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Development of Computer Scenarios of Buisiness Games for Personnel Training at Industrial Enterprises

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ABSTRACT

This study proposes an approach to solving the problem of the optimization of organizational structures and management decisions through their use in the design, development and implementation of a formal representation of such systems and the modelling of the corresponding technological processes. The ultimate goal is to improve the efficiency of the technological processes of industrial associations through study provides the development and use of formal models for describing processes, organizational structures and management campaigns. To achieve this goal, the solution to one of the problems, namely the task of developing a method to convert the formal representation of technological processinto a business game scenario. Methods of general systems theory, the classical set theory, the theory of stochastic processes, queuing theory and experiment planning theory, graph theory and methods of mathematical programming, simulation, etc., were used for the development of formal models of the components. The methods and algorithms developed here have been tested and implemented for practical use in a number of companies and are used at the Moscow State Automobile and Road Technical University for educational purposes. The results of the implementation and operation confirmed the efficiency of these methods.

Key words: Business game, corporate learning system, distance learning, formal models and method, Petri nets, queuing networks

INTRODUCTION

The organizational and technological level of modern industrial enterprisesis largely determined by the creation and application of effective mechanisms for the formation and implementation of strategic plans for the development and effectiveness of the operational management of all production, logistics and organizational processes which aim to achieve high profitability, development and improvement of production. Therefore, the construction of the organizational structure of enterprise management is a complex multi-level problem (Barinov *et al*., 2007a, b, 2009a, b, 2010, 2011a-f; 2012a, b; Barinov and Ostroukh, 2008; Barinov and Kartashev, 2011). Principles and methods of the construction of organizational management structure are directly dependent on many factors. The most significance of them are the specifics of the particular production process, the set of technological processes used, production volume, productive capacities used, tactical, technical and quality parameters of the products, the issues of standardization and certification, the qualification level of technical, administrative and management personnel, the management system utilized, the regulatory and legal framework of the enterprise and the organization of internal and external documents. The task of building the organizational structure in an industrial environment is a high-priority task in relation to other problems of industrial process control. Formulation and solution of this problem at a high scientific and technical level is a prerequisite for the effective organization of production, the output of highly competitive products, the growth of financial and economic indicators, dynamic development and continuous improvement of production.

The relevance of the topicis determined by the need to optimize the organizational structure of the enterprise management as the problem of the "upper level" to be the priority decisions as a basic component of a successful and efficient operation of any industrial enterprise, regardless of the type of products and production capacity.

FORMULATION OF THE BUSINESS GAME FRAMEWORK

The main part of the Business Simulation Game (BSG) includes as imulation model of the environment, the virtual game participants and interaction algorithms between these model sand real trainees (Barinov *et al.*, 2007a, b; 2009a, b, 2010; 2011a-f; Barinov and Kartashev, 2011; 2012a, b; Barinov and Ostroukh, 2008). The BSG body is constructed out of parallel strings of arbitrary algorithmic complexity, one for each party involved in the BSG. The data separation describing the current status of each role type with in this role limits is carried out by means of the fragment and not at the assembly level of the BSG framework in the structural elements designer.

The mechanism is similar to critical sections based on the blocking thread when synchronizing the variables in a single process (Fig. 1) (Barinov *et al.*, 2009a, 2010, 2011a, b, c). To ensure the synchronization process in the local network, the zero-size file is used as a blocking variable. The presence of the file indicates that the resource is busy while its absence shows that the resource is available.

The BSG frame consists of a set of fragments combined into a scenario generated according to the algorithm. The scenario is assembled in a structural elements designer. The framework is intended to form the organizational and structural environment of the BSG as players register in the BSG and its subsequent dissolution when the player leaves the game. For the user, execution fragments of the frame look like a step-by-step wizard, where he/she can terminate the registration process or return to the previous step at any moment (Fig. 2).

Figure 2 legend r_{ij} is fragments that implement these cenario-throle; try .. finally .. end-exceptions handling at the level of the BSG scenario; it provides guaranteed performance of de-initializing fragment of the frame.

Some fragments constituting the frame are visual and are intended for visual organization of the User Interface during the registration of the player in the BSG. Other fragments are non-visual and are designed to perform as a support for the operation of the BSG frame.

