Development of Multi Agent Resource Conversion Processes Model and Simulation System

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Abstract. The mathematical model of multi agent resource conversion processes (RCP) is developed by the means of discrete-event simulation systems and expert systems. Within the framework of mathematical model RCP are defined: production system of the RCP structure, that taking into account conflicts origin. The discrete-event simulation system "BPsim" is developed on the basis of the multi agent RCP mathematical model. The "BPsim" system is inculcated on the firms in Ural region (Russia).

1 Introduction

One of the perspective directions of simulation and modeling (SM) tool development is the problem-orientation, which allows to reduce the requirements that presented to a knowledge level of end users in the programming area essentially. In the given work the results of creation and application of the resources conversion processes theory and SM system "BPsim", created on the basis of that theory, are described.

2 Mathematical Model of the Multi Agent Resources Conversion Process (RCP)

In this research, we shall understand the resources conversion process as the process of an input conversion (resources necessary for process execution) in an output (products - outcomes of process execution).

The tasks of problem area RCP are: new RCP designing and existing RCP perfecting, the forecast of resources and conversion device state, the estimation of the process time and cost characteristics, the resources costs estimate and mechanisms usage time.

To the basic disadvantages of the visual problem-oriented SM tools such as Arena, ARIS, ReThink (G2), with reference to the RCP, it is possible to attribute the complexity of the RCP description and carrying out of computing experiments, weak modeling means of the conflicts arising with the general resources and tools, absence of Russian language support. In this paper we examine mathematical model of the

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RCP and SM system “BPsim”, which is substantially free from the above mentioned disadvantages.

Creation of the RCP mathematical apparatus is based on the widespread mathematical schemas of dynamic processes description (Petri networks [1], queuing system [1, 2], models of system dynamics [1, 2, 3]). However, with the help of the specified models it is difficult enough to present all the features of the RCP.

The main objects of discrete Multi Agent RCP are (Fig. 1): operations (*Op*), resources (*Res*), control commands (*U*), conversion devices (*Mech*), processes (*PR*), sources (*Sender*) and resource receivers (*Receiver*), crossroads (*Junction*), parameters (*P*), agents *(Agent)*. The process parameters are set by the object characteristics function. The relations between resources and conversion device are set by the link object (*Relation*). The agents existence resumes availability of the situations *(Situation)* and decisions (action plan) *(Decision)*.

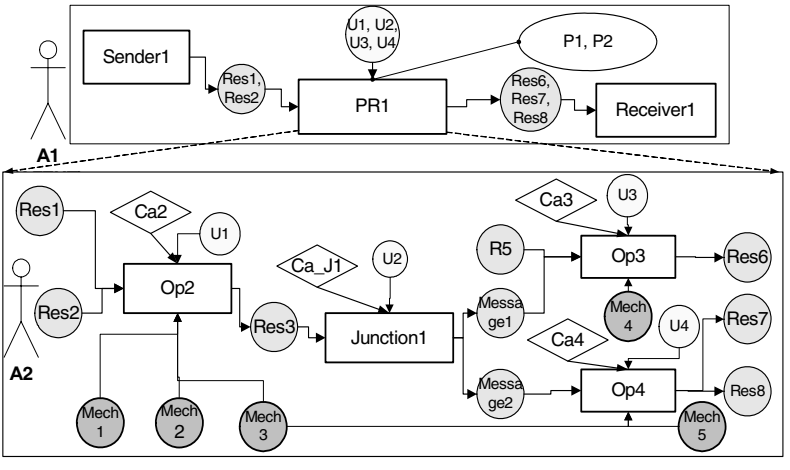

Fig. 1. Hierarchical Multi Agent RCP. PR1 process works out in constituents Op2, Op3, Op4, Junction1 and corresponding resources and tools; agents A1 and A2 control different RCP levels

Agents operate the RCP objects. For every agent there is a model of the person taking a decision. An agent executes the following actions: 1) analyzes the environment (current situation); 2) diagnosis the situation, apply to the knowledgebase. In the case of determine any corresponding (exceptional) situation an agent try to find a decision (action scenario) in the knowledgebase or work out it himself; 3) works out (take) a decision; 4) determines (remolds) the goals; 5) controls goals achievement; 6) delegate the goals to his own or somebody else's RCP objects, and also to another agents. 7) exchanges messages.

