The approach to organization of the production multi-agent system

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Abstract. Multi-agent systems are usefully employed in banking sector, logistics and military commitments. In machine-building industry the trend line is implementation of digital productions and Internet of Things concepts. In our opinion combine of digital production and multi-agent systems gives the opportunity of production control improvement. In this paper we propose the approach to the organization of a production multi-agent system based on the service-oriented architecture. The agent’s technology is considered, services are separated and communication between them is defined. As the means of communication we propose the XML manifest that provides an opportunity to informational support of interaction between agents and services. The results of this work are relevant to building of a multi-agent system for production control in machine-building industry.

1. Introduction

The problem of resources management effectiveness in a real-time mode becomes clear in machine-building industry. Aggregation of manufacturing and technological data in digitized form requires the analytics for planning processes and production resources accounting. Using solutions based on ERP/APS systems, enterprises solve the problem of idealized production planning but without the possibility of a progressive response to external changes. Centralized information system cannot control the all components of production environment. The changing rate of a system is higher than its decision time for controlling information system [1,2].

In view of the above restrictions, we consider a multi-agent approach for information support of an enterprise. The advantage of the approach is a real-time adaptation to the internal and external impacts in a production system. A production system includes of processes and resources and can be considered as a multi-agent system (MAS). Advantages and positive experience with using of multi-agent systems in resources management, satellites constellation and banking sector were described in [3,4], where the architecture problems of a multi-agent system in resources management of an enterprise were considered.

2. Problem description

2.1. Features of machine-building industry

While impacting designing of a multi-agent system (MAS) the features of the resources management problem of machine-building industry are considered:
existence of a product manifest that describes a product structure and configuration, taking into account its seriality and options;
- technological process is the main decision document that defines a production route, resources list for each operation and usage norms;
- technological process order and ready time are defined by the assemblage technology that adjusted under the external impacts;
- existence of a rating system for materials, labor resources and machines are defined as a culture of planning manufacture;
- each product manifest has a life-cycle;
- the struggle for resources is regulated by human factors in the process of resources-seeking behavior production;
- production process is not constrained with deadlines because this process is inseparable from the human reason.

2.2. Agents ontology

MAS implementation is divided into the several agents types: the agents are associated with physical resources of a process environment; the agents are associated with technological processes; the agents are associated with human resources; the agents of product components.

The agents associated with physical resources are represented as virtual doubles of environment, tools, equipment and material supplies. Within the concept of Internet of Things, the agents are receiving all information about its physical doubles. It allows to react the changes more adequately in cooperation with other agents. Each agent identifies oneself in a common system and leads to the life-cycle of its physical double.

The technological process agents have no physical associations but they are related to the technological production data. This agent is born with the production start-up. The main part of the agent is created by engineering-technological service at the preparation stage and can be represented as a product design management system (PDM). After the completion of a technological process the agent will be terminated.

The agents associated with human resources are designed for embedding a human into a multi-agent system. With graphical user interface the agent is interacted with personality and this interaction gives an information about between other agents. This approach provides the control of human intervention into a system. The other methods of human participating are not desirable.

The agents of the product components are associated with the physical components (assembly units, items, standardized products and etc.). They provide the product integrity and controlling technological process performing. The agent passes through all stages of production from semi-finished to final product. Regular accounting of each product provides supporting of manufacturing and the maintenance service. The implementation of this approach requires high level of device.

3. The main methods of organization of production multi-agent system

3.1. Multi-agent system prototype

While testing a multi-agent system prototype in machinery production the number of problems and restrictions were revealed. These aspects lead to reviewing the existed system architecture. Figure 1 shows the prototype scheme.

There are some of them:
- if a new agent subtype will be added, there is the necessity of the program code changing. It restricts the platform extensibility;
- in-depth analysis of the agent subject area reveals the necessity of its behavior functions extension. It leads to the algorithm changing that should not effect on the other agents;
• agent communication language demonstrates the low flexibility in developing process. Switching to the new architecture leads to developing a new language version;
• increasing the number of active agents leads to performance degradation of a communication process. Identification using TCP/IP protocol shows low efficiency [5].