It is possible to organize the parallel execution of the processes within a given game set to reduce the delays associated with performing lengthy operations (e.g., being in the waiting regime). In this case, the non-visual (auxiliary) process will runin the background. The mainthread of the scenario and auxiliary processes can interact (communicate) and sync. Background processes can also interact with each other.

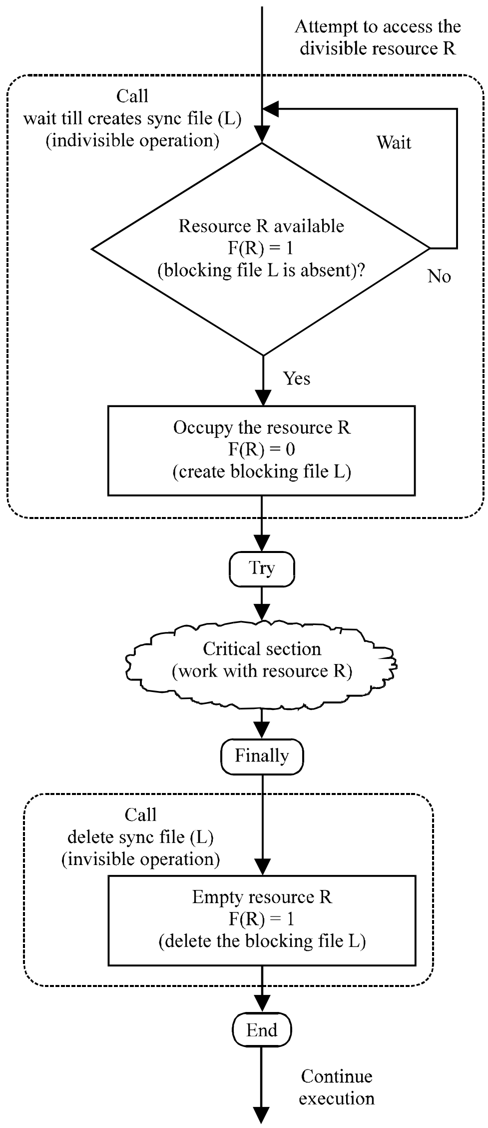

Fig. 1: Mechanism of critical sections based on the blocking variables

FORMULATION OF THE TECHNOLOGICAL PROCESSES IN TERMS OF PETRI NETS

Most of the operations of the technological process share resources. Execution of the operations is partly synchronous and partly asynchronous. Hence, in addition to the above description, a model describing processes in the form of Petri nets is suggested (Barinov *et al*., 2009a, 2010, 2011a, b, c). These network models of the processes are the basis for the description and the scenario execution of an interactive simulation model (IMU). They allow to check whether the framework is correct, to identify the presence of dead ends and blockages in its description; as well as to identify possible options for further development of the simulated technological process at an early stage while training the personnel and in the process of simulation itself.

There are additional restrictions for a given type of Petri nets:

$$\text{A4.}\quad \forall \chi, \gamma \in XP \cup T: \quad \chi\, F^{+} \gamma \Rightarrow \neg(\gamma\, F^{+} \chi)$$