The RCP elements take part in message exchange and realize their converter functions on the base of their behavioral models (state graphs) following the incoming messages. The frames are selected as an agent’s knowledge representation language.

The possibility of the use of typical process description models for the creation of the mathematical model of the RCP is examined; the typical process description

models are: the augmented Petri networks; the queuing systems. It's shown that given models don't allow making an adequate representation of the RCP. There are some disadvantages revealed for the Petri networks: absence of timing; absence of the concurrent activities conflicts; the lack of the division of mark types (resources types); models of real processes described in the terms of Petri networks are bulky and badly readable. Owing to the fact that the change of the N_E – schemas has only two positions, there is no ability of process interrupt modeling. The conceptual apparatus of the Q-schemas are not corresponding with the problem area of the RCP, Q-schemas are oriented on the modeling instruments activity, and in the RCP there are modeling of the consecution and parameters of the conversion processes.

The apparatus production rules are used for building a kernel of simulation system [4, 5]. The structure of the production rules of the RCP system is defined as:

$$PS = < Rps, Bps, Ips > . \quad (1)$$

In equation (1) $Rps=\{RES(t)\} \cup \{MECH(t)\}$ is the current state of resources and conversion devices (operative storage); *Bps* is a set of resources transformation rules (knowledge base); *Ips* is an inference engine.

The operation algorithm of the inference engine consists of the following main stages: 1) definition of a current instant $SysTime = min\ Tj,\ j \in \{RULE\}$ (standard algorithm of the discrete-event simulation (DES)); 2) agent's actions processing (current situation diagnosis, executive instruction working-out); 3) queueing of transformation rules; 4) execution of transformation rules and operative storage state transition. Imitator applies to the expert system module for the current situation diagnosis and executive instruction working-out.

3 Multi Agent Simulation System "BPsim"

The problem-oriented SM system is developed on the basis of surveyed model. SM package of the RCP "BPsim" is worked out on the basis of the following means:

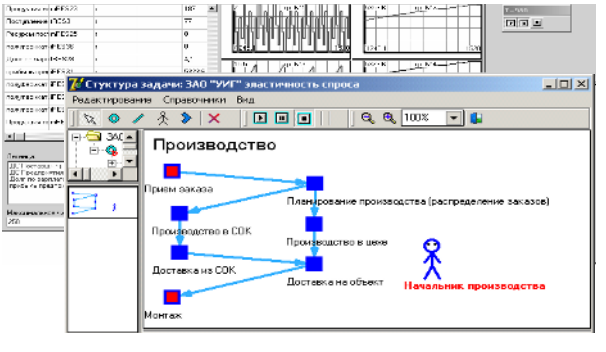

Fig. 2. A fragment of the industrial process model which is worked out for the "Urals Industrial Group" enterprise and made with the help of the simulation system "BPsim". For every graph node in the form view there is an operation or RCP, for every connection between the nodes there is a resources flow, for every agent there is a model of the director of operations.

Borland Delphi 7 and database control system MS SQL Server. The SM system "BPsim" provides execution of the following functions: the creation of dynamic model RCP [6]; the simulation (Fig. 2); the analysis of the simulation experiment results; obtaining reports on the results; export of the experimental results in MS Excel and MS Project formats.

4 The "BPsim" System Application

Some tasks of the evaporator machine-building production process which count 420 technological operations was solved for the large chemical engineering Urals plant "URALKHIMMASH": planning of the operations schedule; estimation of equipment loading; estimation of man power loading. The dynamic model of activity with the "BPsim" was designed for "The Ural industrial group". The use of the designed system allows defining the optimum schedule of windows delivery and mounting links operation; the optimum quantity of mounting links depending on seasonal demand (volumes of orders); and also it allows reducing the periods of execution of orders from 14 days to 11, that helps to increase profits of the firm by 21 %.

5 Summary

The mathematical model of the multi agent RCP is developed on the basis of the means of dynamic expert systems. Within the framework of mathematical model multi agent RCP are defined: production system of the RCP structure.

The package of multi agent simulation modeling "BPsim" is developed and inculcated on the firms in Ural region and in the Ural State Technical University.

The multi-agent method application to the dynamic model of the RCP helps to increase its intellectuality owing to expert and simulation fusion.

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