Tools of production and logistics support life cycle of high-tech products

Andrey Borisovich Nikolaev[1], Vyacheslav Mikhailovich Prikhodko[1], Victor Yurevich Stroganov[2], Pavel Gennadyevich Tregubov[1]

[1]The Federal State Funded Educational Institution of Highest Vocational Education, Moscow Automobile and Road State Technical University – MADI, Leningradskiy Prosp., 64, Moscow, 125319, Russia
[2]Bauman Moscow State Technical University – National Research University, Baumanskaya 2-ya str., 5, Moscow, 105005, Russia

Abstract. Moscow Automobile and Road State Technical University (MADI). In this article the instrumental means are described which provide an imitation models` creation, a planning of an experiment, an optimization and integration of models into a support scenario of a decision making, for a support of a science-intensive products cycles through the example of road-building machines (RBM).The instrumental means and the total of analytical imitational models and models of the production processes` models as well as service and repair service (RBM) allow to create controlled analytical imitation models, to use standard mathematical packets for a realization of procedures for an experiment planning and for a task solution optimization.

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Introduction

The final point of any management process is a management solution taking. A decision preparing and making is one of the management function. It is not a mere coincidence that a management itself is a process of deliberation, decisions taking (programs, directions, orders, plans etc.) and their realization [1]. The critical importance it acquires in production where a production output is connected with a necessity of large amount of theoretical calculations, scientific prospects and experiments, that is to say a science intensive production [2].

The complex of management process and procedures which are aimed at expenses reduction in post-production stages of life cycle (LC), which are called as “occupancy expenses” and is united by the notion of the Integrated Logistic Support – ILS [3].

Until recently in the modern Russia the necessary attention was not given to a problem of ILS. That led to an essential underrun of the Russian industry within this direction. Today this problem acquired a critical actuality. It is connected with an increasing aspiration of the Russian enterprises to enter the international markets. Foreign contractors present the same requirements to the Russian products as they do to the same products of the foreign enterprises. In this regard the problem of an ILS organization for the Russian enterprises becomes of a high priority as far as this problem solving considerably affects the competiveness of the Russian science intensive products in the world markets [4].

According to the scheme the ILS of a complicated science-intensive product consists in a realization of four basic processes [5-9]:

a logistic support analysis of a product (LA) which is conducted within all the stages of the LC, and which may be implemented by means of creation and using of monitoring system;

a planning of maintenance and repair planning processes (MRP), which is implemented at the stage of the projection and is specified at the process of production and usage of a product is the spare parts` needs determination;

Integrated Supply Support Procedures Planning which is implemented at the stage of the projection and is specified at the process of production and usage of a product;

a training of a personal and providing an electronic maintenance documentation and electronic repair documentation. This training is implemented at the stage of the projection and realized at the process of production of concrete products.

A basis for an analytical-imitation models` complex creation is a formalized description of a technological processes total. The main production functions which demand a formalized description are: a production activity management, reference data following, the reclamations` management, a production activity planning, the limits` management, spare parts` purchasing management, spare parts` move, a financial management, spare parts` planning, a planning of spare parts` payments, summary reports` forming etc.

A considerable part of a total quantity of technological processes is the spare parts` management and planning function. There are about fifty detailed schemes which describe the basic processes of any enterprise that is maintenance and repair. The timely and qualified order implementation is the main result of maintenance and repair activity.

The data analysis of the spare parts and component parts` supply

For the following modeling the spare parts and component parts` management data were put in a standard form of OLAP-technologies with the indexes` classification, measuring, objects and zones. It gives a possibility to realize selectable requires and make a statistical analysis.

Indexes: W – the supply volume, V – the supply intensity.

Measures: Ntov – component parts, DCn – an enterprise, Sost – a condition of a request, Tp – a type of a request, DG – discount group, PG – production group, Obk – an overturn code, Kpl – a price list code, Modn – a model, T – time.

Objects; Sost – a state of a request [0 – not accomplished; 1 – accomplished, 2 – a dealer refusing, 3 – not under processing, 4 – a reserve, 5 – under processing, not in stock, 6 – under processing, incomplete disposal]; Tp – a request type [1-S – of a stock, 2-T,W – operational, 4-A – additional, 7-G – MMC guarantees, 5-N – new conditions, 3-V – customer].

