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Architecture of a software system for designing robust business processes

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Abstract. Nowadays, in order for a company to remain competitive, efficient and attractive to investors it needs to have reliable and threat-resistant business processes. The question of methods for building such business processes remains relevant. This paper proposes a software system, which involves the use of methods and tools of DSM (Domain Specific Modeling), ontological approach, simulation modeling methods, mass service theory, Petri nets. As an example, the logistics process of ship boarding in the port is considered. Software tools implementing simulation modeling and DSM are ANYLOGIC and METALANGUAGE.

Keywords: multi-model approach; reliable business process; business process risks; simulation modeling; domain-based modeling; queuing systems; Petri nets; ontologies

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Архитектура программной системы для проектирования надежных бизнес-процессов

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Аннотация. В наше время для обеспечения конкурентоспособности, эффективноти и привлекательности для инвесторов компаниям нужны надежные и устойчивые к угрозам бизнес-процессы. Остается актуальным вопрос о методах построения таких бизнес-процессов. В данной статье предлагается программная система, которая предполагает использование методов и инструментов DSM (Domain Specific Modeling), онтологического подхода, методов имитационного моделирования, теории массового обслуживания, сетей Петри. В качестве примера рассматривается логистический процесс погрузки судов в порту. Программными средствами, реализующими имитационное моделирование и DSM, являются ANYLOGIC и METALANGUAGE.

Ключевые слова: мультимодельный подход; надежный бизнес-процесс; риски бизнес-процессов; имитационное моделирование; доменное моделирование; системы массового обслуживания; сети Петри; онтологии

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1. Introduction

Nowadays, in order for a company to remain competitive, efficient and attractive to investors, it needs to have reliable and threat-resistant business processes. At the same time, modern processes tend to have more complex and multi-level architectures. Therefore, in the case of a risky situation, the consequences can seriously affect not only the company owning the process, but also the associated companies, thus determining the relevance and necessity of developing sustainable processes.

Under the risks (threats) for a business process is usually considered a set of conditions, actions and factors, the implementation of which cause any damage or hinder its implementation and achievement of the goal of these business processes. You should consider how these threats will affect the operation of a business process, whether they are triggers for each other, and what the consequences of a particular risk will be. Therefore, at the stage of analysis and process design, it is necessaryto decide on the modeling method, the way to identify threats and ways to prevent them, and the order of bottlenecks identification.

The description of your own business processes is necessary first of all because you can describe your activities, adequately assess the processes, identify problem areas, as well as represent the relationships between the participants and the elements. To analyzea business process, it is necessary to study its model. Under the model we will take a set of tools that can describe, document, and design the area under consideration. As a rule, several classes of models are considered, but often the business processes are described by analysts, using graphic models in one or another notation: IDEF, BPMN, UML, etc. There are papers that present methodologies (ROPE [1], INMOTOS [2], PoSem [3]) for detectingrisks in business processes with subsequent application of countermeasures for their elimination.

The authors present a software system that proposes the use of simulation modeling methods to study the functioning of business processes over time. In this case, an automated transformation of the conceptual model M_X , where X={IDEF, BPMN,...,UML} (M_X is a graphical model of a business process whose description is performed using one of the notations: IDEF[4], BPMN[5], UML[6], etc.) into a simulation model M^Z, where Y = {GPSS, AnyLogic, ..., NetLogo}. Here M_Y is a business process model that isdescribed using simulation languages: GPSS[7], AnyLogic[8], NetLogo[9], etc. Z ={QT, PN,...,MC} – a set of mathematical schemes that underlie this or that simulation system (queue theory, Petri nets, Markov chains, graph theory, etc.). Thus, a multi-model approach can be used to study business processes [10], namely, the business process model is transformed into a simulation model, which is based on a particular mathematical scheme. The transformation is performed using DSM (Domain Specific Modeling) Meta Languagesoftware [11,12]. As a result of the simulation experiment the risksof business processes are determined. For their identification and neutralization, the ontological approach is used [13]. Then, an automated modification of the original M_X model according to the specified countermeasures is performed and the actions associated with business process research are repeated (transformation of the conceptual M_X model into a simulation M_Y, simulation experiment, risk identification and countermeasures, application of countermeasures for business process reengineering, etc. Thus, the construction of a robust business process is iterative in nature.

The distinctive feature of the scheme proposed by the authors ofbuilding a reliable business process is the possibility of using a multi-model approach, involving the use of different mathematical apparatuses for dynamic research of business process functioning, analysis of countermeasure effectiveness, ontological approach for risk identification. In addition, any simulation modeling tool available to the researcher can be used for research, and any of the notations can beused to describe the business process.

In the following, the existing solutions for building reliable business processes, transformation rules, ontological approach for risk identification and countermeasures for their elimination, modeling results are discussed in detail.

