Using an Information System for Distributing Orders at an Industrial Enterprise for Efficient Capacity Utilization

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Abstract. The article provides a comparison of enterprise management information systems. Their functionality is analyzed with the definition of the pros and cons when used in an industrial enterprise, and the presence of a simulation module in them is checked, which allows for preliminary modeling of production processes to determine the ability of the enterprise to fulfill its obligations under existing orders. The information system developed by the authors is described, which includes three different, but interconnected modules, namely, a module for determining the optimal order distribution plan, a simulation module for "running" the model and comparing data with the optimal result obtained in the module for determining the optimal plan, as well as an analysis module, accounting and moving parts. In this system, when modeling processes, the distribution of enterprise orders is carried out by modeling the process of manufacturing item items using a new approach of "order distribution". This approach is based on the Kanban method, which differs from the standard method in that it is extended by the use of intelligent agents that collect, analyze, distribute, and store enterprise orders.

Keywords: Information technology · Production planning

1 Introduction

The article compares corporate information systems used for production management at industrial enterprises, considers the main directions of production activities of enterprises and their automation through the use of the considered information systems. The availability of the simulation module is checked to determine whether it is possible to analyze the execution of production orders at existing production facilities with minimal labor costs. The developed information system is considered for the distribution of production orders with the functional ability to simulate the process of manufacturing products using the developed approach of "retailing" which is based on the Kanban method. This approach is complemented by intelligent agents that determine which production chain to produce products on and that are responsible for dividing orders, check available production capacity and the ability to fulfill an incoming order. The structure of the system is presented, as well as the algorithm of the action of intelligent agents used in the simulation module which is part of the system.

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2 Formulation of the Problem

Choosing the optimal corporate information systems for solving the problem of enterprise management, including the subtask of obtaining an effective production plan for a calendar period, is not a simple task that includes an analysis of existing systems on the market by functionality according to the list of production areas characteristic of industrial enterprises [1–3]. Large industrial enterprises often [4, 5] have divisions that allow them to produce products of the same type. Here is an example of one of these cases.

Machine-building enterprise consist of two different productions: metallurgical and assembly equipment. For the release of goods, the procedure consists of a full production cycle, namely the supply of the necessary materials and the production of the final product. The output chain of metallurgical manufacture consists of four workshops that organize the production scheme for the items and transfer of goods to the assembly shop. The technological process of production.

We will conduct a comparative analysis of corporate information systems for the purpose of drawing up an effective production plan for loading the same type of structural divisions present at an industrial enterprise.

3 Theory

Various information systems, such as (OmegaProduction [6], SAP S/4 HANA Cloud ERP system [7], ERP—Galaxy [8], Microsoft Dynamics AX [9], SmartFactory [10]) are used in various enterprises and allow, depending on the implemented functional modules, to solve various tasks. Consider the systems.

3.1 OmegaProduction

The OmegaProduction information system is an item of the Byelorussian corporation OmegaSoftware. This software is developed to control the trade and resources of the enterprise. The software belongs to corporate information system and integration of automation in all management processes of the enterprise, being a kind of CALS system. The system is a 2-link client-server architecture.

Considering this system as a system for production planning at a machine-building enterprise, it should be noted that the calculation of production plans is made according to the most common MRP II and APS methodologies.

3.2 SAP S/4HANA Cloud ERP System

The SAP S/4HANA cloud ERP system is a product of the SAP company which is a multifunctional information system belonging to the class of enterprise systems. The use of several modules together, such as SapPLM, SapERP, SapCRM, forms a CALS system in industrial enterprises. The most common product of the SAP company is the Sap ERP corporate information system. The system is a three-tier architecture (client-application server—DB).

Due to the fact that the management of engineering data is carried out in another module in Sap ERP, there is only the maintenance of specifications, material consumption rates, and a description of operations for manufactured products. Production planning takes place according to the MRP II and APS planning methodology. If there is no accurate data in the system, the production plan will contain incorrect data.

3.3 ERP-Galaxy

The ERP-Galaxy information system is a Russian development and also belongs to the class of corporate systems. The system architecture can be two-tier or three-tier. The planning function of this software is based on the MRP II methodology, a planning standard that is used to prepare production plans in an enterprise.

