AN APPROACH TO BUSINESS PROCESSES REENGINEERING BASED ON INTEGRATION OF THE PROCESS MINING METHODS AND DOMAIN SPECIFIC MODELING TOOLS

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***Abstract**: An approach to reengineering business processes through the integration of the domain specific modeling platform and Process Mining tools is described. An analysis of the existing approaches to business processes improvement is presented and restrictions are shown. The Process Mining methods are related to business process reengineering stages and tasks. Comparative analysis of Process Mining tools is executed. The advantages of the using of domain specific modeling tools (language workbenches, DSM platforms) are substantiated. Brief comparison of various visual languages notations and model transformation examples are described. The DSM platform ensures mutual understanding between specialists. The MetaLanguage DSM platform is the basis of integration tools. Some DSL (metamodels) are described and transformations are illustrated. The implementation of integrated tools reduces the complexity of analyst's work.*

***Keywords**: business processes reengineering, domain specific modeling, DSM, modeling languages, DSL, language toolkits, DSM platform, model transformations, business process analysis, Process Mining.*

***ACM Classification Keywords**: H.4 INFORMATION SYSTEMS APPLICATIONS: H.4.1 Office Automation – Workflow management; H.4.2 Types of Systems – Decision support (e.g., MIS). I.6 SIMULATION AND MODELING: I.6.2 Simulation Languages; I.6.4 Model Validation and Analysis; I.6.5 Model Development Modeling methodologies.*

Introduction

One of the most important directions in modern management is business process reengineering.

In accordance with the definition [Hammer, 1993], [Kotler, 2010] "*Business process reengineering* is the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance such as cost, quality, service and speed". Business process reengineering (BPR) allows to achieve the maximum effect of production, commercial, financial and economic activities, issued by the relevant regulatory and administrative documents. Reengineering uses the specific means of problem information representation and processing, clear to both managers and developers of information systems.

Business process reengineering assumes the solution of several tasks, which are carried out step by step, in particular, it is necessary to carry out:

1) modeling and analysis of existing business processes, defining key performance indicators, and identifying processes that require change;
2) rethinking and development of basically new business processes, definition of the "ideal" embodiment of each business process in accordance with the selected indicators;
3) optimization of the existing business processes translation to "ideal";
4) actually reengineering, implementation of new ("ideal") business processes;
5) monitoring and continuous processes improvement based on key performance indicators.

Business process reengineering is often associated with the introduction of new information technology (IT), the establishment of information systems (IS), automating business processes or individual labor-intensive operation. However, automation of "imperfect" business process usually has quite low efficiency, reduces the utility of IT implementation: automated system will repeat the shortcomings of existing processes and the cost of correcting errors in the implementation of automated business processes, increases many times. The most effective approach is to introduce the IS, which is accompanied by a reengineering of business processes.

Business processes reengineering main problems are the lack of integrated tools, complexity and immensity of the issue to solve, leading to high requirements for professionals, engaged in reengineering, qualification and experience.

Reengineering is impossible without the use of business process modeling tools. At that, modeling is considering both as a process of formal models construction, and the process of their research.

It is accepted to develop two models of business processes: the existing (model “as is”) and future (model “as to be”). In the "standart" business process optimization existing model is considered as a basis for future processe models, and in case of reengineering – model of the future processes is developed "from scratch".

Building the model “as is” allow to illustrate

– redundant operation, which can be eliminated in the optimization process;
– possibilities for process parallelization;
– business process “hot spots” – transactions which can cause faults;
– possibilities for automating business processes or individual operations.

Analysis of the existing business processes and development of models are labor-intensive tasks which traditionally require interviewing staff at all levels, monitoring of their work, document analysis, the study of critical cases, etc. Partially automation of the time-consuming work to create formal models of existing business processes is possible by means of Process Mining tools.

Applying different analysis methods is often connected with usage of instruments that support such methods, but choice of instruments is based on languages for model development.

Present-day modelling instruments usually supports different notations and business process analysis methods, but neither of them provides complex solution of tasks. Integration of modelling tools can be realized on the basis of model transformation. It means conversion of models according to tasks for which different tools based on different modelling notations can be applied.

During realization of reengineering specific attention is on team forming and organizing interaction with specialists engaged in business process execution. Different specialists can be engaged in team, they have access to instruments which must be understandable for different specialist categories. Right framework for development of such instruments can be domain specific modelling (DSM) instruments (DSM platforms).

Research goal is to study possibility to apply DSM platform as basis for development of complex instrument to integrate Process Mining and DSM tools in order to solve business process reengineering tasks.

Approaches to Business Process Improvement

There are different approaches to organize business process reengineering on the basis of present-day information technologies.

A lot of research works [Aleksandrov, 2009], [Andreeva, 2004], [Landsberg, 1998], [Ostankov, 2008] offer to solve separate reengineering tasks, on the basis of applying mtehod chosen during research, in particular tasks can be include information system development and implementation for business processes automation. Other researchers [Konnova, 2008], [Panarin, 2006] offer methodologies based on the applying complex instrument for implementation of all reengineering stages, unity of approaches and succession for tasks solving during different methods integration.

The other research [Aksenov, 2015] includes analysis of existing reengineering methods and shows that solution of labor-intensive tasks and reengineering costs, high requirements to analyst qualification level is actual. Nowadays there is no general method to implement business process reengineering for different object domains effectively. Even the most popular software for business modelling does not provides advanced tools for end-to-end automation of all reengineering tasks. Generally such software is oriented to model development, documentation and visualization.

Need to solve listed problems determines actuality of different approaches development, improvement and integration as well as development of successive methods for reengineering tasks solution and realization of instrument to automate this kind of activity.

Researcher [Aksenov, 2015] compares his own analysis method and “bottle neck” of multi agent process of resources converting with methods considered at [Aleksandrov, 2009], [Konnova, 2008], [Filippovich, 2015].

Researchers [Konnova, 2008], [Panarin, 2006] determine reengineering as set of strategic actions for complex improvement of management system, technologies of activity and interaction. Research area concerns consulting. Note that main problems with which enterprises face during implementation of reengineering concern with absence of complex methodic instrument and united reengineering conception. In addition it is necessary to consider complication and scope of tasks to solve as well as high requirements to qualification and experience of analysts involved in reengineering. Consulting companies specifying on business process optimization help to solve problems. Reengineering methodologies offered by consulting companies are similar at the levels of main stages. In this conditions quality and effectiveness of projects realization depend on adaptability of methods for specific tasks solution.

