# Coalition model of multi-agent resource conversion process*

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## Abstract

In this research paper, we try to solve the problem of the expansion of the resource conversion process (RCP) of multi-agent model that is used to solve modeling and decision-making problems in the field of production and business processes, as well as organizational and technical systems. To test the coalition model, we took data from the window construction market model. The window structures department of Ural Industrial Group CJSC is engaged in the production and sale of plastic windows.

## 1 Resource Conversion Processes

In this paper, we try to solve the problem of the expansion of the resource conversion process (RCP) of multi-agent [1-2] model that is used to solve modeling and decision-making problems in the field of production and business processes, as well as organizational and technical systems [3-4].

Consider the basic concepts of resource conversion processes (RCP). Resource - a quantitative measure of the ability to perform any activity [6-8]. Resource - what you can use, spend; possible duration of operation of the machine. The order is a special type of resource. The order is the resource with a specific set of attributes. An order (an analogue of a transaction in GPSS or AnyLogic [5]) allows you to allocate individual instances of resources.

RCP is understood as a continuous or discrete operation of converting input (resources that are necessary for the process) to output (products - the results of the process). The conversion is carried out by using the tool [3].

Agents manage the objects of the transformation process based on the content of the knowledge base. Agents correspond to the elements of a management system or a model of decision makers.

Coalition - the union of several agents in a community, in order to achieve a common goal. Agents participate in the coalition in order to allocate resources and public utilities. The processes of coalition formation and breaking lead to structural and parametric changes in the RCP model, as well as changes in behavior models and knowledge bases of agents. The formation and breaking of the coalition takes a certain time and does not occur instantly. In a real form coalitions are processes of interaction between business entities that participate in a common process, using common resources and united by a common goal (s).

The problem was solved in of choosing the formalization model of RCP and the organizational and technical system (OTS). In the course of the study, the following models were identified of dynamic simulation that support the agent-based representation of the OTS: GAIA model by M. Woldridge and N. Jennings [1]; model D.Yu. Bugaychenko; model A.V. Masloboev; simulation model of the interaction of intelligent agents G.V. Rybina and S.S. Parondzhanov; Model Resources-Actions-Operations (RAO) V.V. Emelyanov, S.I. Yasinovsky; model of RCP [3]. An addition, to the results

of the analysis of these models presented in [4] is that the possibility of implementing coalitions and agent communications is not supported only in the RAO model. As the result of the analysis, the model of RCP was selected.

## 2 Model of Resource Conversion Processes

The basis is the author's hybrid model, built as a result of the integration of simulation, expert, situational and multi-agent modeling for creating a coalition model of RCP [3]. To implement coalitions and communications, the model of RCP [3] was expanded with the following elements: coalition ($C$), coalition knowledge base ($KB_C$), coalition goal ($G_C$), coalition action model ($D_K$), agent and coalition life cycle. The model was supplemented with the following procedures: forming and breaking coalitions, agreeing decisions and holding auctions. The main objects of the coalition model of RCP are presented in Fig. 1, where the following notation is also used: *SPC* - scenario of coalition behavior; *SPA* - agent behavior scenario; *U* - management team; *Msg* - message.

