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A Study of the Production Process Simulation System Based on Workflow Management

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Abstract: The paper presents a method for designing a production process simulation system using workflow management technique, which consists of three parts: process model, organization resource model and workflow engine. Based on this method, we put forward a production process simulation system structure, and discuss the function of the key modules in detail. At last we present a sample in practical application.

Keywords :workflow management, simulation, process model, BPR

1. INTRODUCTION

Production process simulation is one of the main means used in the production process analysis. The simulation can not only simulate dynamically operation ability of the system, but also can collect the operation information promptly and accurately, in order to provide a quantitative analysis of data to measure the effect of the process. Generally speaking, there are two aspects of the main purpose of simulation. Firstly, in the period of system diagnostics, through the simulation of the original production process, to identify problems and find out the crux of the problems. Secondly, in the period of system optimization design, in the case of non-implementation of the newly created process, by means of simulation to analyze and evaluate its running effect, to assist in the selection and final optimization decisions. To achieve the purpose of simulation of the production process, we have to first transfer shop business model into a computer model that is making a rational organization of people involved in the production process, resources, information, applied tools and others to achieve process integration. Workflow management technology derived from computer supported cooperative work field is considered to be an effective way to process integration.

The concept of workflow appeared in the 1970s. In recent years, workflow management system has gradually become a new generation of information management system. According to the definition of workflow alliance, workflow process is all or part of the implementation of automation. Workflow management system(WfMS) is a software system of complete definition, management and implementation of workflow, the execution order of the software depends on the computer representation of the workflow logic. Since workflow management technology appeared relatively short time, the domestic research is still in its initial stage, The main work is still in the theory discussion and simple application of the workflow system structure, lacking of comprehensive research and practical use experience. This paper discusses the workflow management thinking

into the production process simulation to discuss the production process simulation using the principle of workflow management thought. Based on this, a research of realization ways of workflow management system supporting production process simulation system has been made.

2. WORKFLOW MANAGEMENT IN THE PRODUCTION PROCESS SIMULATION

Production process simulation is the simulated implementation of the already defined production process model, the factors involved include: a variety of specific activities in the production process, information need to deal with and organizational resources. However the production process itself is a complicated, rich content process. Therefore, the use of workflow theory to describe the production process simulation mechanism, involving the workflow process modeling, organizational resources modeling and workflow engine.

From the production process structure view, it can be understood as a series of activities organized in accordance with certain constraints rules, there are association between various activities, such as order relationship, resources sharing, target related or conflict[1]. Process modeling is mainly to describe different levels of complexity of the production process and its associated information in accordance with the management level.

Organizational resources modeling mainly is a performer of defined activities, constructing related organization structure and assigning the appropriate permissions. A production process is distributed, collaborative relationship in the entire workshop and even in the entire enterprise, different partners are responsible for various process implementation, therefore the process description must clearly define which organization, which roles are responsible for which activities. Resources are safeguard in workshop activity implementation, the needed resources (type, quantity, etc.) support of each operating activity must be described during the description of workshop activities process.

3. WORKSHOP PRODUCTION PROCESS MANAGEMENT SIMULATION SYSTEM BASED ON WORKFLOW MANAGEMENT

3.1 Division of the system function modules

According to the workflow reference model structure, in order to meet the standardization and openness of the system, the simulation system architecture is shown in Figure 1. It consists of five main sections: organizational resource model, process model, simulation model generator, simulation engine, simulation report generator and simulation database. Let's discuss each one of the key module.

3.2 Process model

Process model is used to define the workflow process logic, including all the activities of the workflow and the dependencies between activities. It is the foundation and core of the whole simulation system. At present, there are many definition methods of process model, such as active network-based modeling approach, based on the formal representation modeling approach, based on dialogue modeling method, based on state and activity

diagram modeling method, based on transaction modeling methods, etc. We make three model design principles before modeling: firstly, considering the simulation system oriented users for general technical workshop staff, the premise should be simple, intuitive and easy to master. Secondly, it should have strong process description ability, and it can define various process logic of possibility. Thirdly, it should reflect multiple view characteristic of the complicated system of production workshop. After weighing, in the process of the system development, we use the graph modeling method based on the active network, and thus a production process can be viewed as a digraph composed by a node and the connecting arc. Among which, the node represents activities, the connecting arc represents order relations between activities. On the basis of activities network chart, two concepts of "state" and "conditions" are added to enhance the semantics of the process model, which can deal with enough complicated process logic to meet the needs of users.