There was no formal methods of business process reengineering until the last years, the approaches described changes only on an intuitive level without any strict formal models of business processes. But now there are methods based on the use of certain mathematical theories and aimed to solve a certain class of problems.

Business processes reengineering metods based on the integration of structural analysis methods, expert systems and formal grammars, proposed in [Konnova, 2008], [Filippovich, 2015] are based on the theoretical work [Kalyanov, 1996], [Telnov, 2003, a], [Telnov, 2003, a], [Telnov, 2004], [Telnov, 2005]. The structural approach is used for the formal business processes description. The focus is on information flows and binding resources to the company organizational structure. For the analysis of business processes various scenarios an expert system based on the "classic" reengineering rules is used, the quantitative analysis of the process dynamic characteristics is not carried out. This method allows to automate and construct the algoritm for evaluation and analysis of the initial business processes. Results of the analysis are used to find alternatives for their implementation, satisfying the basic principles of reengineering.

The method has limitations, which are noted as in [Aksenov, 2015]:

1) lack of tools for analyzing the dynamic characteristics of the processes;
2) lack of tools for "bottlenecks" identification;
3) inability to conduct parametric and structural process models changes;
4) lack of tools for simulation analysis of the constructed models, their comparisons;
5) inability to formalize the decision-making scenarios;
6) possibility of change in the business process models only at the organizational structure level.

Modeling methodology for distributed business processes management systems [Aleksandrov, 2009] is focused on solving the problems of distributed information systems designing and business processes modeling and progress monitoring.

Author's method of "tactical business process reengineering" isn't focused on large-scale processes models transformations. This technique mostly focused on the adjustment of the organizational structure project and related documents (function diagram, staff schedule, regulations on structural units, job descriptions, contracts and so on.). This methodology is based on the modeling of structures on the basis of models in IDEF0. Analysis of business process models and calculation of resources for their implementation is based on the «Bill of Material» (BOM) approach, which is applicable in the operational management for the ERP systems implementation. To solve the problems of analysis and eliminate bottlenecks by means of simulation modeling colored Petri nets are used.

In [Aksenov, 2015] for the simulation and analysis of the technological, logistical and organizational processes in the automated system of manufacture of steel products (VMP AS) researcher used multi-agent model of the process of conversion of resources (MPPR). The main elements of the model are MPPR operation, agents, sources and receivers of resources, processes, intersections, resources, tools, applications. Multiagent resource conversion process is built in the form of multi-channel queuing system. The model allows to analyze and eliminate the bottlenecks of the processes. The method is implemented in an automated system of manufacture of steel products.

Analysis has shown that the task of creating an integrated tool for solving reengineering problems remains relevant. In particular, in considered tools the problem of automation of formal models construction, and integration created tools with other systems, or they are hesitant to limited conditions.

Applying Process Mining Tools for Solving Business Process Reengineering Tasks

Generally different business process reengineering methods require to solve following tasks (*stages*):

1. *Development of reeingeeniring project and identification of business to reform* (project objective, tasks and reengineering approach are determined, project team are formed and it is useful to include specialists of different areas as well as representatives of external environment in project team).
2. *Documenting business processes* (graphical models of business processes are developed based on the documentation methods and business process operations are timed).
3. *Comparative analysis of business processes* (business processes are analyzed and compared with progressive and advanced business processes of enterprise divisions or competitor organizations).
4. *Development of future organization model* (ideology system is formulated for new organization an according to its aims and possibilities).
5. *Analysis of existing problems and reengineering of processes and technologies* (identification of problems of existing technologies and business processes, development of new processes models).
6. *Implementation of new business processes and technologies*, *evaluation of results* (comparison of reengineering results, performance evaluation of system operation according to specific criteria).

Process mining tools can be used for solving every tasks.

Most of data that can be used for reengineering tasks solution are not structured or structured poorly. That is why serious processing problems of business processes identification and analysis tasks can occur. One of the key approaches to solve such problem is to extract useful information about processes from data stored in informational systems. Such approach is realized in Process Mining tools, which unite process data mining instruments [Tiwari, 2005], [Aalst, 2007], [Aalst, 2011], [Aalst, 2012], [Wen, 2009].

Process Mining is powerful instrument to use for rationalization of business process reengineering on the different stages. Process Mining tools can be used for business process effectiveness increase at the enterprises and organization of different industries.

Two key factors determine potential and need of the method:

1. There is a lot of information stored in corporate informational systems. Such information is history of processes, in particular, information technologies are used for process implementation. Events are recorded in logs of operational systems and DBMS, databases and software. Although abundance of event data, process identification and analysis as well as problem diagnostic are often based on the expert notion, subjective conclusions and propositions, but not on facts.

2. Software for using by analysts is not customized to reengineering tasks: most tools of business analytics are focused on the data, reports generation, analysis results visualization, but don't describe business process essence and form complex understanding of all company processes by users.

Basis of Process Mining is methods and technologies of business process modelling and Data Mining. However, other methods can be applied for solving tasks in particular statistic methods, genetic algorithms and so on [Medeiros, 2006].

Process Mining includes three *main approaches*:

– *Discovery* is identification of processes and development of business process formal model based log records about real events in system.
– *Conformance checking* is checking correspondence of business process models with real business processes to determine where process deviates from expected behavior and why such deviations occur.
– *Enhancement* is search of response for a question that model changes to improve some business processes indicators (search of fast and effective means to implement business processes).

In summary, we can propose that application of advanced instruments of Process Mining provides to solve more laborious and complex tasks of reengineering. Process Mining provides not only to identify processes and build their formal models but also check compliance of models with real situation and determine deviations by comparison of event data in system with process model. It supports decision making and gives recommendations to improve processes.

Central element of Process Mining is support of connection between process models and reality represented as event logs.