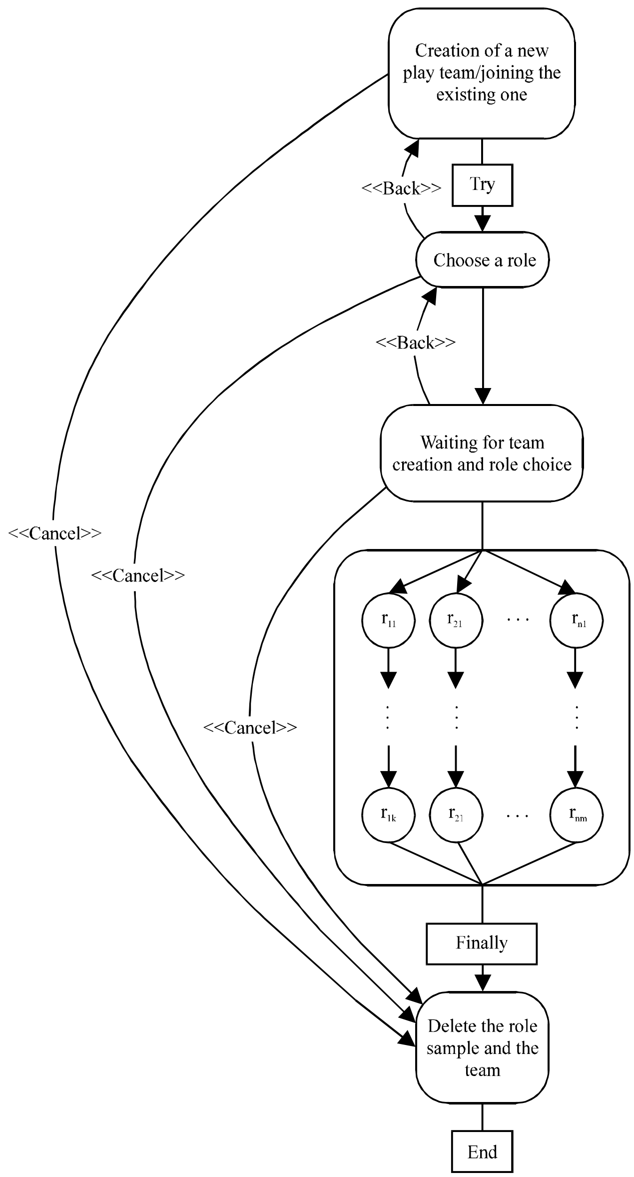

Fig. 2: Schematics of the BSG framework

if $\chi \neq \gamma$, that is relation F^{+} (transitory closure of F) is not symmetric and the network does not contain loops:

$$A5. \quad H(N) \neq \varphi \quad \wedge \forall \chi \in X, \quad \forall D^{-1}(\chi): \quad D^{-1}(\chi)$$

is fine it. This limitation requires that any network are presenting the process should not have a non-empty set of main places and does not contain, infinite' paths:

$$A6. \quad \forall t \in T: \quad {}^{\bullet}t \neq \varphi \quad \wedge t^{\bullet} \neq \varphi$$

that is any transition has at least one entrance and one exit:

$$\text{A7.} \quad \forall p \in P : M_0(p) = \begin{cases} 1, & \text{if} \quad p \in H(N), \\ 0 & \text{otherwise} \end{cases}$$

Such network processes have a standard initial layout where only head-points contain one token.

Let's consider the network shown in Fig. 3. It is clear that the description of this particular BSG scenario fragment, simulating the processing of incoming complaints, has several disadvantages. If transitionstime_out_1 and processing_2 or transitionstime_out_2 and processing_1 are executed, then the final result of the network performance will be incorrect, because the token will remain in the position c 5orc4. If transitions time_out_1 and time_out_2 are executed then the processing_NOK operation will be performed twice and because there are two tokens in the position the time of completion is unclear.

In this work we show that the process description should meet the following criteria:

- Network has entrance position i (initial condition) and exit position o (final condition);
- Each operation/condition is located on the path from i to o
- For any sample of technological process the performance of the network should have an end and at the end point the chip is at the position o and all the other positions are empty
- There should be no dead-end operations in the network. That is it should be possible to perform any type of task at the corresponding path of the Petri net describing the technological process modelled in the simulation game

Fulfilment of the first two criteria can be checked by using methods of statistical analysis, that is they exclusively have to do with the structure of the Petri network. The other two additional limitations correspond to the so-called property of defect lessness of the network.

A process modelled by the Petri net PN = (P, T, F) is considered defect free iff:

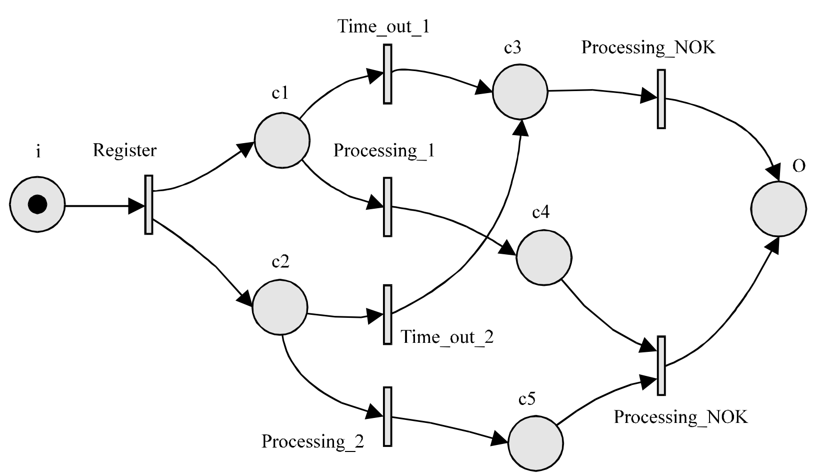

Fig. 3: Petri net for processing the incoming complaints

- For each state M reachable from the state i there is a sequence of execution of transitions leading from the state M to state o. Formally $\forall_M (i \xrightarrow{*} M) \Rightarrow (M \xrightarrow{*} o)$ (Here symbol I denotes both the position I and the state with the only token at the position i)
- State o is the only reachable state from the state i with at least one token at the state o Formally, $\forall_M (i \xrightarrow{*} M \wedge M \geq o) \Rightarrow (M = o)$
- There are no dead-end transitions in (PN, i)
  Formally, $\forall_{t \in T} \exists_{M,M'}\ i \xrightarrow{*} M \xrightarrow{t} M'$

The property of defect lessness corresponds to the dynamic behaviour of the net describing the technological process and can be used for the analysis of their correctness in the composition of the BSG scenarios.

The above-given description of the Petri net allows us to investigate the topology of the BSG scenario, to find loops and dead ends. In addition, the matrix description of the resulting Petri net scan find invariants of the network which allows us to solve the problem of finding all the variants of the simulated process in the course of an educative game with the use of the simulation game.

FORMATION MECHANISMS OF THE BUSINESS GAME SCENARIOS

Let's consider the mechanisms of the formation of scenarios that have software support in the workbench "SOTA". The general case of organizational and structural medium of multirole BSG is shown in Fig. 4.

where:

- **G** : Multirole business game (MBG)
- $\mathbf{R_j}$: Roles in G; $1 \leq j \leq N_R$, where N_R-No. of roles in G
- $\mathbf{g_i}$: Samples of G; $1 \leq i \leq N_g$, ГДе N_g-No. of samples of G
- $\mathbf{r_{ijk}}$: Samples of roles in the samples of G; $1 \leq i \leq N_{Rj}$, where N_{rj} No. of samples of the role R_j

The structure of the individual single-sample BSG which has the possibility to create several interconnected samples of its single role is analogous to the individual BSG with the only sample of this role but supporting several interacting samples of the game. Broken lines indicate the class-sample relationships. Arrows indicate relationships of belonging. Various versions of the

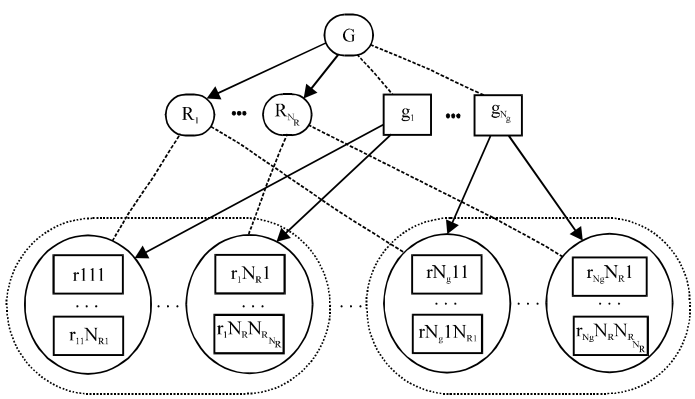

Fig. 4: General case of the organizational structure of the multipart BSG environment

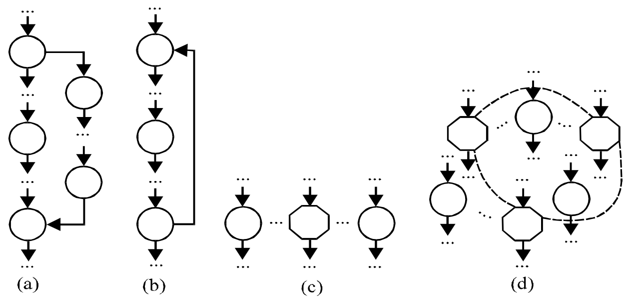

Fig. 5: Options of the flow control

organization of the management flow are possible when developing the body of BSG (Fig. 5). Octagons denote syncing fragments.

Performance of the BSG frame is defined by the following parameters (their values are set during the developmental stage of the game): whether it is single or multipart; there is limitation in the choice of roles.