For the time scale – days, months, quarters, years – the most frequently used in an analysis.

Zones: W-order volume, the orders` intensity. The task of the variety assemblies` building has been solved. These assemblies should provide the minimal time expenses for the necessary data structures which are needed for an analytical processing by means of multidimensional analysis.

The primary data analysis often comes to a following scheme:

1. An assembly building with a variation of two measurements (from a previously formed by three ore four measurements).
2. The realization of sorting by one measurement and the dynamic groups` forming (for example "others").
3. Visualization of the received resulting data in one of the form of multidimensional time series.

For the formation of the groups a universal mechanism is realized which allows to build an assembly of any form.

An instrumental media for a creation of imitation models

For controlled imitation models creation a graphic editor is made which allows to form a structure of parallel-serial technological processes (figure 1), where units are multichannel systems of a mass service [10].

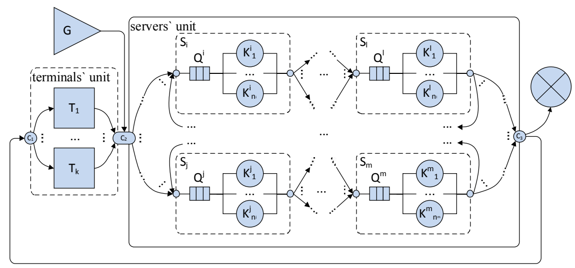

Figure 1. The general structure of QN, which is supported by the instrumental media

Points C_1,C_2,C_3 in a graphic scheme the queuing network (QN) structures are the fixed units of the scheme which are supposed for a connection into a united circuit of a generator, terminals` unit and servers` unit. Each server S_i is represented in a graphic scheme as a single unit. The sequence of the units` distribution may be spontaneous. However, all probability of the outlets` sums (all the arcs are marked by the passes` probability) both from the point C_i and form the end points of each server S_i should be equal to 0.

The x many of all the parameters of the system units is represented as following:

$$X = P^{(g)} \cup \bigcup_{i=1..M^{(t)}} P^{(t)}{}_i \cup \bigcup_{i=1..M^{(s)}} P^{(s)}{}_i, \quad (1)$$

where $P^{(g)}$ – the many of the generator parameters; $P^{(t)}{}_i$ – the many of the parameters of the i terminal; $M^{(t)}$ – the quantity of the terminals; $P^{(s)}{}_i$ – the many of the parameters of the i server; $M^{(s)}$ – the quantity of the servers in the QN.

The many of all the Y characteristics is represented as following:

$$Y = H^{(sys)} \cup \bigcup_{i=1..M^{(s)}} P^{(S)}{}_i, \quad (2)$$

where $H^{(sys)}$ – the many of the system characteristics; $H^{(s)}_i$ – the many of the characteristics of the i server; $M^{(s)}$ – the quantity of the servers in QN.

For the functional dependence creation the following set of parameters is created:

$$r^{(v)} = f(X^{(v)}, X^{(c)}, c^1_{end}, c^{cm}_{begin}, t^{cm}_{end}, \quad (3)$$

where $X^{(v)}=\{x^{(v)}{}_j\}$ – the many of the running parameters of the system units $X^{(v)} \subseteq \mathbf{X}$, where **X** – the

many of all the parameters of the system units; $X^{(c)}=\{x^{(c)}_j\}$ – the many of the fixed parameters of the system units; $Y^{(v)}=\{y^{(v)}_j\}$ – the many of the outlet variables, $Y^{(v)}\subseteq\mathbf{Y}$, where **Y** – the many of all the characteristics of the system and its assemblies.
The suggested instruments allow to create new imitation models of a separate technological production processes, maintenance and repair, and to conduct the analysis of the algorithm convergence optimization.

The instrumental means and the experiment planning technology

For the modeling results` analysis the instrumental media of the experiment planning is offered using the analytical imitational models of the production processes, maintenance and repair.

The Headlink application automatically defines the variable models` parameters, as well as the range of values of each parameter and according to a chosen plan of an experiment on the basis of an interface connection with a Statistica block realizes a parameterization and activation of a model for formed combinations of the factors to receive an optimization criterion. To the basic stages of a program component functioning the following is referred:

1. a reading of parameters or initial data of an application;
2. an experiment plan creation with the help of a Statistical block;
3. a calculation start in applications with changed parameters or initial data;
4. a collection of calculations` results.

