Workshop Scheduling Research Based on Workflow Management Technology

Lin Huiping Fan Yushun Wu Cheng
Dept. Of Automation, Tsinghua University, China

Abstract: Scheduling is a problem related tightly to enterprise production efficiency. Due to the complexity of scheduling problem, traditional scheduling methods can't meet the requirements of manufacturing such as generating schedule scheme in time, and response to changes quickly. In this paper, a new workflow-based scheduling method - Workflow Scheduling Management System (WfSMS) is proposed. The integration of workflow management system and rule-based scheduler provides us an effective way to generate correct task sheet according to the states of system and the scheduling object. First, the definition of workflow model for scheduling is proposed. Then follows the discussion of architecture and mechanism of the proposed WfSMS. At last a prototype system is established to test our idea.

Key words: workflow management system, rule-based scheduling, WfSMS

0 Introduction

Scheduling is a problem related tightly to enterprise production efficiency. The severe market competition gives new requirements to scheduling method, that is:

- Practicability: Scheduling method can be used in complex large workshop with acceptable computing time.
- Fle1xibility: The method is flexible enough that it can suit various workshop environments.
- Dynamic: The method can make the system response quickly to the changes such as machine breaking down, job coming, and so on.

During last several decades, researchers have done a lot of work in the field of scheduling and great results were achieved. However, due to the complexity of the problem, traditional scheduling methods can't meet the requirements of manufacturing.

In this paper, we try to use process modeling and management technology in scheduling. A new workflow-based scheduling method - Workflow Scheduling Management System (WfSMS) is proposed. Workflow Management System (WfMS) provides us an efficient way to model, control, and monitor complex production processes[1]. In our method WfMS and schedule policy are integrated in order to achieve practicality, flexibility, and dynamic of scheduling. First, activity-based process modeling method is employed to establish workflow model of workshop. Then the realization of the integrated workflow engine and scheduler is discussed. At last, a prototype is proposed to test our idea.

1 Establishment of Workshop's Workflow Model

In our method, a workflow model is established to describe the constraints of the scheduling problem, such as resource constraints, process constraints, and time constraints. The goal of scheduling is treated as the performance of workflow instance.

The workflow model is composed of three components: Process Model, Resource Model, and Workflow Related Data. The relationship between them is shown in Fig.1.

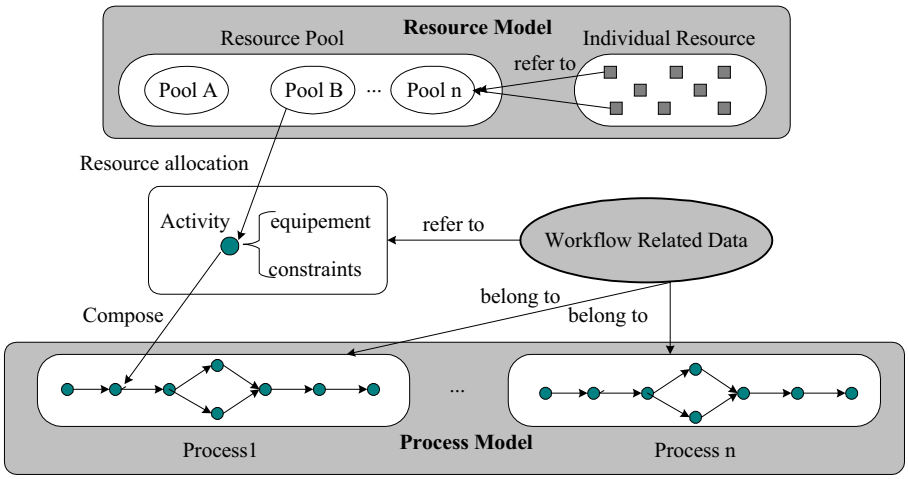


Fig.1 Composition of Workflow Scheduling Model

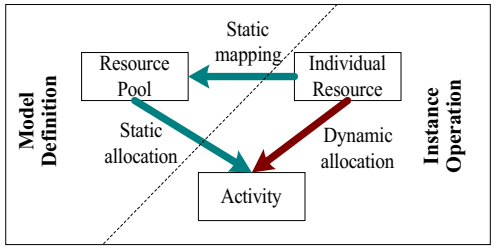
- Process Model

  Process model is made up of one or several processes. A process describes the operations needed for one job, and the relations between operations (such as operation A must be completed before operation B can start. We call this kind of relation process constraints.), while several processes describe operation routes for different jobs. Process model is built by using activity-based modeling method, in which an operation is modeled as an activity. According to the definition of Workflow Management Coalition, there can be several instances of different processes running at the same time. The relation of these instances is the competition for resource.