2. Existing solutions

One of the methods that meets current conditions is the application of the ROPE methodology. Risk-Oriented Process Evaluation or ROPE is a three-layer model: synthesis of business process modeling, risk coordination and business continuityrepresentation [1].

The model contains:

- A business process layer that describes the core activity of theprocess.
- Activity component definition layer - CARE (Condition, Action, Resource, Environment) diagram [1].
- Layer defining the consequences of occurred risks and possible threats, as well as making business decisions aimed at minimizing possible losses.

Because ROPE is aimed at revealing and removing of threats caused by the lack of resources, this method is applicable only to thecoordination of the elementary processes, because more complex processes can lack the existing functionality.

Based on the ROPE model and taking into account the need to evaluate risks on the basis of several approaches, assessments and perceptions, the INMOTOS methodology was developed [2].

In general, the INMOTOS methodology begins with the modeling of business processes, using the CARE - diagram, followed by decomposition. Also, the necessary resources to perform the process are taken into account. During the threat prediction phase, an auxiliary agent is introduced, capable of identifying risks or their consequences, and triggers a process of predefined countermeasures. The process is completed by preventing threats and mitigating their impact on resources. However, the INMOTOS model does not take into account that threats as rules manifest themselves in complex ways and are most often triggers for each other.

POSeM (Process Oriented Security Models) methodology aimsat exploring the relationship between business process re- engineering or general process modeling and methods to strengthen their resilience to risks, or to facilitate the choice of taking countermeasures to prevent risks by forming recommendations derived from the process description [3].

The implementation of this methodology follows two basic rules. Firstly, by means of the developed SEPL language, the requirements for business process resilience are provided. Secondly,a couple of rule bases are used to check the resilience of business processes to risks.

This method does not pay enough attention to external threats, the sources of which are not directly related to the process itself.

3. The example of constructing a reliable business process

So, we have considered a number of methodologies related to enhancing the reliability of business processes. In contrast, the authors propose to use models described using common notations with subsequent transformation (by DSM methods [11,12]) into simulation models developed in one of the popular simulation languages, as the ones studied for stability of business processes. The study of business processes for sustainability is performed by simulation modeling methods. As a result of risk detection, countermeasures for their elimination and automated modification of the original model-business process are determined. The general scheme of research of business processes on reliability is shown in fig. 1.

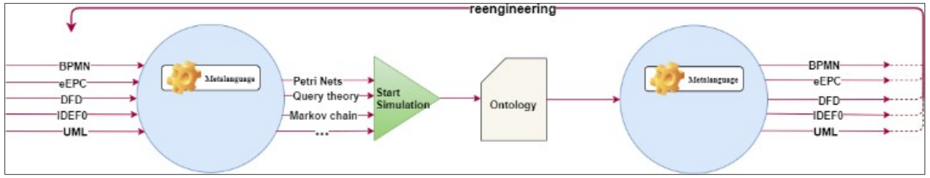


Fig. 1. Scheme for determining the sustainability of a business process, identifying and eliminating risks

Therefore, the proposed software system has metamodels that can be used to represent a business process in a particular notation and perform the transformation into a simulation model. As an example, we will consider the logistics process described in BPMN 2.0 notation (see fig. 2.) and its transformation into a simulation model (here we use AnyLogic [8], and Petri nets as the mathematical apparatus).

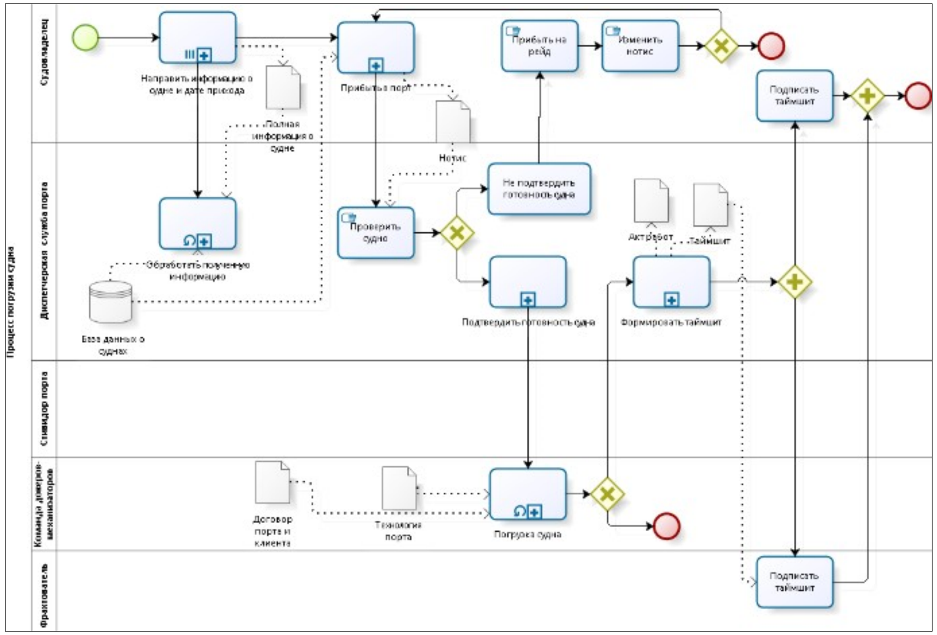


Fig. 2. Logistic process "Ship boarding in the port"