3.3 Organizational Resource Model

The organizational model is used to define the organizational structure of the workshop personnel, including several different forms of organizational elements as well as each of the organizational elements within a hierarchical relationship. The main task of the organizational model is to provide a flexible organization definition for the implementation of workshop personnel, to provide people's support for process model.

The resource model is used to define the organizational structure of the workshop resources, including

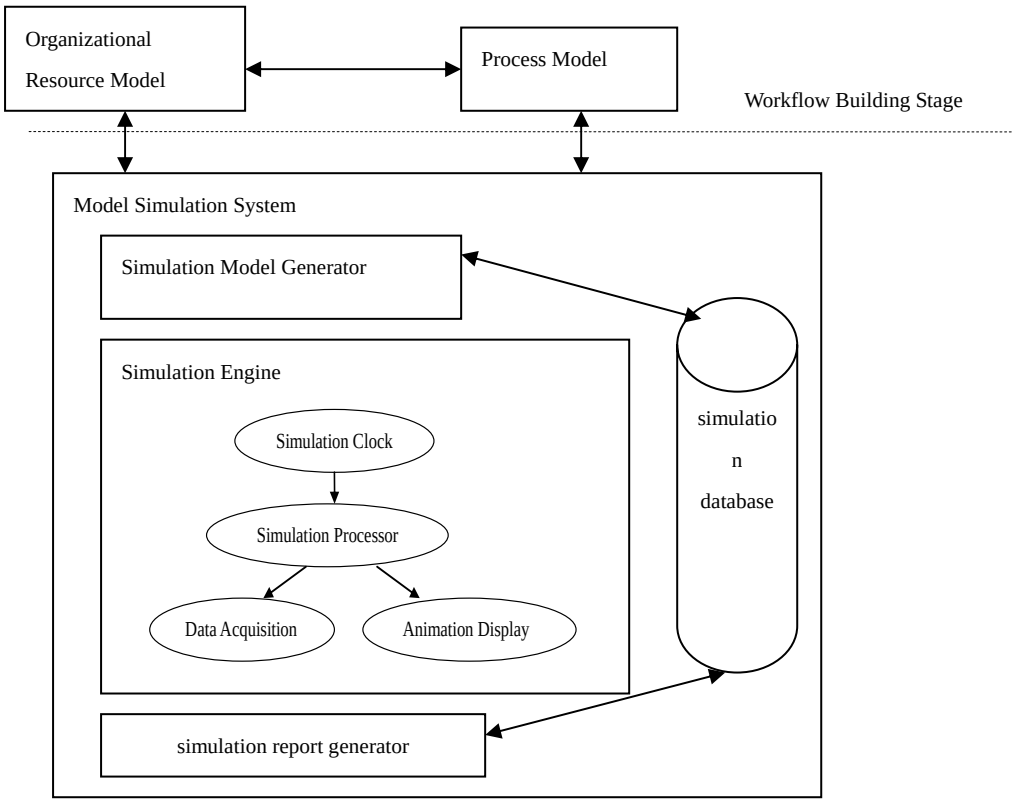

Figure 1. Simulation system architecture

several different forms of resource container elements and container internal hierarchical relationship, or even the final atomic level of resource individual. The main task of resource model is to provide material support for

performing workflow of workshop personnel.

3.4 Simulation Model Generator

After defining production process model by workflow modeling tool[2], through setting corresponding simulation parameters in the simulation scenarios interface by users, and storing them into the database, finally the simulation model has been got.

3.5 Simulation Report Generator

The simulation report generator calculates the collected data in the execution of simulation, such as the actual using time of the machine tool, waiting time, idle time, the working hours of the shop workers and ultimately generate a variety of reports. In order to understand the use of critical resources, to find production bottleneck and potential dead center, and thus to predict workshop production capacity for reference of production plan, and finally to provide basis for business process reengineering(BPR) of enterprises[3].