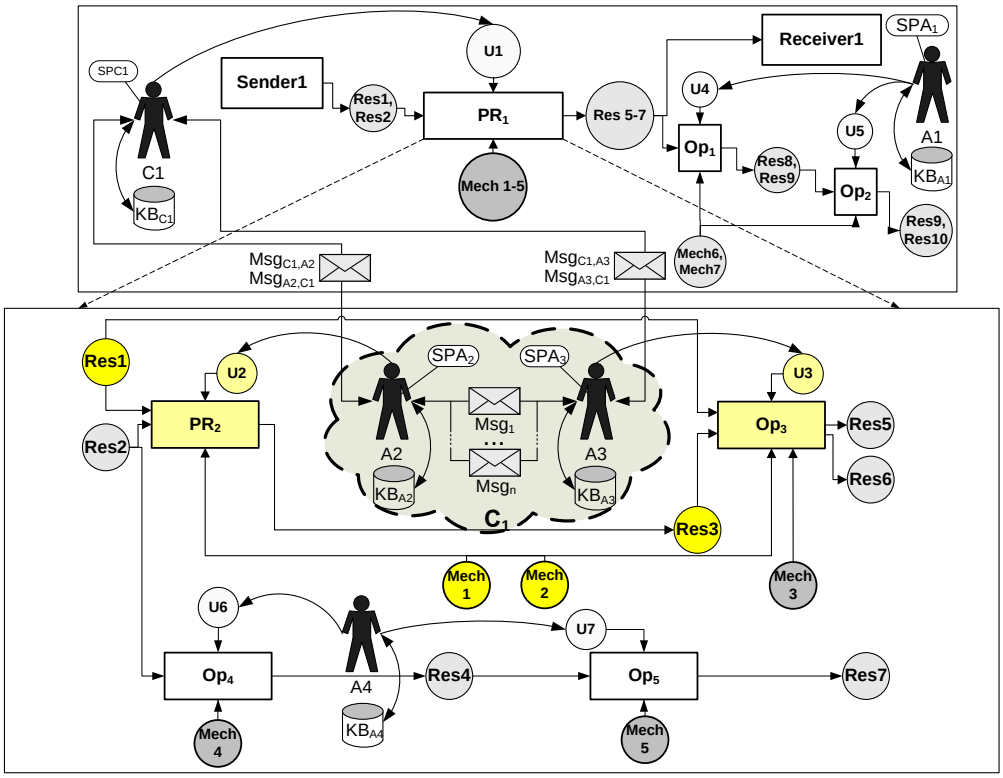


Figure 1: Objects of the coalition model of RCP

To test the coalition model, we took data from the window construction market model, previously implemented in the first version of BPsim.MAS. The window structures department of Ural Industrial Group CJSC (UIG CJSC) is engaged in the production and sale of plastic windows. The practical task of improving the window construction market model is to analyze the options for holding organization as a result of the merger of CJSC "UIG" with one of the players. The motive is to increase the profitability of the business of merged enterprises (by reducing overhead costs, increasing production and sales) for forming a coalition. A prerequisite is a developed sales network of one agent and a good production base of the second agent for the formation of a coalition.

In the example that is shown in Fig. 1, agents A2 and A3 act as participants of the coalition, while the coalition C1 itself can act as a supervisor. A multi-agent simulation model of the resource transformation process that supports the functions of forming and breaking up coalitions should be able to carry out the following structural and parametric changes at the moments of forming / breaking up a coalition: 1) linking / breaking of operations (processes) of agents; 2)

enabling / disabling individual blocks of the model and agent rules; 3) separation / association of resources and funds; 4) changing in the state of resources, funds, applications; 5) a dynamic changing in the priorities of operations and the rules of agents for the consumption / usage of resources and means. These changes in the model should be supported during the simulation experiment.

The introduction of coalitions and communication into the expansion model broadens the possibilities of modeling conflicts that arise on common resources and means. Conflict resolution can be implemented on the basis of communication (exchanging messages, conducting auctions) and coalitions (conflict resolution rules can be described in the coalition agent). The processes presented in Fig. 2 function in the coalition model of RCP.