Schematically, the process of creating a new multirole BSG on the basis of the framework and using the developed tools can be represented by the diagram on Fig. 6. Typically, the BSG scenario then consists of the main part and auxiliary part.

The auxiliary part represents a universal frame work that implements initialization and de-initialization functions common to a large class of BSGs. These functions are preparatory for the formation of the organizational structure of the BSG in accordance with limitations introduced at the developmental stage and are responsible for the dissolution of the BSG. The organizational and structural environment created during the BSG forms as a result of registration of participants of the game.

The BSG framework consists of the following four elements:

Initialization part:

- $\mathbf{F_1}$: Creation of the new BSG sample (new gaming group) or choosing the existing one (choosing the group)
- $\mathbf{F_2}$: Choosing a role from the list of roles provided in the BSG, creation of the sample (joining the group in the quality defined by the chosen role)
- $\mathbf{F_3}$: Waiting for the selection of the other compulsory available roles (the number for each role has a predefined number of samples) by the remaining participants of the game. Any participant registered in the given sample of the game can initiate the game if the conditions below are satisfied

    - **a :** There are BSG roles assuming an arbitrary number of samples
    - **b :** All the compulsory roles with the predefined number of samples are occupied in all the current BSG samples

If a new participant of the game started registering in at least one of the samples of the BSG and has not finished the registration yet, the initiation of the game can temporarily be blocked even if

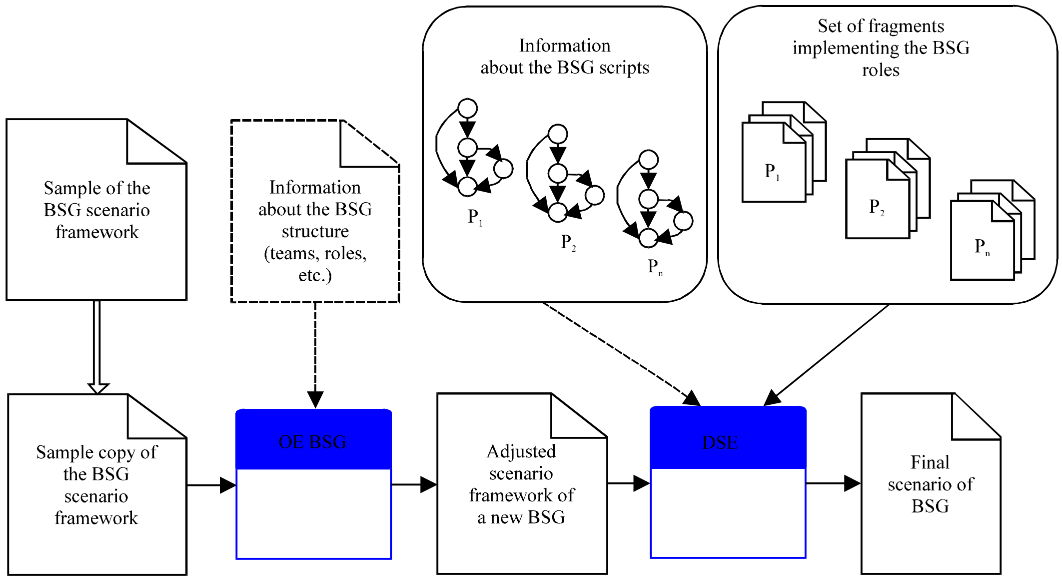

Fig. 6: New BSG creation process

all the above-mentioned conditions are met. Once all the participants are registered the game can be initiated by any of the participants. This fragment of the game is syncs the game.

De-initialization part:

- **F_4:** Completion of the role sample. If this was the last incomplete sample of the role among all the samples of roles connected to the given sample of BSG then the completion of this BSG sample takes place. This fragment of the game is non-visual

FORMAL APPROACH TO THE AUTOMATION OF THE BUSINESS GAME DEVELOPMENT PROCESS

The proposed principles of BSG can partially automate the process of developing new games. This can be done through the usage of a quick scenario assembling designers, parameter adjustment of the template frame of the BSG, storing of the most commonly executed fragments and their re-use, the availability of means to integrate with mathematical packages-the latter can be used to realize particular aspects of a scenario.

It is possible to estimate the qualifications of the personnel based on the results of the game on the basis of the proposed interactive gaming model. It allows the calculation of the time required to make decisions regarding the management of the production processes.