3.6 Simulation Engine

As shown in figure 1, the simulation engine contains the simulation clock, simulation processor, data acquisition and animation display.

(1) Simulation clock. It is used to control the simulation process

(2) Simulation processor. It is used to simulate the implementation of activities and promote process instances. Mainly to judge whether the activities are executable, and it is responsible for modifying the state of activities and resource, and responsible for the accumulation of time

(3) Data acquisition. It is used to collect data during the simulation, and write the data into the simulation database.

(4) Animation display. Refresh animation display area and the text display area in the interface of users according to the current activities state. If there are some state changes of activities in the simulation process, then the animation display will be triggered, and it will refresh the interface of users.

Simulation completely abandon the interaction with users, and it simulates the implementation of activities by simulation engine, and it promotes process instances automatically. It mainly makes simple time accumulation and state modifying, and it is responsible for recording related simulation data(the execution time of the activity, the use time of resource, the cost of activities, etc) ,at the same time it credits them into the corresponding database. During the simulation engine explaining and performing the simulation model, under the control of simulation clock, by a series of sequence process of routine processing, through the case of the simulation model state changes over time, it indirectly reflects a dynamic change on the actual process system. Simulation engine mechanism is shown in Figure 2.

In this system, the production process model is established on the basis of activity network diagram. Therefore, the interpretation rules of simulation engine to process model is : finding out all of its precursor activities and getting their current status before the implementation of activities, then judge its transfer conditions, if the transfer conditions meet the active to set "ready to run", and then verify whether the assigned

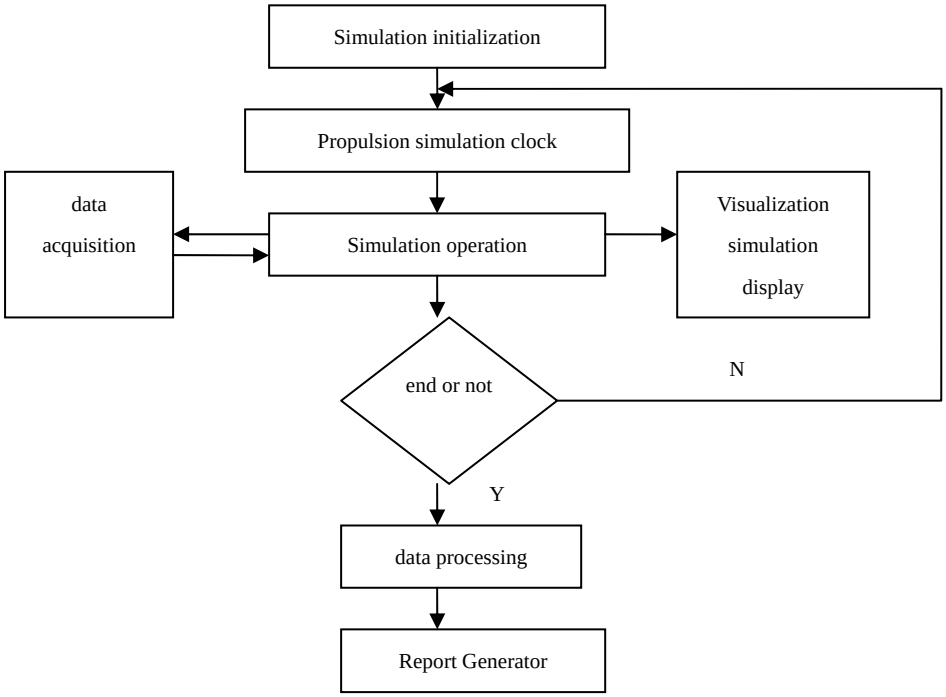

Figure 2. Workflow engine mechanism

resources are idle, put the activities to "run" if they are idle, meanwhile, a variety of data during the operation should be written into the database table. If we do simulation to many process at the same time, it may appear that the contention phenomenon of the same resource at the same time[4]. Here the task priority and minimum occupancy time rules are used to handle this anomaly, firstly according to the priority requirement of the task itself, resources are allocated to the task of high priority, when the priorities are the same, resources are allocated to the task which occupy shorter time, when both the same, the allocation is random. When the task is being executed, if something is wrong with the used resources, the substitute resources which were given in the model definition can replace the original resources. If the substitute resources are in a busy state, then set the task to " suspend state " until the resources are available. When the execution of the simulation is to the end of the activity, and it meets the activity over condition, we think a simulation is over. Simulation engine state transitions is shown in Figure 3.