3.4 Microsoft Dynamics AX

Information system Microsoft Dynamics AX belongs to the class of corporate systems and is a software product that allows you to manage the resources of the enterprise throughout the production process, putting under control the functions of the supply chain of materials, conducting trade and procurement procedures, personnel management, financing, production planning. Microsoft Dynamics AX supports a three-tier architecture.

The production management and planning function is also based on the MRP II and APS methodologies. The construction of the plan can be either "forward" or "backward", taking into account the limited production capacity.

3.5 SmartFactory

The production planning system from SmartSolutions is a Russian development which was released relatively recently. The system is designed to work at the MES level. This system is based on a multi-agent approach as a basis for production planning which radically distinguishes it from the previously considered systems. The multi-agent approach is based on the method of networks of needs and opportunities (PV-networks) [11]. The idea of this method is to use separate intelligent programmed agents for each existing entity, for example, a machine, a production line, a process, a person, a site, a production shop. Agents exchange information among themselves, so-called negotiations, and come to mutually beneficial solutions to obtain the optimal result and the earliest possible fulfillment of an existing goal or goals. Thanks to the use of this approach, the system has a flexibility in comparison with other information systems, due to which there is no need to perform calculations of a previously created production task when a new order appears.

4 Results of the Comparison

After reviewing the system data by application and function, we will summarize all the data in a table and compare these systems. In Table 1 shows the functional features of information systems.

Table 1. Functional features of the systems

No	Parameters	OmegaProduction	SAP	ERP-Galaxy	Microsoft DynamicsAX	SmartFactory
1	Production dispatching	+	+	+	+	+
2	Production planning (including splitting the order between multiple routes)	+	+	+	+	+
3	Warehouse accounting	+	+	+	+	+
4	Production planning	+	+	+	+	+
5	Engineering data management	+	−	−	−	−
6	Simulation module	−	−	−	−	−
7	Bottleneck analysis	−	−	−	−	−

Basing on the data in the table, we can see that the systems considered allow us to solve similar tasks, for example, sales accounting, supply accounting, but there are also differences, for example, focusing on business analysis, accounting unit, design and technological preparation of production, while support for order separation is implemented in almost all systems which allows us to talk about the presence of the so-called "Capacity Balancing" function. This function works both in automatic and manual mode, which does not allow you to determine the most effective plan and also requires significant time resources to create it in other words, systems build a plan based on current constraints, without taking into account the fact that it is possible to offer solutions for improving/reengineering processes, which can have a positive effect on planning. The presence of a simulation module is absent in all the systems considered which means that it is impossible to create a model and play it back to determine the most effective plan.

The considered information systems are ready-made software products with the introduction of which there is a greater change in the business processes of the enterprise than the customization of systems to meet the requirements of the customer, this is especially clearly observed in foreign companies such as SAP.

5 Planning Methods

In the considered information systems, various methods are used to build a production plan: the method of PV-Networks, APS, MRP-II.

5.1 Method APS

The APS method is a concept of optimized (or synchronous) production planning. Main features: increased planning detail; reduction of production stocks; improvement of product supply activities; better use of fixed assets; increased rhythmic utilization of production resources; more flexible response to competitive demands.

5.2 Method MRP II

The method is a production planning strategy that provides operational and financial planning for production.

5.3 Method PV-Networks

The main idea of the approach is to use software agents for each process or operation, as well as for each worker, equipment of the enterprise or workshop. The APS method and MRP II are more planning methodologies that define planning criteria. In view of this, it is proposed to take the Kanban method as the closest in terms of criteria to the APS method for conducting a comparative analysis. Replace the MRP II method with the simplex method of linear programming, because in both cases only the available resources and their limitations are taken into account in planning.

The task of assembling a car assembly product was considered. In the divisions of the plant, 3 different parts are manufactured (part 1, part 2, part 3), each of which has a different manufacturing process and one assembly product consisting of these parts. The applicability of each part included in the assembly unit is equal to 1 pc. The participating units are shown in Fig. 1. Each part and assembly unit is assembled according to the technological process. On the basis of the Kanban and PV-networks methods, simulation models were constructed and the results were carried out, in the case of the simplex method, mathematical calculations were performed. The data is shown in Table 2.