This work solves the distribution of the personnel and assignment of a particular task problem directed at improving the time parameters of the technological process through variation of the number and time characteristics of human resources in the simulation model associated with each operation in the technological process.

Thus, the random elements a_{ij} of the matrix of responses A are indicative of the successfull execution of the task at the jth level of BSG by the ith participant, that is:

$$a_{ij} = \begin{cases} 1, & \text{if the solution is correct} \\ 0, & \text{if it ís not} \end{cases} \quad (1)$$

probabilities of possible values of a_{ij} in the main logistical rasch model are described by the success function:

$$p_{ij} = p\left\{a_{ij} \left| \left(\Theta_i, \delta_j\right)\right.\right\} = \exp\left[a_{ij}\left(\Theta_i - \delta_j\right)\right] \cdot \left[1 + \exp\left(\Theta_i - \delta_j\right)\right]^{-1} \quad (2)$$

where the level of readiness Θ_i of the ith participant and the complexity level δ_j of the task j are parameters which can be evaluated; i = 1, 2, ...n ; j = 1, 2, ...k.

The likelihood function L of a discrete random variablea ij is a function of the arguments Θ_i, δ_j as the product of the probabilities (2) for all possible values of i and j:

$$\begin{aligned} L\left(a_{ij}; \Theta_i, \delta_j\right) &= \prod_{i=1}^{n}\prod_{j=1}^{k} p\left\{a_{ij} \left| \Theta_i, \delta_j \right.\right\} = \\ &= \exp\left[\sum_{i=1}^{n}\sum_{j=1}^{k} a_{ij}\left(\Theta_i - \delta_j\right)\right]\left[\prod_{i=1}^{n}\prod_{j=1}^{k}\left(1 + \exp\left(\Theta_i - \delta_j\right)\right)\right]^{-1} \end{aligned} \quad (3)$$

The values of latent parameters $\hat{\Theta}_i, \hat{\delta}_j$ at which the likelihood Eq. 3 reaches the maximum (we are talking about the global maximum and not the local one here) are taken as the point estimate of the latent parameters. These estimates of $\hat{\Theta}_i$ and $\hat{\delta}_j$ are called the highest likelihood estimates.

Since the functions L and lnL reach a maximum at the same values of their arguments, instead of looking for the maximum of L, one can look for the maximum of the log-likelihood function lnL:

$$\ln L = \sum_{i=1}^{n} b_i\Theta_i - \sum_{j=1}^{k} c_j\delta_j - \sum_{i=1}^{n}\sum_{j=1}^{k} \ln\left[1 + \exp\left(\Theta_i - \delta_j\right)\right] \quad (4)$$

where:

$$\sum_{j=1}^{k} a_{ij} = b_i, \quad \sum^{n} i = 1 a_{ij} = c_j \quad (5)$$

are initial scores of the participants and levels of BSG, respectively.

It has been shown that the log-likelihood function depends on the primary scores b_i and c_j only, which are sufficient statistics Eq. 5 of the initial observations, Eq. 1.

Extremum of the function is achieved only at the critical points, so we can look at the partial derivatives of the function Eq. 6 for each of its arguments:

$$\begin{aligned} \frac{\partial \ln L}{\partial \Theta_i} &\equiv b_i - \sum_{j=1}^{k} \frac{\exp\left(\Theta_i - \delta_j\right)}{1 + \exp\left(\Theta_i - \delta_j\right)} \equiv b_i - \sum_{j=1}^{k} p_{ij} = 0; \quad i = 1, 2, \ldots, n \\ \frac{\partial \ln L}{\partial \delta_j} &\equiv -c_j + \sum_{i=1}^{n} \frac{\text{txp}\left(\Theta_i - \delta_j\right)}{1 + \exp\left(\Theta_i \delta_j\right)} \equiv c_j + \sum_{i=1}^{n} p_{ij} = 0; \quad j = 1, 2, \ldots, k \end{aligned} \quad (6)$$

The system of Eq. 6 represents a system of equations of likelihood. It is nonlinear and contains n+k equations with n+k unknown latent parameters $\Theta_i, ..., \Theta_n, \delta_1, ..., \delta_k$.

This work demonstrates that the system Eq. 6 has only one solution which corresponds to the maximum of log-likelihood function.