It is well-known that the rules of transformation from BPMN notation to Petri net notation were mentioned in literature [14].

Transformation of the model is performed using the Metalanguage language toolkit [12]. MetaLanguage was developed at Perm State University and meets all the key requirements for DSM platforms. The toolkit allows developing modeling languages of any subject area with the possibility of quick editing, implementing multilevel and multilingual modeling. Our task is to represent a logistic process described in BPMN notation with a list of rules into a model that can be represented by a Petri net (the mathematical apparatus that we chose to study the reliability of the process). The following are the rules of transformation $T: M_x \rightarrow M_Y^Z$ (M_Y^Z is the description of a business process in terms of temporal Petri nets (Z), the simulation experiment must be performed on one of the simulation platforms (Y – AnyLogic)) (see fig.3)

The platform for the implementation of simulation of the logistics process is the development of a Russian company – AnyLogic. AnyLogic is a domestic simulation modeling system widely used by specialists both in Russia and abroad. Models built in AnyLogic are scalable. When using this modeling system AnyLogic, the number of model elements is not limited [8].

As a result of transformations (Table 1), the initial process takes the following form (see fig. 3).

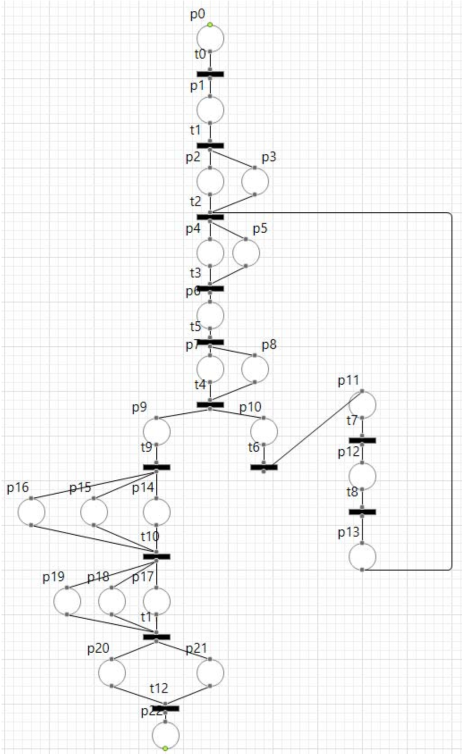


Fig. 3. Logistic process "Ship boarding in the port" (temporary Petri nets)

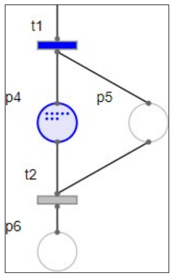


Fig. 4. The result of the simulation experiment - a transition that cannot be performed is identified

Next, a simulation experiment is performed, as a consequence of the simulation experiment the errors in the section t1-p4-p5-t2 are determined (fig. 4). To trigger transition t2, tokens must be present at place p4 and p5. Since transition t1 transfers tokens to place p4, and place p5 remains

empty – transition t2 fails. So, place p5 displays the use of the database of ships unloaded in the port. Thus, transition t2 cannot work if there is a database failure.

In order to determine what actions (countermeasures) should be taken to avoid the risk of an unregulated business process execution, we will use the ontology (fig. 5) and SPARQL query.

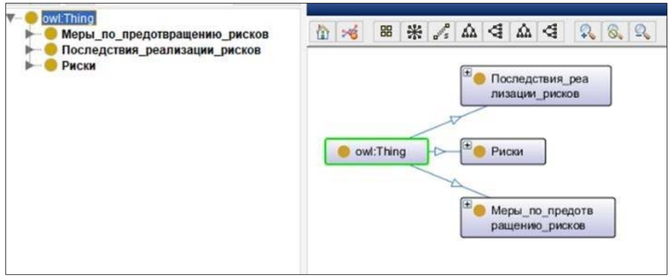


Fig. 5. Risks Ontology

The results of the SPARQL query are presented in fig. 6.