Traditional tools for business analysis don't correspond for deep process analysis, therefore new software is developed and focused on Process Mining tasks solution. The system ProM is more popular framework with open code, it supports different Process Mining methods. Analysis tools are completed by large number of plugins to extend possibilities of the system [Shershakov, 2013]. At the market, there is range of commercial tools for deep process analysis (Futura Reflect, Disco and so on.) In summary traditional reengineering tools (tools for interactive graphics, visual modelling of business processes, simulation etc.) are extended by means for deep mining of business processes.

Nowadays it is actual to use Process Mining tools by users who are not IT-specialists (business development managers, business analysts etc.). Such approach can largely simplify business process reengineering. One of the important features of Process Mining tools is possibility to work with not only event logs of some formats but also business process models of different notations. Contradiction is that system for speedup and simplification of analysts work leads to problems connected with processing of business process models by hands and presents analysis results in unclear form for users. It leads to wrong interpretation of process analysis results and wrong conclusions. Additionally important feature is integration of used tools with other instruments, informational and analytical systems for complete analysis of processes under investigation and development of new system to realize models developed by analysts.

The general BPM scheme including business process reengineering stages is changed too (Fig. 1). Monitoring results can be used by analysts for specification of model realized.

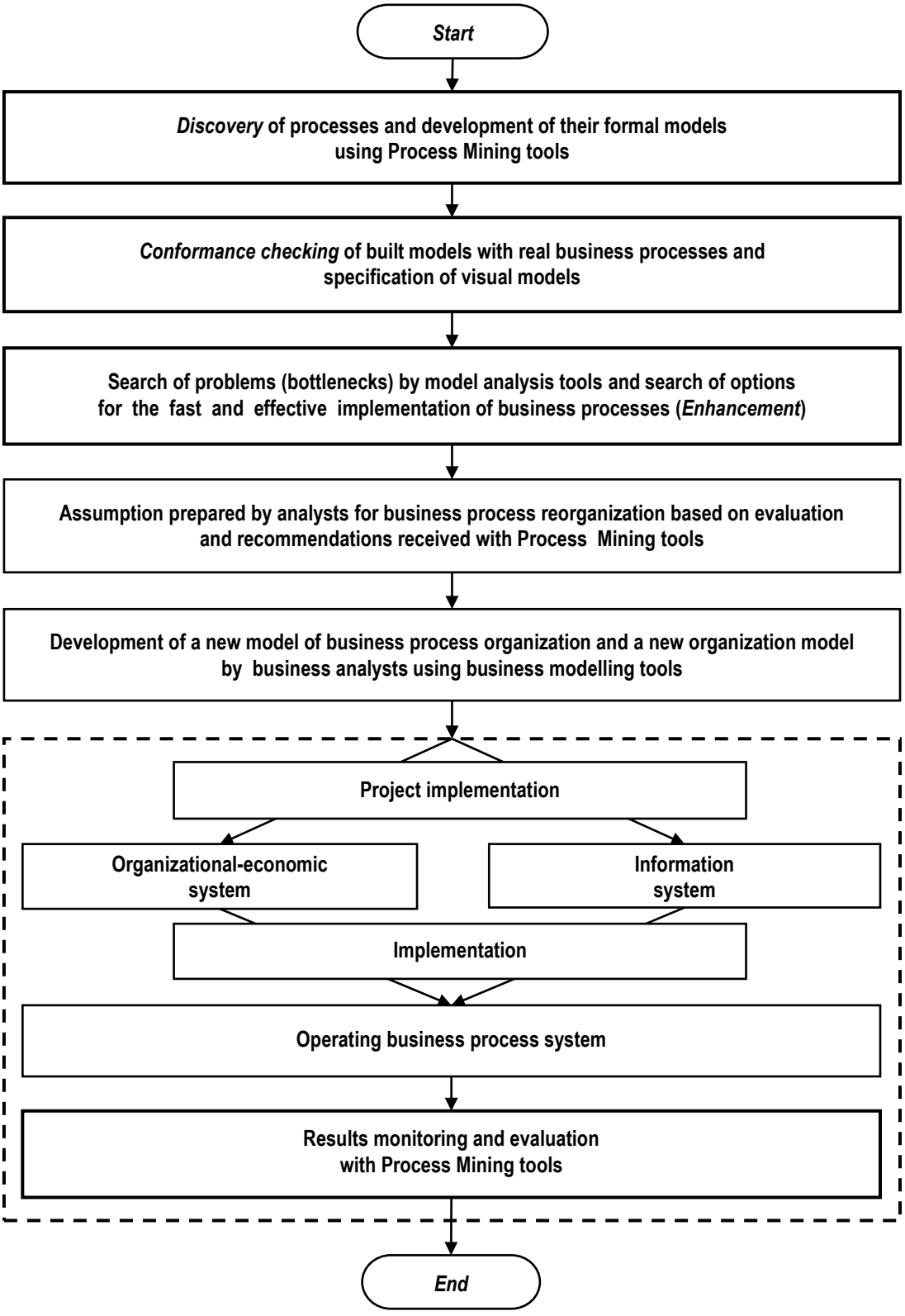


Figure 1. Business process reengineering stages using Process Mining

The Table 1 includes results of Process Mining instruments comparing. Systems are evaluated by scale from 0 to 10, where 10 is maximum mark. Thus, ProM system is leader on all indicators (maximal performance is achieved by system openness).

Table 1. Comparative analysis of Process Mining tools

Process Mining System	System integration	Import model support	System functionality	Sum of marks
ARIS Process Performance Manager	6	6 (supports to use model developed by other ARIS tools)	8	20
ProcessAnalyzer	4	–	5	9
ProM	8	7	10	35
Disco	8	7 (due to compatibility with ProM)	6	28

Many of ideas realized in ProM were introduced in such commercial products as Disco, Perceptive Process Mining, Celonis and QPR ProcessAnalyzer.

ARIS Process Performance Manager (Software AG) is the most convenient, user friendly and understandable for user system from all described above. However, such system is very expensive. Disco is more efficient to use by small and medium business. Such system is convenient, ease of use and oriented on clients. Although ProM open system supports to extend and add system functionality for users, conduct research and solve actual Data Mining problems. Additionally one of key criteria to choose process analysis tools is possibility to enter not only event logs but also graphic process models. Such feature is realized in ProM system thought developed plugins [Shershakov, 2013].