Figure 1. A multi-agent system prototype.

3.2. Designing of a multi-agent system architecture
The new version of a multi-agent system is based on the two main approaches: implementation of the service oriented organization and describing the agent behavior defined by the self-determination file. Separate services allow to unify the actions of the agents. The services using provides the flexibility changes that is available the all agents in a system. Figure 2 shows the new approach of a multi-agent system organization.

Each agent subtype passes through his own life-cycle. This route description is considered as a workflow process that is associated with agent actions, service requests. Figure 3 shows the part of an agent path where states and actions are defined while a task performing. Agent and service are interacted by the messages [6].

Windows Workflow Foundation is a service implementation tool. It is the part of .NET oriented on a visual programming and has the declarative programming model. Three types of processes are used for an agent behavior description:
• Sequential workflow – is a transition from one step to another irreversibly;
• State-machine workflow – transferring from one step to another with optional reversing to previous states;
• Rules-driven workflow – is a special case of the sequential workflow where the next step is defined by the rules.
Figure 2. Approach to a multi-agent system organization.

Figure 3. Approach to a multi-agent system organization.
3.3. Description of a multi-agent system services

The following services are defined in this architecture:

1. Maintenance service of the business processes for agents. The functionality of service is defined by controls the agents' behavior and the initializing accesses to services with the defined route of work. When the agent is born subtype of business process is created. The agent is interacting with it and the inner processes is controlled. The possibility of a unified agent is created and agent self-identification and living are defined by the set of preferences.

2. Modeling time synchronization service. Taking into consideration that the agents are executed in a single environment, they demand time synchronization. Emphasis on a simulation time allows to apply virtualizing the execution of a multi-agent system for experimentation. The experiments make a forecast of an agent responding to change.

3. Agents’ planning service. Here is implemented a schedule management system. The service interacts with the planning database, keeps accounts the registered ranges in a schedule and cancels the registered ranges by the command form an agent. The time ranges are related with the agents that provides the reports generation.

4. Decision service. The service provides the agent’s analytics for making a decision in choosing the order performer. It also analyses the advisability and benefits of the ordered works. The service architecture has the expanding possibility in an optimal case choosing. It makes possible improving a multi-agent system.

5. Agents’ communication service. The service provides communication between agents through the messages exchanging, keeps accounts of the active agents and their statement. The format of messages is MASXML that is based on XML manifest. The service execution is provided through Windows Communication Foundation (WCF) framework. It makes possible building the secured and sustainable transactional systems. WCF works with the simple unified model of multi-platform interaction.

6. Technical-economic parameters calculation service. The service provides the performing calculations in an order for the agent. Hereafter the results are using in a decision making process.

7. Data parsing service. The service extracts the required data from the input messages and generates the responses. The single XML manifest is used in a multi-agent system.

Figure 4. MasXml scheme fragment.
3.4. Informational pattern of communication
Social component of the program agents involves interacting with the other entities (agents, people and etc.) that is implemented through the messages in XML format and additional files [7]. The format is also used for messaging between services. The specification of xml (MASXML) was developed for describing information structure system. The main development task was to provide format generality for all agents. Figure 4 shows the connections between elements in MASXML.

4. Conclusion
The developed approach allows organizing a workflow between the programmed agents in the Internet of Things concept. The agents’ ontology in a manufacturing management and behavior customizing allows expanding a system and improving the quality of making decisions. The proposed approach to the organization of a production multi-agent system is based on a service-oriented architecture, which will allow the system to be developed in the future. Dedicated services determine the mechanism of interaction of software agents with each other within the system and ensure the performance of the tasks set. The solution is based on controlling the behavior of a software agent as a sequential access to various services during its reaction to an internal state, events and external influences. As a means of communication between agents, the xml specification has been proposed, which allows organizing information support for interaction processes between agents and services. This multi-agent system has prospect to be introduced to innovating production and promotes the development of digital economy strategy of Russia.

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