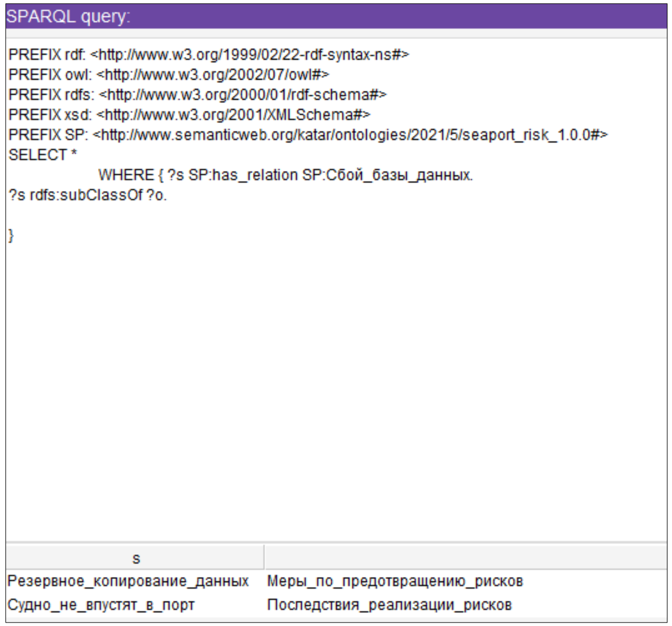
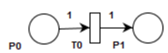
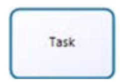
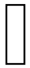
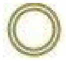
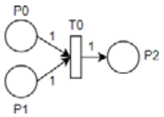
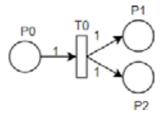


Fig. 6. SPARQL

Table 1. Part of the result transformation rules

Name of the rule	Left part of the rule	Right part of the rule
Place0Transition0 Place1_Task	Place0Transition0Place 1 	Task 

Transition_Events	Transition 	Events 
Place0Transition0 Place1Transition0 Place2_ ParallelJoinGate way	Place0Transition0Place1 Transition0Place2 	ParralelJoinGateway 
Place0Transition0 Place1Transition0 Place2_ ParallelForkGate way	Place0Transition0Place1 Transition0Place2 	ParallelForkGateway 

Then, using measures to prevent risks, the main process is restructured, and all stages are repeated again (see fig. 7).

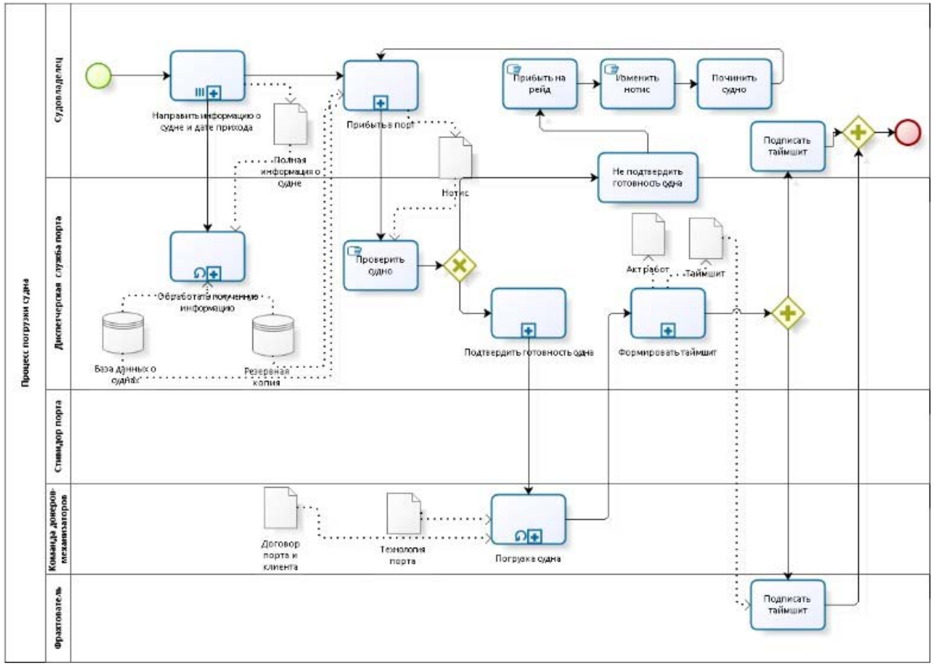


Fig. 7. Restructured logistic process "Ship boarding in the port"

4. Conclusion

The paper presents a methodology and software system that allows to identify risks in the business process model and perform reengineering actions in accordance with the recommendations for the application of certain countermeasures. Incontrast to the methodologies discussed in the review part, the authors propose to use any well-known business process notations (DFD, EPC, BPMN and so on) made using notations, transform it into any simulation languages (AnyLogic, NetLogo for example) and use any mathematical apparatus (Queue network, Petri nets and so on). Thus, DSM methods are used to transform a business process model into a simulation model and back.

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