DSM Platforms help to provide model interoperability and possibility to work with them for different user categories, as well as integrate Process Mining tools with other business analysis and system development cases. DSM platform also offer to develop models of DSL notations, implement transformation and export them to external information systems.

DSM Platform Usage for Solving Business Process Reengineering Tasks

All domain-specific modeling systems for models creation involve the use of domain-specific languages (DSL), allowing modelers (domain experts, analysts etc.) to work in the familiar terms of subject areas, using tools designed to solve specific professional problems for development and analysis of models. Language toolkits, or DSM platform, provide the ability to create new languages at minimal cost.

To solve described problems DSM platform should except opportunity to create new languages for modeling business processes, also provide ability to perform model transformations (both vertical and horizontal). These particular features allow to consider the DSM platform as a basis for integration of various tools (used in various stages of reengineering by different categories of users) for business modeling and information systems creation. The results of a DSM platforms comparative analysis is shown in the Table 2 [Suhov, 2012].

The MetaLanguage system is based on the use of *metalanguage* the basic elements of which are following [Suhov, 2013, a], [Suhov, 2013, b]: *entities* – domain objects that are essential in terms of the current task; *relationships* represent relationships between entities (inheritance relationships, association and aggregation); *restrictions* allow to describe rules of domain models creation through the restrictions imposed on entities and relations. *Transformer* is one of the central MetaLanguage components, the operation of which is based on the use of graph grammars. Transformation component allows the conversion of user-created graphical models (diagrams) into text or visual models, described in other graphical notation [Sukhov, 2014].

A simplified DSM-platform usage diagram for solving business processes modeling and analysis tasks during reengineering is shown in Fig. 2.

Table 2. DSM-platforms comparison results

System feature	MetaEdit+	DSL Tools, State Machine Designer	Eclipse GMF	QReal	Meta-Language
Creation a DSL for a wide range of areas	+	+	+	+	+
Means of describing an abstract syntax	GORP	MOF	Encore	MOF	+
The possibility of modifying the meta-language	+	–	–	–	+
The multi-level modeling possibility	+	–	–	–	+
Changing the metamodel without code regeneration	+	–	–	–	+
The ability to "manual" DSL adaptation	–	+	+	+	+
The ability of horizontal transformation	–	–	By plugins	–	+

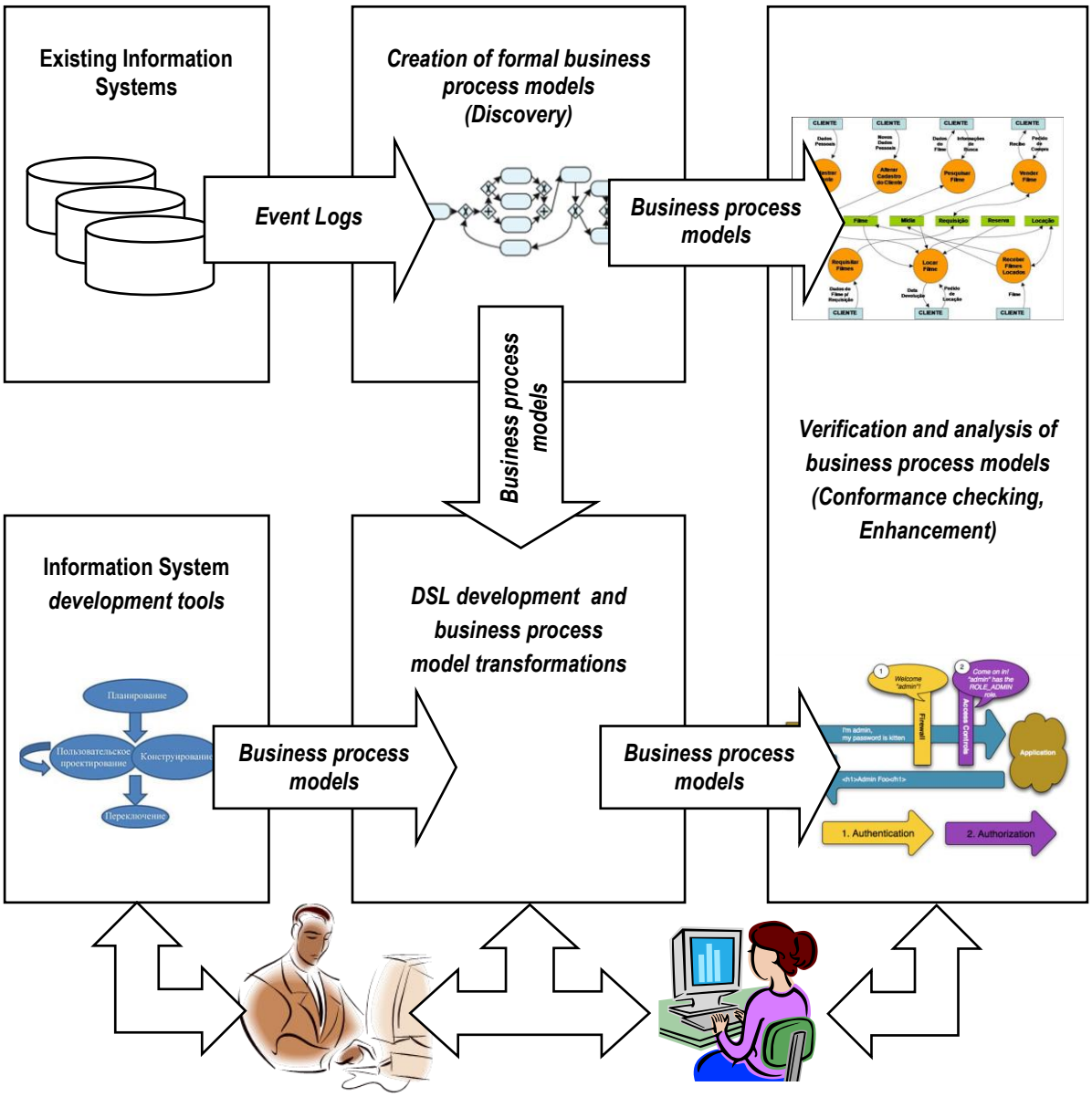


Figure 2. The solution of business process reengineering tasks with usage DSM platform

Various notations used in business analysis systems include the "standard" elements allowing to model business processes in solving reengineering tasks. The Table 3 demonstrate the comparison of some widely used business process modeling notations, their elements (as exemplified by solving the tasks of refinery holding's business process reengineering). The given data can be used to develop model transformation rules. The results of implemented in MetaLanguage rules were analyzed to identified "losses", the elimination of which requires "manual" improvements and model's completions.

