically performed
3. Using ACS model, development of the recommendations and guideline for ACS implementation.

The first stage of the suggested approach is considered.

Enterprise business processes modeling and optimization includes the following stages:

1. Business-processes modeling.
2. Definition of business-processes performance efficiency criteria.
3. Definition of the business-processes performance requirements.
4. Estimation of business-processes performance efficiency by set criteria.
5. Business-processes optimization according to set requirements and using criteria and developed algorithms.

Algorithm for optimization of business-processes, consisting of sequentially fulfilled stages

The business process consisting of n sequential stages is considered: each following stage begins when the previous has ended.

Business-process performance time at fixed resources is taken as business-process performance efficiency criterion. As any resource type can be measured in a money equivalent, the unique resource measured in a money equivalent will be considered while set tasks solving. It is identified as x.

$\eta_k(x)$ is time for k-th stage performance when x resource units is designated. $m_k(x) = M\eta_k(x)$ is average time (time expectation), $m_k(x) = D\eta_k(x)$ is a variance.

Task 1.

$F(x) = \min_{\sum_{k=1}^{n} x_k = x} M\sum_{k}^{n} \eta_k(x_k) = \min_{\sum_{k=1}^{n} x_k = x} \sum_{k}^{n} m_k(x_k)$ should be found.

Principles of a dynamic programming [4] are applied to find $F(x)$.

$F_k(y) = \min_{\sum_{j=k}^{n} x_j = y} \sum_{j=k}^{n} m_j(x_j)$ is time expectation which should be spent to stages from k to n, having y resources if optimal control is applied.

Then $F(x) = F_1(x),\ F_n(x) = m_n(x)$ and recurrent formula, connecting $F_k(x)$ and $F_{k+1}(x)$ is

$$F_k(z) = \min_{y \in [0;z]} (m_k(y) + F_{k+1}(z - y)) \tag{1}$$

(The solution is found from the beginning to end: $F_n(x), F_{n-1}(x), ..., F(x)$)

Let $y_k(z)$ is value at which the minimum in (1) is reached. $y_k(z)$ is an optimal resource, necessary for k-th stage if z resources are given to stages k, …, n.

ALGORITHM 1

1) Finding $F_n(z)$ then $F_{n-1}(z), F_{n-2}(z), ..., F_1(z)$ and optimal control (a optimal resources amount) $y_k(z)$ (for all $z \in [0; x]$)

2) Puting $y_1^* := y_1(x)$ to the first stage, $y_2^* := y_2(x - y_1^*)$ - to the second one, $y_3^* := y_3(x - y_1^* - y_2^*)$ - to the third one, and so on until y_n^* is found.

Results are:

- business-process execution time is minimized;
- the recourses distribution between business-process stages is found in the conditions of the minimized execution time.

Task 2. Business-process performance time minimization with very small inaccuracy.

As probability that variate exceeds its expectation in triple standard deviation has very small value (0.001 for normal distribution, 0.02 – for exponential distribution)

$H(x)$ (2) is «reliable time» (inaccuracy is very small) for business-process performance while optimal recourses distribution.

$$H(x) = \min_{\sum_{k=1}^{n} x_k = x} (M\sum_{k=1}^{n} \eta_k(x_k) + 3\sqrt{D\sum_{k=1}^{n} \eta_k(x_k)}) = \min_{\sum_{k=1}^{n} x_k = x} (\sum_{k=1}^{n} m_k(x_k) + 3\sqrt{\sum_{k=1}^{n} \sigma^2{}_k(x_k)}) \quad (2)$$

As there is radical in expression (2), $H(x)$ cannot be found, using algorithm 1.
Using Taylor's formula

$$f(t) = f(t_0) + f^{'}(t_0)(t - t_0) + o(t - t_0), t \to t_0$$

$$f(t) \approx [f(t_0) - f^{'}(t_0)t_0] + f^{'}(t_0)$$

(2) is transformed.
Expression under the radical through $\sqrt{\sum \sigma_k^2(x_k)}$ is indicated as t, then

$$f(t) = \sqrt{t},\ \ f^{'}(t) = \frac{1}{2\sqrt{t}},\ \ t_0 = \sum_k \sigma_k^2(x_k^0).$$

Having made certain transformations, we receive new value of expression (2)

$$H(x) = \min_{\sum_{i=1}^{n} x_i = x} [3A + \sum (m(x_k) + 3B\sigma_k^2(x_k))], \quad (3)$$

where

$$A = \frac{\sqrt{\sum \sigma_k^2(x_k^0)}}{2},\ B = \frac{1}{2\sqrt{\sum \sigma_k^2(x_k^0)}}$$

The following algorithm 2 is used for finding $H(x)$.