- Resource Model

  Resource model defines the resource that can be used during manufacturing. Two kinds of resource entities are described in the model: the Individual Resource and Resource Pool. The former refers to the real production equipment, while the latter is in fact a classification of the former according to their functions. Thus the individual resource in the same resource pool has the same function. The mapping among individual resource, resource pool and the activity is shown in Fig.2.

Fig.2 Resource allocation



- Workflow Related Data

  Workflow Related Data describes the state changing condition for process instance. These data can be accessed or modified by the workflow application during the instances operation. Workflow management software should manage the workflow related data between instances.

Then, we will give the formal definition of proposed workflow model.

Workflow model for scheduling

$SM = \{P_1, P_2, ..., P_m, R, F_1, F_2, RD\}$, in which P_1, P_2, ..., P_m, present the process model, R present the resource model, F_1、F_2 define the mapping from resource pool to individual resource and individual resource to activity respectively, and RD refers to workflow related data。

$P_i = \{U_i, A_i\}$ is a directed, acyclic graph, in which the node set

$U_i = \{u_{i1}, u_{i2}, ..., u_{in}\}$ is the operation set for job J_i, $A_i \subseteq U_i \times U_i$ is the set of arcs, which present the relationship between activities. Thus, from A_i we can form control flow of the workflow model. According to WfMC's definition[2], the normal control flow is serial, parallel, AND-split, OR-split, AND-joint, OR-joint, and iterative operation.

$R = \{r_1, r_2, ..., r_\alpha; rp_1, rp_2, ..., rp_\beta\}$ is the set of individual resource and resource pools.

$F_1 \subseteq \{r_1, r_2, ..., r_\alpha\} \times \{rp_1, rp_2, ..., rp_\beta\}$ describes the mapping from the individual resource to resource pool.

$F_2 \subseteq \{rp_1, rp_2, ..., rp_\beta\} \times \{U_1 \cup U_2 \cup ... \cup U_m\}$ describes the mapping from resource pool to activities.

Thus, the scheduling problem is to find proper sequence $f_1' f_2' ... f_\sigma', (f_i' \in F_2 \circ F_1)$, and determine the occurrence time of f_i', which can satisfy the scheduling goal. In fact, two sub-problems are involved: resource allocation and activity sequencing.

Compared to traditional model methods such as disjunctive graph and Petri net, our method has many advantages, as shown in table 1.

From the table we can see that the main advantage of workflow model for scheduling is that it is easy to establish, the scale of the model is acceptable.

2 Architecture of WfSMS

After building the workflow model, workflow engine can execute workflow instances according to the predefined model. Being integrated with scheduler, WfSMS provides an efficient way to realize the real-time dynamic workshop scheduling.

The proposed WfSMS is discussed as follow. Suppose the operation of system is based on message queue. As shown in Fig.3, the system is composed of workflow modeling tool, workflow engine, scheduler, and task list manager.

Workflow modeling tool: establish workflow model for scheduling problem, describing the activities, relation between activities, and the constraints.

Workflow engine: operate the workflow instance by navigating the activity instance one by one. After one activity is initiated, workflow engine reads the relative data from the database and send the information to scheduler. Only when workflow engine gets the feedback information that one activity instance is already executed, the engine can read the model and choose the next activity to execute.

Table1 Compare of three modeling methods

	Workflow model for scheduling	Disjunctive Graph	Petri net Model
Modeling	Based on activity	Based on activity	Based on system states
Scale	Small	Small	Large
Describing Ability	Strong	Weak	Strong
Building	Easy	Easy	Difficult

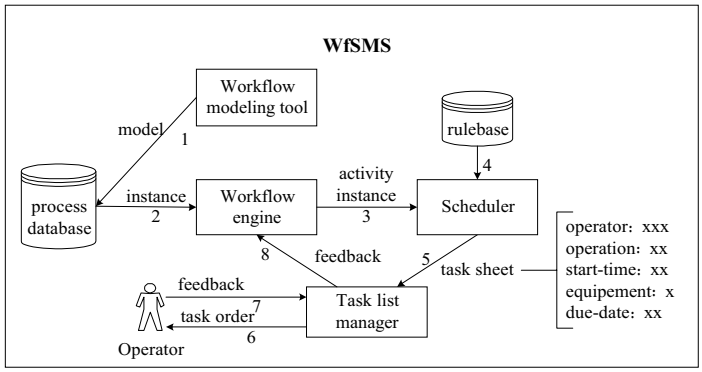


Fig.3 Architecture of WfSMS

Scheduler: It is the most important part of WfSMS. There are two main functions of the scheduler. The first one is resource allocation, that is, establishing the mapping from individual resource to activity according to F_1, F_2, and the real-time state of the system. The other one is activity sequencing, which select the next activity to execute from resource waiting list. The task sheet is generated by scheduler, which includes information about where (which equipment) and when to execute what activity. Rule-based scheduling method is used for the following reasons. First, rule-based scheduling is suitable for real-time dynamic schedule because it has less computing complexity[3]. Second, it is effective enough if the proper rules are chosen. Third, it is easier to built rule-based schedule.