Table 3. A comparison of business process modeling visual language notations

Notation	IDEF0	UML Activity Diagram	AnyLogic	ARIS eEPC	ARIS VAD
Function	+	+	+	+	+
Organizational element	+	+	+	+	+
Event	–	+	+	+	not required
Information object	+	+	–	+	+
External business process	–	–	not required	+	not required
Means of function performance	+	–	+	+	not required
Branch	–	+	+	+	not required
Merging	–	+	–	+	not required

The main criterion for evaluating the performance of transformation is to keep in converted models:

– functional structure of processes (it is necessary that the target model has retained all the features of the original model);

– logical structure (after the transformation the model must preserve the logic of the functions);

– organizational structure (responsible for the performance of functions rests with the organizational elements involved in the business process, so this information should be communicated to the target model);

– information flows (after models transformation the input data and function results stream must be monitored).

Some transformation analysis results are shown in the Table. 4. Although the process of transformation rules developing is quite labour-consuming and requires time, all rules are developed only once and then can be used by analysts repeatedly.

Table 4. Evaluation of models transformation

Transformations	Functional structure	Logical structure	Organizational structure	Information flows
ARIS eEPC – AnyLogic	Completely preserved in the target model	Partially preserved in the target model	Completely preserved in the target model	Not required
UML Activity Diagram – ARIS eEPC	Completely preserved in the target model	Completely preserved in the target model	Completely preserved in the target model	Completely preserved in the target model
ARIS VAD – IDEF0	Completely preserved in the target model	Completely preserved in the target model	Necessary to complete the target model	Not preserved in the target model
ARIS eEPC – IDEF0	Completely preserved in the target model	Not preserved in the target model	Not preserved in the target model	Partially preserved in the target model

It should be noted that, if necessary, the analysts themselves can create the necessary metamodels for new modeling languages and develop rules for their transformation or supplement the existing rules with the help of visual modeling and model transformation platform – MetaLanguage. During the reengineering of business processes by companies specialized in providing consulting services and using corresponding business process modeling tools to perform their work, the use of DSM platform can significantly reduce the complexity of the work and reduce the time spent on the models construction.

An example of the model transformation is described below:

– The source business process model in ARIS eEPC notation is shown in Fig. 3.
– The metamodel of the ARIS eEPC visual language in MetaLanguage system is shown in Fig. 4.
– The metamodel of the AnyLogic language is presented in Fig. 5.
– The transformation rules for the “ARIS eEPC – AnyLogic” model transformations are presented in the Table 5.
– The model transformation result is shown in Fig. 6.

This model requires "manual" improvements and model completions. The result of these improvements is presented in Fig. 7.