Based on the data in the table, it can be seen that the optimal method is a simplex method, but this is a mathematical calculation that shows the maximum allowable number of products to be assembled. The closest result is shown by the new method proposed by the authors. This is the MPPR/Kanban that is used in the created system. Models built using intelligent agents allow you to get any level of abstraction: high, medium and low, as well as to combine them with each other, which allows you to get realism and flexibility in describing the system, the ability to simulate the most complex nonlinear feedbacks, use any necessary level detail. In the future, the agent-based approach will be referred to as a multi-agent resource conversion process (MPPR), which displays the production processes at the enterprise with the participation of agents - decision makers.

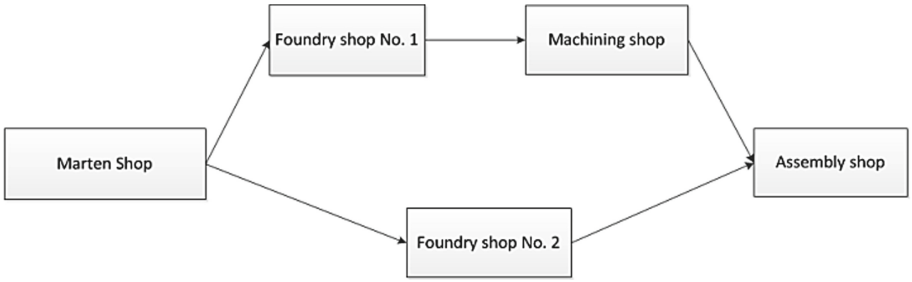

Fig. 1. Scheme of the manufacturing process.

Table 2. Model simulation results.

Parameters	Kanban	PV-Networks	MPPR/Kanban	Simplex method
Collected Products	62	70	71	87

6 New Information System

The developed information system is based on the objective function (1).

$$\sum_{j=1}^{z}\sum_{i=1}^{m}(c_{ij}) + c_v \rightarrow \min \tag{1}$$

where overhead costs $-c$, and c_v - shop costs with a decrease in production volumes. The developed order distribution system for the tasks of efficient order distribution at a machine-building enterprises is a system for obtaining an optimal plan for the distribution of orders along technological routes, simulation systems, taking into account resource constraints, and systems for accounting and movement of parts and assembly units that are integrated with each other. The relationship with other enterprise information systems occurs at the MSSQL Server database level.

The system includes:

1. The decision support system (DSS) BPsim [12]. DSS is designed to solve problems of technical and economic design and dynamic business modeling of organizational and technical systems, problems of dynamic intelligent modeling of multi-agent decision-making processes [13–15], problems of system analysis and development of models of production, business systems, bottleneck analysis, reengineering, optimization. Design of a conceptual model of the process of manufacturing components in the structural divisions of the enterprise. The problem was solved using the simplex method which was implemented by BPsim.DSS using the Transact SQL language.
2. The implementation of the method of "re-engineering" of parts and assembly units, in the distribution of production orders at a machine-building enterprise in various production planning approaches, is carried out in the system of dynamic situation modeling (SDMS) BPsim.MAS. BPsim.MAS is obtained as a result of the integration

of simulation, expert, situational and multi-agent modeling methods. The results obtained in the BPsim.DSS system are checked on the developed simulation model
3. The results obtained on the distribution of production tasks by structural units are transmitted to the shop MES system, where the production schedule is built for the planned period.

7 Discussion of Results

The application of the developed system in the conditions of the existing metallurgical production, which is a part of the machine-building enterprise, allowed to obtain an increase in the productivity of the divisions, in comparison with the original model, by 1.56 times. The use of the "re-engineering" method made it possible to evenly load the same type of structural divisions, i.e., to balance the capacities in the simulation model of metallurgical production.

The use of this system in large industrial enterprises will allow you to effectively load duplicate structural divisions by step-by-step solution of the problem:

1. obtaining the optimal result
2. testing it in a production simulation model, where there are various resource constraints
3. transmitting information to the MES system for distribution by site. In comparison with the ERP systems discussed above, carrying out these works involves minimal time and financial resources.

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