CONCLUSION

In conclusion, the principles of the scenario construction and instruments of the BSG were developed. We proposed network models of the technological processes that form the basis of the description of the interactive simulation scenario and allow us to check the correctness of the scenario, to see the presence of dead-ends and blocks in its description. Also they allow us to identify possible options of the development of the simulated technological process at the early stages of the game.

It was shown that it is possible to transform formal description schemes of the technological processes into a multipart BSG scenario automatically similar to the usage of the critical sections based on the blocking variables during the syncing of the flows of a single process.

REFERENCES

Barinov, Ê.À., À.V. Ostroukh and N.Å. Surkova, 2007a. Implementation of the business games in computer-based learning systems/Open and distance learning, No. 3 (27). Tomsk State University, pp: 28-33.

Barinov, Ê.À., À.V. Ostroukh, Ì.N. Krasnyanski, P.S. Rozhin and N.E. Surkova, 2007b. Implementing the innovative multimedia methodological complexes in the learning process. Vestnik MADI (GTU), 8: 89-94.

Barinov, K.A and A.V. Ostroukh, 2008. Application of the module-competentive approach in development of electronic educational resources for an e-learning system of professional education institution/Engineering competencies-traditions and innovations. Proceedings of the 37th International IGIP Symposium, September 7-10, 2008, Moscow, Russia, pp: 253-254.

Barinov, Ê.À., À.V. Bugaev, D.À. Burov and À.V. Ostroukh, 2009a. Development of role playing games for training and re-training of the production plant and transportation of industry personnel. Nauchnyj vestnik MGTU GA, 141: 189-197.

Barinov, Ê.À., D.À. Burov, Ì.N. Krasnyanski and À.V. Ostroukh, 2009b. Development and testing of electronic educational resources of new generation distance learning. Nauchnyj vestnik MGTU-GA, 141: 181-188.

Barinov, K.À., D.L. Dedov, Ì.N. Krasnyanski, À.V. Îstrouh and À.À. Rudnev, 2010. Virtual training complexes for the training of the chemical and Virtual'nye trenazhernye kompleksy dlja obuchenija i treninga personala himicheskih i mechanical engeneering industries. Vestnik TGTU., 17: 497-501.

Barinov, Ê.À., À.B. Vlasov, V. Yu. Stroganov and G.G. Yagudaev, 2011a. Formation of the organizational management structure of the production plant using multipart business games. Science and Education. Moscow State Technical University, Electronic Magazine, August 8, 2011. http://technomag.edu.ru/doc/206805.html.

Barinov, K.À and Ì.I. Kartashev, 2011. Methods and algorithms of adaptive computer-based testing. World Sci. Discoveries, 21: 93-106.

Barinov, K.À., À.À. Solncev, P.À. Timofeev and V.Ì. Rachkovskaya, 2011b. Application of business game tools to the problems of the management of production in the highly competitive environment. Science and Education, Moscow State Technical University, Electronic Magazine, September 9, 2011. http://technomag.edu.ru/doc/207618.html.

Barinov, K.À., Î.B. Rogova and D.V. Stroganov, 2011c. Correlation between the educational plan modules. World Sci. Discoveries, 21: 28-34.

Barinov, K.À., B.S. Goryachkin, L.V. Ivanova and À.B. Nikolaev, 2011d. Formal models of representation and organization of business games. Moscow State Technical University, Electronic Magazine 2011. September 9, 2011. http://technomag.edu.ru/doc/207391.html.

Barinov, K.À., L.V. Ivanova and K.À. Nikolaeva, 2011e. Quality evaluation of the heterogeneous testing. World Sci. Discoveries, 21: 126-130.

Barinov, K.À., L.V. Ivanova, E.Y. Tolkaev and G.G. Yagudaev, 2011f. Intellectualization of the test controls in the open education. World Sci. Discoveries, 21: 86-92.

Barinov, K.À., Ì.N. Krasnyanski, À.Yu. Malamut, À.V. Ostroukh and G.G. Yagudaev, 2012a. Algorithm of the virtual training complex for re-training of petrochemical company personnel. World Sci. Discoveries, 26: 168-174.

Barinov, K.A., M.N. Krasnyanskiy, A.J. Malamut and A.V. Ostroukh, 2012b. Algorithm of virtual training complex designing for personnel retraining on petrochemical enterprise. Int. J. Adv. Stud., Vol. 2.