3.7 Simulation Database

Simulation database is used to store various data produced by data acquisition during the operation of the system, and as the support of simulation report generator it ultimately generates a variety of reports required by users.

4. APPLICATION EXAMPLES

An example will be used to illustrate the specific application of the simulation system as follow. This is a workflow of a die-casting mold production process, the modeling will be made by the process model definition module of the system[5].

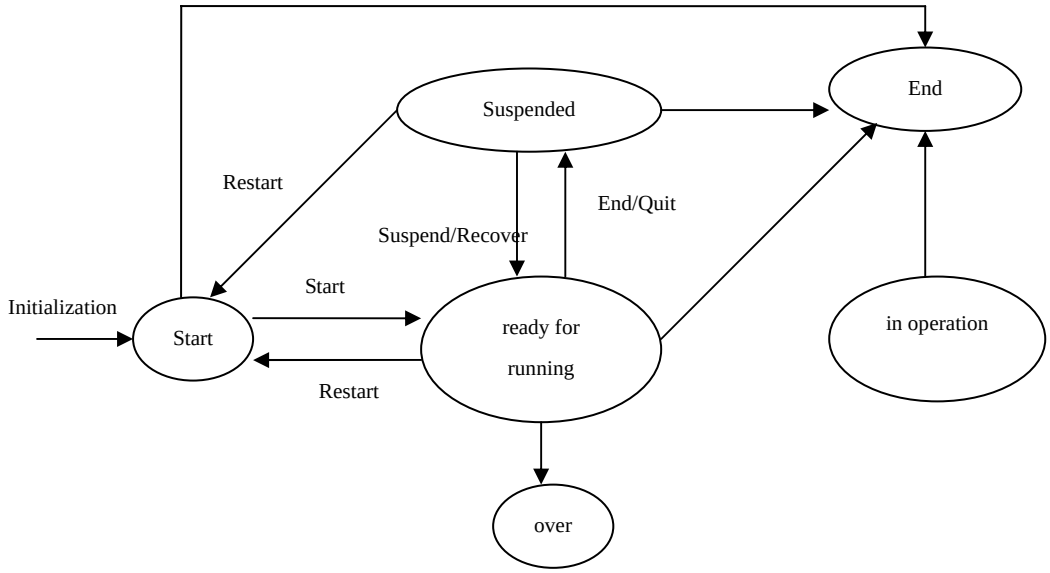

Figure 3. Process instance state transitions diagram

The workflow process includes the start, production planning, planning review, production task conveying and other activities and sub procedures, And the arcs and synchronization nodes are used to describe the logical sequence relationship between activities in the entire process. Meanwhile, the properties of the activities and process itself can be set in this environment, finally importing model data to the database for process simulation[6].

After the model definition, transforming the process model into the simulation model by simulation model generator, then set the corresponding simulation property, such as the simulation reports storage path, reports names, whether to display animation, the number of simulations, simulation time and others, and finally starting the simulation, getting the simulation report. Through the simulation of this example, we can get a lot of reports, such as resource statistics report, process / activity statistics reports and so on. Shown in table 1.

Table 1. Use statements of lathe 1

Simulation Time:2004.4.1—2004.4.15

	se Time/min	Free Time/min	Utilization Rate%
Lathe 1	4438	2762	61

5. CONCLUSIONS

Anomalies can be predicted in the actual production process through the simulation of various process model in the workshop by developed system, and finding out its production bottlenecks, calculating the utilization rate of all kinds of resources. It is of great reference value for workshop decision makers to convey workshop production plan, workshop task management and business process Recombinant (BPR), which is the value of the production process simulation system.

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