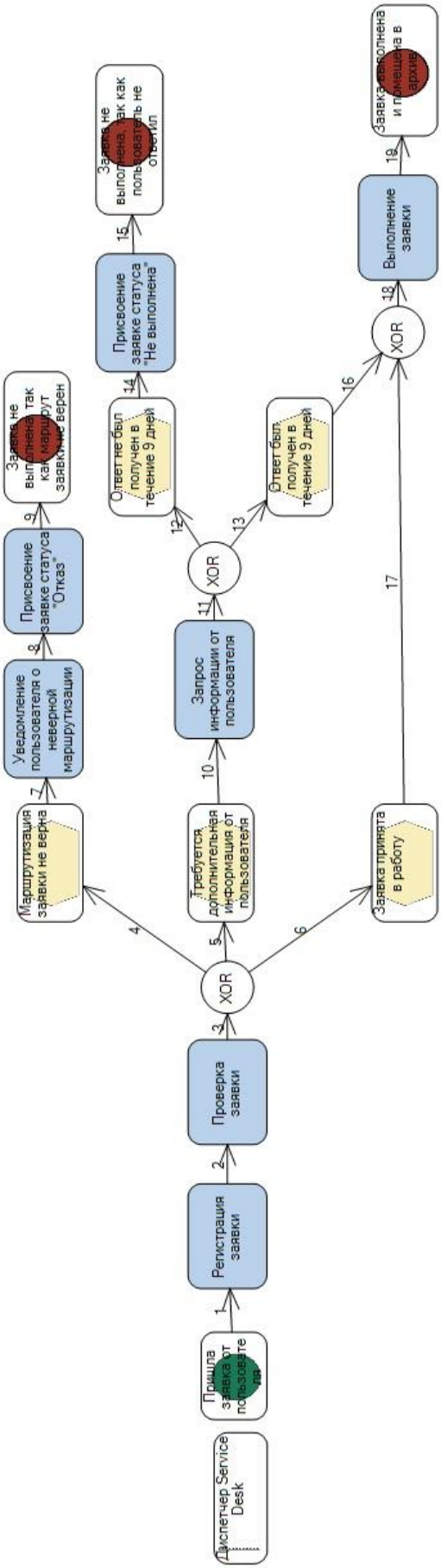


Figure 3. The example of business process model in ARIS eEPC notation

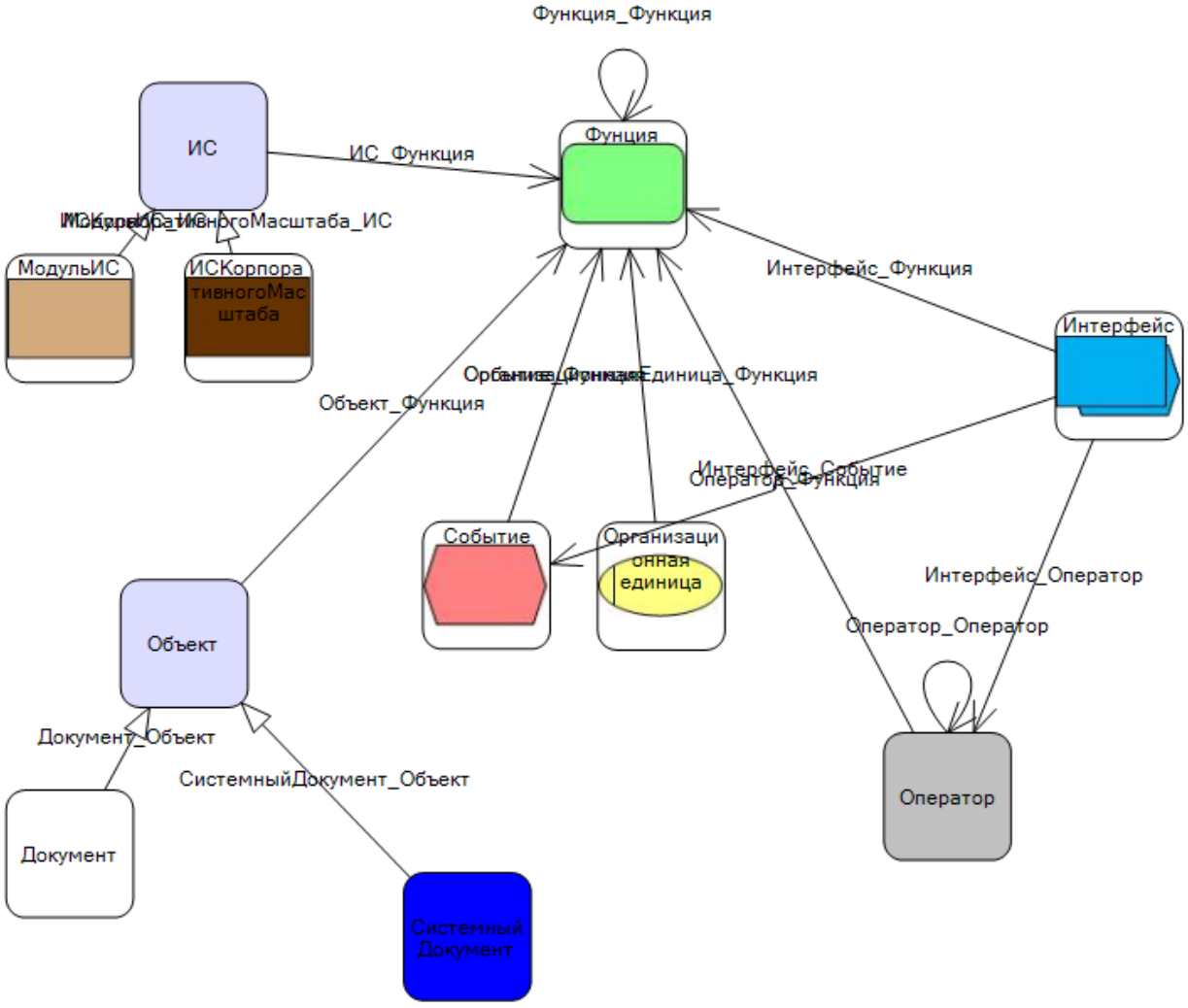


Figure 4. The metamodel of the ARIS eEPC language in MetaLanguage system

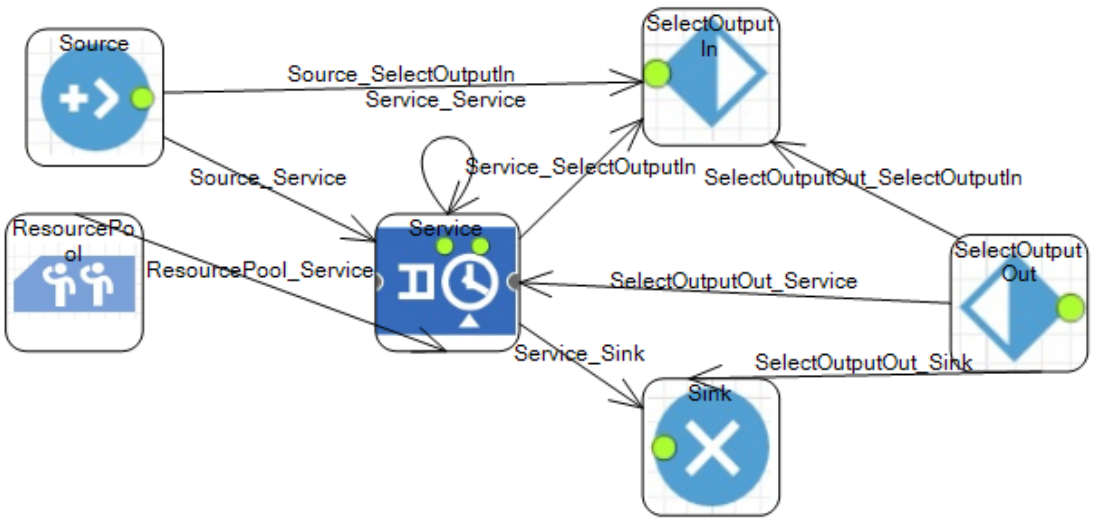
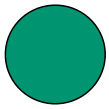
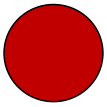


Figure 5. The metamodel of the AnyLogic simulation system language in MetaLanguage system

Table 5. Transformation rules for the "ARIS eEPC – AnyLogic" model transformations

Rule name	**Left rule part**	Right rule part
Entities		
НачальноеСобытие_Source (Initial Event – Source)	 НачальноеСобытие	source 
КонечноеСобытие_Sink (Final Event – Sink)	 КонечноеСобытие	sink 
Функция_Service (Function – Service)	 Функция	service 
Роль_ResourcePool (Role – Resource Pool)	 **Роль**	resourcePool 
Оператор_SelectOutputIn (Operator – Select Output In)	 Оператор	selectOutputIn 
СмежноеСобытие_SelectOutputOut (Adjacent Event – Select Output Out)	 СмежноеСобыти е	selectOutputOut 
Relations		
ФункцияФункция_ServiceService (Function – Service)	ФункцияФункция	ServiceService
НачальноеСобытиеФункция_ SourceService (Initial Event – Source Service)	НачальноеСобытиеФункция	SourceService
ФункцияКонечноеСобытие_ ServiceSink (Final Event – Service Sink)	ФункцияКонечноеСобытие	ServiceSink
НачальноеСобытиеОператор_ SourceSelectOutputIn (Initial Event Operator – Source Service Output In)	НачальноеСобытиеОператор	SourceSelectOutputIn