The data out for the Headlink is parameters and variables description used in a calculation process in controlled programs. The experiments` planning technology is based on the following optimization criteria: D-an optimal plan – $\Phi(F)=\mathbf{det}D(F)$; collectively D – an optimal – $\Phi(F)=\mathbf{det}(A^TD(F)A)$, A – a full rang matrix; L – an optimal – $\Phi(F)=\mathbf{tr}LD(F)$, L – L-a fixed nonnegative defined matrix, where F – an experiment plan matrix ($\Phi(F)$ – a criteria of an experiment plan optimality) [11].

Instrumental means of an optimization of imitation models

For the optimization tasks` solution in the regenerative processes` imitation models a combination of a process of imitation and search optimization. That leads to a controlled imitation model creation [12].

An extreme experiment for regenerative processes will be conducted for a uniform network of controlled space parameters.

$XX^C\subset XX$.

The task consists in a choice.

$$X^*=\boldsymbol{argmax}Y(X), X\in XX^c, \text{где } Y(X)=M\xi_x \quad (4)$$

For a solving of this task an algorithm is offered, which consequently specify estimation values Y(X) in the network points XX^C. Rough estimates received on the basis of small quantity of cycles are used for a search direction choice. Such an approach defines a process of spontaneous wanderings in a space of controlled parameters within the researched field XX. General estimates are accumulated a basis of partial estimates during a controlled model functioning.

Every j-cycle of an algorithm defines a couple of adjacent values of a controlled parameter $X^{j,l}$; l=0.1. For each of the values the estimate of an objective function $Y(X^{j,l})$ is calculated on a basis of K regenerative cycles $\hat{\xi}(X^{j,l})=\int_{t(2j+l)k_i}^{t(2j+l+1)k}\hat{\xi}_{X^{j,l}}(t)dt$, где $\hat{\xi}_{X^{j,l}}(t)$ – selected process trajectory $\xi_{X^{j,l}}(t)$, t_j – regeneration moments (it is considered that regeneration is the same for the whole regenerative processes class), $\Delta T(X^{j,l})=t_{(2j+l+1)k}-t_{(2j+l)k}$ – a durability of an interval control.

On a basis $\hat{\xi}(X^{j,l})$ and $\Delta T(X^{j,l})$ is calculated $\hat{Y}(X^{j,l})$: $\hat{Y}(X^{j,l})=\hat{\xi}(X^{j,l})/\Delta T(X^{j,l})$. In a process of modeling the values $\xi^0(X_i)$ и $\Delta T(X_i)$ are accumulated and for all the network points $X\epsilon XX_i^C$ where $\widehat{\xi^0}(X_i)=\sum_{j,l:X^{j,l}=X_i}\hat{\xi}(X^{j,l})$, $\Delta T^0(X_i)=\sum_{j,l:X^{j,l}=X_i}\Delta T(X^{j,l})$. While a modeling is finished overall evaluations of an objective function are calculated and these overall evaluations are for all the values $X\epsilon XX_i^C$ и $\hat{Y}(X_i)=\hat{\xi}^0(X_i)/\Delta T(X_i)$.

An accuracy of each evaluation depends on regeneration cycles in which a model takes controlled parameters values. The values in a j control interval may be considered as a spontaneous. A process control is the Markov chain. Its state is defined by ordered couples of controlled parameters values $C == \{C^+\}_{i=0}^{l-1} \vee \{C^+\}_{i=1}^{l}$, $C_i^+ = (X_i, X_{i+1})$, $i = \overline{0, l-1}$, $C_i^- = (X_i, X_{i-1})$, $i = \overline{1, l}$, where C - the many of the Markov chain states. With every chain state $C_i^+(C_i^+)$ the following actions are connected: K cycles 'regeneration modeling for a model with the X_i estimate calculation $\hat{Y}(X_i)$; K cycles' regeneration modeling for a model with a parameter $X_{i+1}(X_{i-1})$ and an estimate calculation. $\hat{Y}(X_{i+1})(\hat{Y}(X_{i-1}))$.

Transitions between the states of the chain are implemented on a basis of an objective function estimates. On the figure 2 there is a diagram of Markov's chain transactions.