1. Zero approach – search of optimal recourse distribution for $F(x)$(algorithm 1). Optimal distribution of resources ($x_1^0, x_2^0, ..., x_n^0$) is got.

2. (3) is found by task 2 linearization. For linear functions the algorithm 2 is similar to algorithm 1. New resources distribution is got - $x_1^1, x_2^1, ..., x_n^1$, using ($x_1^0, x_2^0, ..., x_n^0$). Then task 2 linearization in new conditions ($x_1^1, x_2^1, ..., x_n^1$) is done, and so on until resources distribution ($x_1^k, x_2^k, ..., x_n^k$) with required accuracy and efficiency is found.

Suggested algorithms allow to find optimal resources distribution between sequential stages of enterprise business-processes performance, minimizing business-processes performance time.

Algorithm for optimization of business-processes stage, consisting of parallel substages

$\xi_k(x)$ is time for performance of k-th substage (process) of k-th stage when x resource units is designated for k-th stage.

Let us assume that $\xi_k(x)$ is not stochastic, but determined function. Minimal time T should be found, which is enough for stage performance when optimal resource allocation, i.e.

$$T = \min_{x_1+...+x_m} \max_k \xi_k(x_k) \tag{4}$$

$\upsilon_k(x)$ is the symbol for minimal time, needed for all parallel substages k,…,n (of one stage) performance when optimal resource allocation.

Then $\upsilon_m(x) = \xi_m(x)$,

and

$$\upsilon_k(x) = \min_{y\in[0;x]} \max\{\xi_k(y); \upsilon_{k+1}(x-y)\}, T = \upsilon_1(x) \tag{5}$$

Using described mathematical models, minimal time, needed for separate stage, consisting of parallel substages, and optimal resource allocation can be found.

Robust algorithm for optimization of business-processes stage, consisting of parallel substages

Let us assume that that some (small) number $\alpha \in [0;1]$ is given.

Minimal time T should be found, which is enough for business-process stage execution with the probability $1-\alpha$. And the algorithms of resources allocation while stage execution in minimal time T should be found.

The function $r_k(x,z)$ is also put to the consideration. It equals to minimal number t when the probability that time of stage execution exceeds t is less than $z \in [0;1]$ -

$P(\xi_k(x) > t) < z$.

$r_k(x,z)$ is eciprocal distribution of stochastic variable $\xi_k(x)$ [5].

It should be noticed, that time of all parallel substages (in one stage) execution doesn't exceed $\max_k r_k(x_k, \alpha/m)$ with a probability , which doesn't exceed α. That means that the task of finding minimal time T is reduces to the previous algorithm (4).

$$T = \min_{x_1+...+x_m} \max_k r_k(x_k, \alpha/m) \tag{6}$$

When the distribution of $\xi_k(x)$ is unknown, but $m_k(x) = M\xi_k(x)$ - average time of substage (process) execution and $\sigma^2{}_k(x) = D\xi_k(x)$ - dispersion are known, it is possible to use the $m_k(x) + 3\sigma^2{}_k(x)$ instead of $r_k(x_k, \alpha/m)$.

$$T = \min_{x_1+...+x_m} \max_k (m_k(x) + 3\sigma_k^2(x)) \tag{7}$$

Taking found minimal time and optimal resource allocation for each stage, consisting of substages, as initial data, minimal time and optimal resource allocation for the separate business-process can be found, using above described algorithms.

Conclusion

The suggested approach will allow to optimize enterprise business-processes execution, using developed algorithms, and design ERP system according to optimized enterprise business-processes. That will increase probability of ERP-systems successful implementation, with time, less than acceptable one and using fixed recourses amount.

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