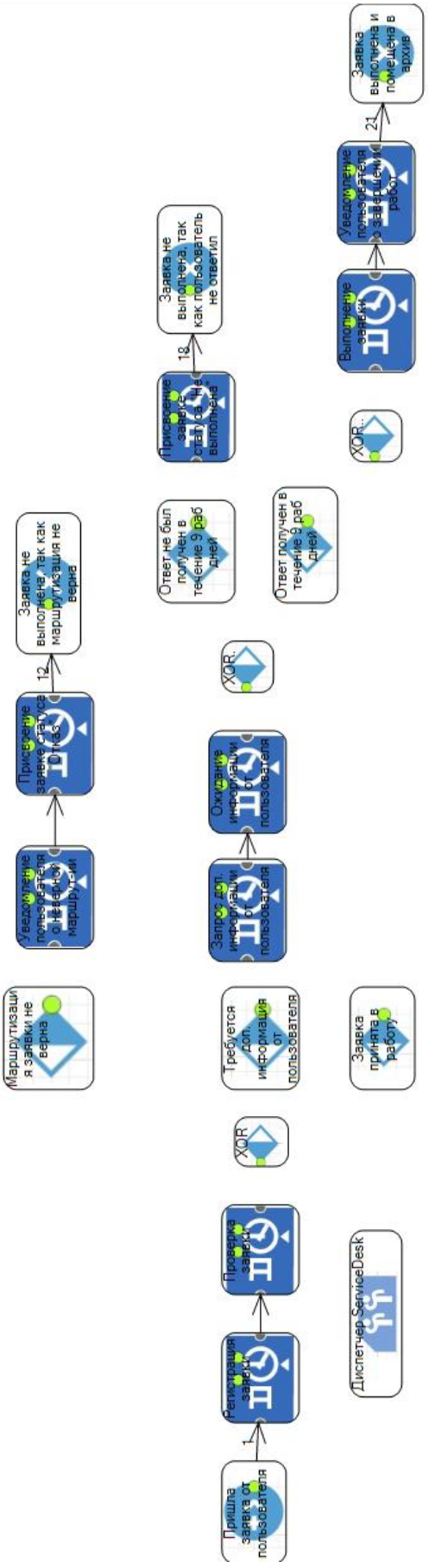


Figure 6. The result of automatic transformation of the business process model from ARIS eEPC notation into AnyLogic model

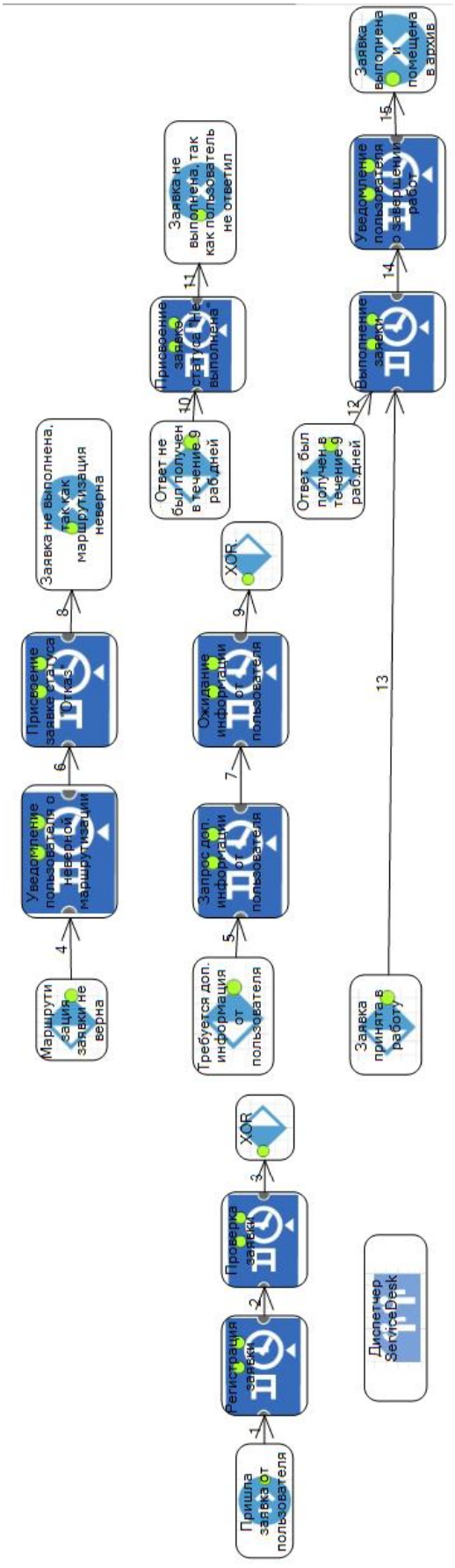


Figure 7. The result of "manual" improvements of the transformed model in AnyLogic simulation system

Conclusion

Studies have shown the promise of an integrated tool, designed to meet the challenges of reengineering including the language tools and means of in-depth mining business processes. Maximum efficiency is achieved when it is the integration of tools to automate the steps of the construction of formal models, analysis and transformation, DSM-implemented platforms and tools Process Mining, and traditional media business modeling [Lyadova, 2012], [Lyadova, 2014].

Bibliography

[Aalst, 2007] Van der Aalst W. Business process mining: An industrial application / International Journal “Information Technologies and Knowledge”. 2007. Pp. 713–732.

[Aalst, 2011] Van der Aalst W. Process Mining. Discovery, Conformance and Enhancement of Business Processes / Springer-Verlag Berlin Heidelberg, 2011.

[Aalst, 2012] Van der Aalst W.M.P., Adriansyah A., Alves de Medeiros A.K. Process Mining Manifesto / BPM 2011 Workshops, Part I. T. 99. Springer-Verlag, 2012. Pp. 169–194.

[Aksenov, 2015] Aksenov K.A. Comparing of the analysis and elimination methods of the resources conversion multiagentny process bottlenecks // Sovremennyie problemyi nauki i obrazovaniya. – 2015. – # 1; URL: www.science education.ru/121-18964 (available: 22.06.2015) (in Russian).