For the created Markov's chain stationary probabilities have been found and correlations have been received which show that the largest quantity of regenerative cycles is realized within extreme values of a controlled parameter. This allows to estimate an objective function values in an extreme field [13].

As a result it is shown that a combination of optimization and imitation process allows considerably increase the optimization tasks' solving efficiency of the imitation models [12].

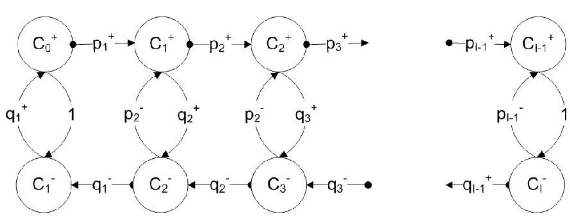

Figure 2. The transaction diagram of the Markov's chain

The instrumental means of the models' integration into the scenario of the decision making support.

Thus the offered method of taking decision support within production processes' management, maintenance and repair goes to an integration of the analytical-imitation models which are included into an optimization contour in controlled models.

The basis of such a hybrid structure is formalized description of a fragment whis is connected with an elementary application:

$$F_i = (t_i, d_i, a_i, \alpha_i, r_i, p_i,), \quad (5)$$

where t_i – a type of a fragment, (informational, expected, choice etc.); d_i – a difficulty level (for a test control); a_i – a fragment access level; α_i – an operation of a user access level and fragment access level (≠, <, ≤, =, ≥, >), s_i – the time of a forced presentation completion; r_i – subaggregate of conditions which are connected with a given fragment, p_i – a parameterization during an activation. A level access defines scenario structures' inclusion, which allows to create a hierarchy of scenarios and to realize a structure of included processes by means of interlock mechanisms' usage. A parameterization of an application gives not only a possibility of an adjustment, but also a task decision connected with a coordination of different applications, included into one scenario.

Instrumental means of a hybrid media allows forming an algorithmic structure of program applications by means of transactions between applications according to the conditions of its completion, using a standardized interface which creates a user scenario (figure 3).

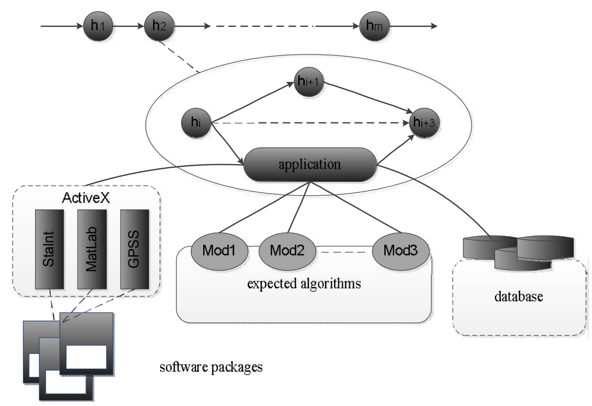

Figure 3.The integrated scenario structure

An elementary application is a flexible means of a system constituent invariant probability widening. In essence, a process of a structure creation of elementary applications' playing may be compared with a stepped algorithms' description where with every step it is supposed to a visual fragment replay with a possibility of the input data impose and the results' sampling.

Conclusion

Developed instrumental means provide a possibility of included the analytical-imitation models, their integration, the experiment planning procedures' realization and algorithms of a search optimization. A cooperative usage of described instrumental means allows defining the running models' parameters, the range of all the values, to set an interface connection with a Statistical block, to choose a plan of an experiment, to realize a parameterization and activation of a model for the formed combination of factors for the purpose of a stated correlation receiving.

In the course of a controlled imitation model functioning, the values of varying parameters are purposefully changed upwards an objective function. A model besides a spontaneous behavior process of a researched characteristic also defines a process of a spontaneous wandering in a space of controlled parameters. On the basis of the conducted research the efficiency of a combination of imitation process and search optimization is shown. Usage of a controlled imitation model using the optimization algorithms allowed to offer a rational and high effective requires management technology. With the aid of the offered instrumental means there was developed a class of original analytical-imitation ILP models of the science intensive products LC and production activity effectiveness which allows a quantitative estimation of the time expenses, financial and material resources.

Corresponding Author:
Dr.Nikolaev Andrey Borisovich
Moscow Automobile and Road State Technical University – MADI
Leningradskiy Prosp., 64, Moscow, 125319, Russia

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