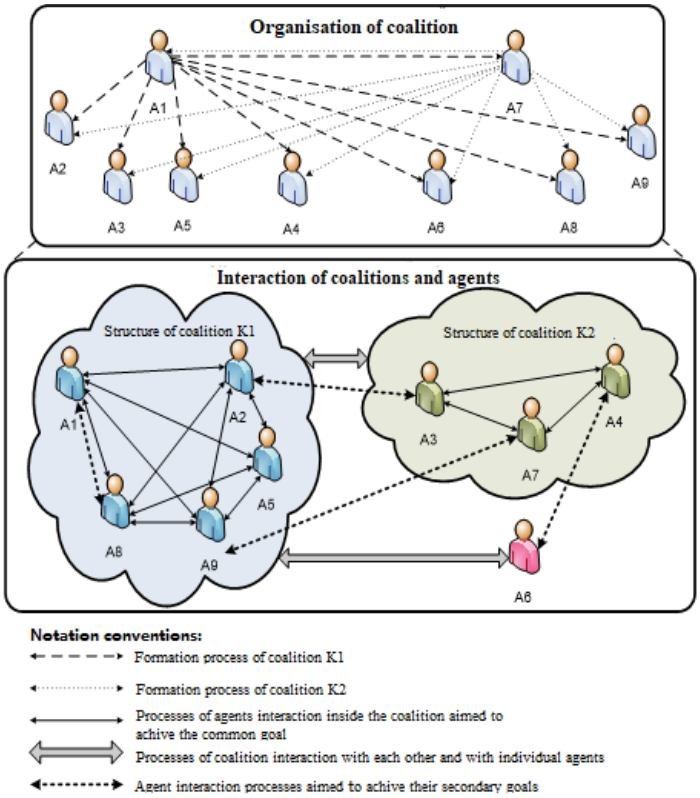


Figure 2: Schemes of processes in the coalition model of RCP

The multi-agent modeling algorithm developed for the practical implementation coalition model of the RCP is presented in [3]. As the basis of this algorithm, the algorithm described in [3] is used, and it consists of the following steps: determination of the current time; diagnosing situations that have arisen, developing control commands, queuing up transformation rules; compliance with the conversion rules and changing the state of working memory (data on the loading of resources and tools).

The algorithm is supplemented by the following two stages: 1) formation / collapse of the coalition; 2) making structural and parametric changes in the dynamic model of RCP.

The general interaction is implemented in the basis of the InteRRap architecture [9] of the subsystems of the hybrid model, the application is presented in (Fig. 3) [10] of the architecture to the model of RCP. The processes of collapse and coalition formation are implemented through an intelligent agent developed in the planning subsystem (built on the basis of a frame expert system).

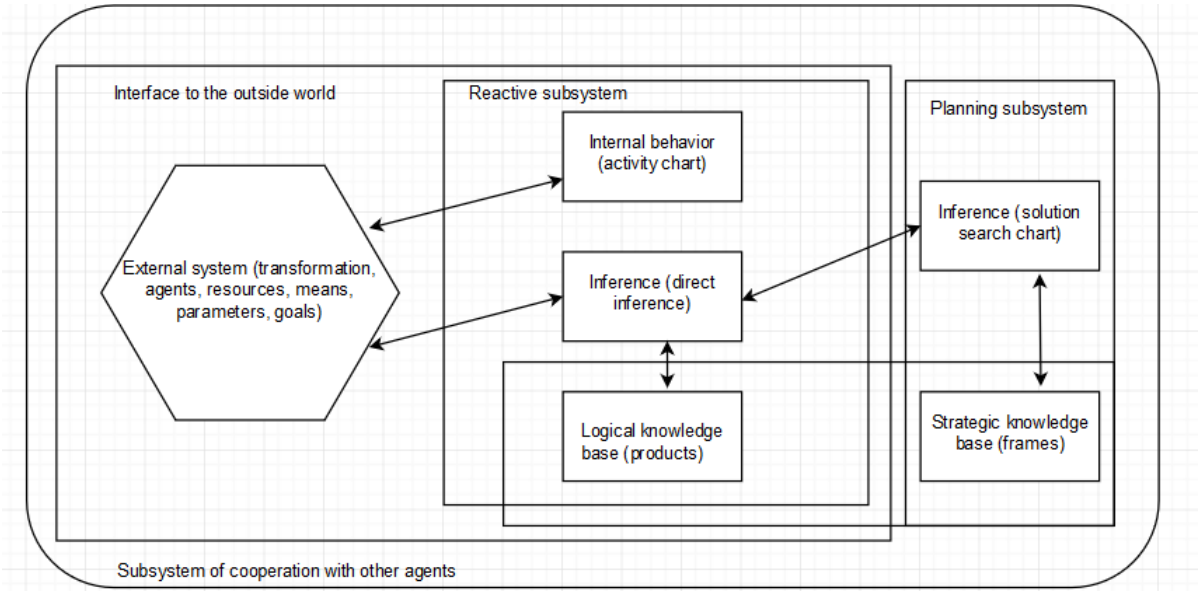


Figure 3: Hybrid architecture of the model of RCP agent [10]