[Aleksandrov, 2009] Aleksandrov D.V. Methodology of simulation of the macroenterprises distributed control systems business processes: avtoref. dis. … d-ra tehn. nauk: 05.13.01 [Tekst] / Vladimir: Vladimir. gos. un-t, 2009 (in Russian).

[Andreeva, 2004] Andreeva S.V. Development of a management information system of the industrial enterprise on the basis of business process reengineering: avtoreferat dis. ... kandidata ekonomicheskih nauk : 08.00.05 / SPb. : S.-Peterb. un-t ekonomiki i finansov Sankt-Peterburg, 2004 (in Russian).

[Filippovich, 2015] Filippovich A.Yu., Konnova E.P. Business process reengineering technique on the basis of expert systems and the formal grammars integration methods [http://it-claim.ru/Library/Articles/publications_Philippovich_Andrew/MethodicRBP.pdf] (in Russian).

[Hammer, 1993] Hammer M., Champy J. Reengineering the Corporation: A manifest for Business Revolution / Harper Business, New York. 1993.

[Kalyanov, 1996] Kalyanov G.N. CASE structural systems analysis (automation and application). M.: Lori. 1996 (in Russian).

[Konnova, 2008] Konnova E.P. Business process reengineering technique on the basis of integration of structural analysis methods, expert systems and the formal grammars: avtoref. dis. … kand. tehnich. nauk: 05.13.17. M: Moskovskiy gos. un t pechati, 2008 (in Russian).

[Kotler, 2010] Kotler F. The Quintessence of Strategic Management: What You Really Need to Know to Survive in Business / Springer; 2010.

[Landsberg, 1998] Landsberg S.E. Optimization of the information business systems design on the basis of integration of simulation modeling methods and CASE technologies: dissertatsiya... doktora tehnicheskih nauk: 05.13.10. – Voronezh: Voronezhskiy gosudarstvennyiy universitet, 1998 (in Russian).

[Lyadova, 2012] Lyadova L.N. Metamodeling as a basis of tools of professional-oriented information systems operational development // Matematika programmnyih sistem: mezhvuzovskiy sbornik nauchnyih statey. Perm: Permskiy gosudarstvennyiy natsionalnyiy issledovatelskiy universitet, 2012. C. 20–32 (in Russian).

[Lyadova, 2014] Lyadova L.N., Sukhov A.O., Zamyatina E.B. An Integration of Modeling Systems Based on DSM-Platform. In: Advances in Information Science and Applications. Volumes I & II. Proceedings of the 18th International Conference on Computers (part of CSCC '14) / Ed.: E.B. Zamyatina. Vol. 1-2. Santorini Island: CSCC, 2014. Pp. 421–425.

[Medeiros, 2006] de Medeiros A. Genetic Process Mining / Eindhoven: Technische Universiteit Eindhoven. – 2006.

[Ostankov, 2008] Ostankov S.A. Rationalization of business process reengineering on the basis of simulation modeling of decision-making processes: avtoreferat dis.... kandidata tehnicheskih nauk: 05.13.10. – Voronezh: Voronezhskiy gosudarstvennyiy tehnicheskiy universitet, 2008 (in Russian).

[Panarin, 2006] Panarin A.A. Organizational and methodical support of the continuous business process reengineering of the industrial enterprise organization on the basis of integration of simulation methods and optimization approaches: avtoreferat dis. ... kandidata ekonomicheskih nauk : 08.00.05 / M. : Moskovskiy gos. obl. un-t, 2006 (in Russian).

[Shershakov, 2013] Shershakov S.A. DPMine/P: model development language of extraction and analysis of processes and plug-ins for ProM // Proceedings of the 9th Central & Eastern European Software Engineering Conference in Russia / Edited by: A. Terekhov, M. Tsepkov. NY : ACM, 2013 (in Russian).

[Suhov, 2012] Suhov A.O. A comparing of systems of visual domain-specific languages development: mezhvuz. sb. nauch. st. Perm: Izd-vo Perm. gos. nats. issled. un-ta, 2012. – Vyip. 9. – S. 84–111 (in Russian).

[Suhov, 2013, a] Suhov A.O., Lyadova L.N. , Zamyatina E.B. A multilanguage modeling with usage MetaLanguage DSM platform / Informatizatsiya i svyaz. 2013. # 5. S. 11–14 (in Russian).

[Suhov, 2013, b] Suhov A.O., Lyadova L.N. On approach to the development of the professional-oriented systems on the basis of DSM platforms / Informatizatsiya i svyaz. 2013. # 5. S. 15–18 (in Russian).

[Sukhov, 2014] Sukhov A.O., Lyadova L.N. Visual Models Transformation in MetaLanguage System. In: Advances in Information Science and Applications. Volumes I & II. Proceedings of the 18th International Conference on Computers (part of CSCC '14) / Ed.: E.B. Zamyatina. Vol. 1-2. Santorini Island : CSCC, 2014. Pp. 460–467.

[Telnov, 2003, a] Telnov Yu.V. Business processes reengineering. M. : Moskovskiy mezhdunarodnyiy institut ekonometriki, informatiki, finansov i prava. 2003 (in Russian).

[Telnov, 2003, b] Telnov Yu.F. Component methodology of business process reengineering on the basis of knowledge management : avtoreferat dis. ... doktora ekonomicheskih nauk : 08.00.13 / Mosk. gos. un-t ekonomiki, statistiki i informatiki Moskva, 2003 (in Russian).

[Telnov, 2004] Telnov Yu.F. Business process reengineering in the distant mode with use of Aris Webdesigner application program package // Materialyi XI Vserossiyskoy nauchno-metodicheskoy konferentsii «Telematika'2004» (in Russian).

[Telnov, 2005] Telnov Yu.F. Business process reengineering. Component methodology / 2-e izd., pererab. i dop. – M.: Finansyi i statistika, 2005 (in Russian).

[Tiwari, 2005] Tiwari A., Turner C.J., Majeed B. A review of business process mining: state-of-the-art. In: Proceedings of ITC19/Performance Challenges for Efficient Next Generation Networks. 2005. Pp. 707–718.

[Wen, 2009] Wen L., Wang J., van der Aalst W.M.P. A novel approach for process mining based on event types / Journal of Intelligent Information Systems. 2009. Pp. 110–116.

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