Task list manager: Manage the task sheets generated by scheduler. It will send the task sheet to the right person, receive the feedback information from the user, and transfer it to the workflow engine.

The operation step of WfSMS can be stated as follows.

Step1. Establish workflow model, and store the model to the process database. After the workflow instance is initiated, the instance will be store to instance database.

Step2. Workflow engine reads the process instance from the database.

Step3. Workflow engine determines which activity can be initiated according to the process constraints, then sends the activity instance to scheduler.

Step4. Scheduler chooses the right resource allocation rule and dispatching rule for scheduling.

Step5. According to the rule, task sheet is generated and sent to task list manager.

Step6. Task list manager manages task sheets and transfers them to the right user.

Step7. Operator completes the task according to the task sheet, then sends the feedback information to task list manager.

Step8. After receiving the feedback information, workflow engine will navigate the process instance to the next activity.

From above statements, we can see that when workflow management technology is integrated with scheduler to solve scheduling problem, several good features are achieved.

- High validity. In the system, only after one activity is completed can next activity in the process be initiated and sent to scheduler. Such kind of working style of the workflow engine secure that all the task sheets generated by scheduler are satisfied with process constraints, in another word, are valid.
- High dynamic. The task sheet is created during the process according to the dynamic coming of the jobs. This makes the system act more quickly to the changes than those systems that schedule are made before manufacturing.
- Flexible. The workflow engine is separated from scheduler, which enable us to modify schedule without touch the engine.

Thus we can change our scheduling policy easily.

3 Application

In order to test our idea of using workflow management system in scheduling, we developed a prototype – CIMFlow Workflow Scheduling System. We use CIMFlow modeler to build a workflow model for job 1 and job 2. The process model is shown in Fig5, while the resource model is shown in Fig. 6. The mapping matrix of activity and resource is shown in table 2. We use CIMFlow simulator, which incorporate workflow simulation engine and schedule together to test our idea. Suppose that one job comes both to process 1 and process 2 every one hour, after simulation we can get a list of task sheet shown in table 3. (Only part of the list is shown here) It took less than 2 seconds to get such a result when the system is running on PIII600. Thus we can see that our idea is a scheduling problem. In our further fast and effective way to solve dynamic research,we will try to dynamically select proper rule to enhance the WfSMS's performance.

4 Conclusions

In this paper, a new scheduling method based on workflow management technology – WfSMS is proposed. First, the definition of activity –based workflow model is given. The model is compared to traditional modeling method: disjunctive graph and Petri net to show its advantages. Then, the architecture and mechanism of WfSMS is discussed. At last, a prototype is established to test our idea. The result shows that WfSMS provides an effective way to solve real-time dynamic scheduling problem.

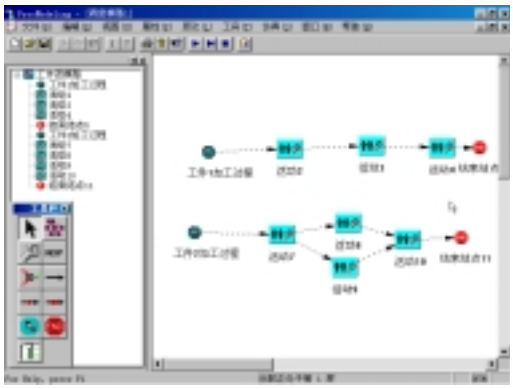


Fig.4 Process model for Job1 and Job2

Fig.5 Examples of Resource model

Table2 Activity-Resource Matrix

	Resource Name
Activity2，8，10	lathe
Activity3，7	milling machine
Activity4，9	FMS cell

Table3 Examples of task sheet list

res_name	res_id	activity	Execcount	start_time	end_time
lathe	A	活动2	1	2001-05-21 07:59:	2001-05-21 10:00:
lathe	A	活动2	3	2001-05-21 10:00:	2001-05-21 12:00:
lathe	A	活动8	1	2001-05-21 12:00:	2001-05-21 13:30:
lathe	B	活动2	2	2001-05-21 08:59:	2001-05-21 10:59:
lathe	B	活动10	1	2001-05-21 11:00:	2001-05-21 12:00:
…	…	…	…	…	…

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