## 3 Software Implementation of the Coalition Model in the BPsim Decision Support Package

Decision support systems BPsim.MAS and BPsim.DSS are software modules that implement the coalition model of RCP. The appearance is shown in Fig. 4 of the multi-agent simulation model in BPsim.MAS.

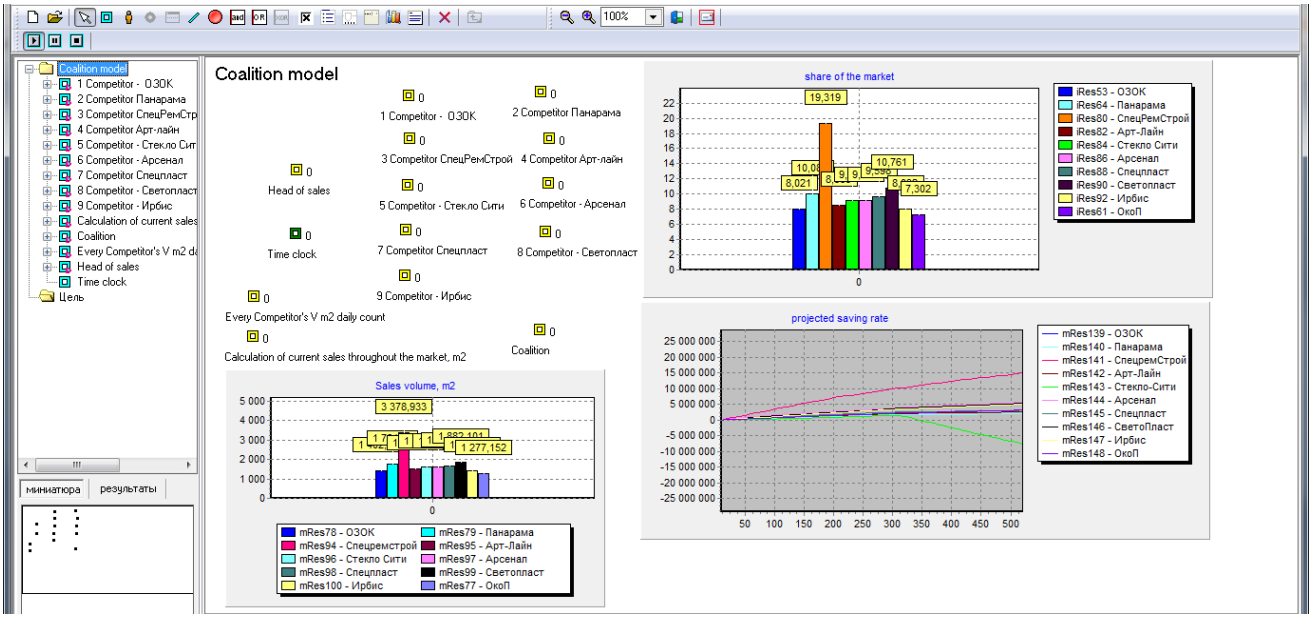


Figure 4: The coalition model of CJSC "UIG".

Implementation can be performed as follows at the program level of coalitions:

1) by using an object-oriented approach and creating a dynamic coalition class. The method of creating a coalition is initiated by a positive decision of the agents participating in the coalition as a result of the exchange of messages between agents;

2) by expanding the knowledge bases of agents or behavior patterns by rules / actions of using / managing / consuming common resources, means, applications as well as a system for resolving internal conflicts of a coalition;

3) by developing a coalition agent (using the existing capabilities of BPsim.MAS). Moreover, the agent-coalition model should take into account both the behavior models of individual agents and the general rules for the distribution of resources, funds and applications;

The implementation is as follows of communications between different types of agents of RCP models:

1) the exchange of messages between agents within the dynamic model of RCP (reactive-intelligent agents and reactive agents) is carried out by introducing applications (messages) into the model of the dynamic process, introducing commands and command syntax for the problem being solved (specific subject area) and describing message processing rules in the agent model;

2) the exchange of messages between agents of the dynamic model of RCP and intelligent agents (in the frame-object expert system) is carried out through a message clipboard containing common variables used in BPsim.MAS dynamic simulation modules and BPsim.DSS technical and economic design modules.

## 4 Conclusion

In this research paper, the task was solved of developing a coalition multi-agent model of the resource conversion process, as well as the following tasks:

- the basic concepts were defined of a coalition model of the resource transformation process;
- a multi-agent modeling algorithm that takes into account the stages of coalition formation and collapse, was developed as well as the possibility of making structural and parametric changes to the dynamic model of the resource conversion process;
- the possibility was shown of implementing applied multi-agent models with coalitions in the BPsim software package.

#### 4.1.1 Acknowledgements

This research paper is supported by 211 acts of the Government of the Russian Federation, agreement No. 02.A03.21.0006.

## References

1. Wooldridge M., Jennings N. Intelligent Agents: Theory and Practice// The Knowledge Engineering Review. – 1995. – Vol.10, №2. – P.115-152.
2. Wittich V., Skobelev P., “Multi-agent interaction models for the design of the nets of requirements and capabilities in open systems,” Automatics and telemechanics, vol. 1, 2003, pp. 177-185.
3. K. Aksyonov, E. Smoliy, N. Goncharova, A. Khrenov, A. Baronikhina Development of Resource Conversion Processes Model and Simulation System // Proceedings of the EUROCON 2005. – Serbia & Montenegro, Belgrad. 2005. – P.1722-1725. WOS:000237248900431
4. Solovyeva I., Sokolov B., Ivanov D. Analysis of position optimization method applicability in supply chain management problem // 2015 International Conference "Stability and Control Processes" in Memory of V.I. Zubov (SCP) 2015. P. 498-500.
5. Andrei Borshchev AnyLogic 4.0: Simulating Hybrid Systems with Extended UML-RT/ Andrei Borshchev // Simulation News Europe, No. 31 April 2001, pp 15-16
6. Sokolov B.V., Pavlov A.N., Yusupov R.M., Ohtilev M.U., PotryasaevS.A. Theoretical and technological foundations of complex objectsproactive monitoring management and control // Proceedings of theSymposium Automated Systems and Technologies Peter the Great St.Petersburg Polytechnic University, Leibniz Universität Hannover.2015. P. 103-110.

7. Shorikov A.F.: Solution of the Two-Level Hierarchical Minimax Program Control Problem in a Nonlinear Discrete-Time Dynamical. In: 2th IFAC Conference on Modelling, Identification and Control of Nonlinear Systems. Book of Abstracts. University of Guadalajara, Mexico, P. 33 (2018).
8. Khalyasmaa, A. I., Zinovieva, E. L., Intelligent decision support system for technical solutions efficiency assessment, Proceedings of 2017 IEEE 2nd International Conference on Control in Technical Systems, CTS, 2017
9. Muller J.P. &M.Pischel. 1993. The Agent Architecture InteRRaP: Concept and Application, German Research Center for Artificial Intelligence (DFKI). 1993.
10. K. Aksyonov, E. Bykov, E. Smoliy, E. Sufrygina, O. Aksyonova and Wang Kai Development and Application of Decision Support System BPsim.DSS // Proceedings of the IEEE 2010 Chinese Control and Decision Conference (CCDC 2010), 26-28 May 2010, Xuzhou, China, Pages 1207-1212. WOS:000290460300245 DOI: 10.1109/CCDC.2010.5498160