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Resources Scheduling System for Collaborative Design in Ontology and Multi-agents

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Abstract

A core issue of collaborative design is scheduling of design resources. In the collaborative design based on network, design resources often have some traits such as half-structured, distributed, isomerized and so on. Therefore, a kind of resources scheduling system based on the technology of ontology and the technology of multi-agents in collaborative design is proposed in this paper. The ontology models of design resources, and the algorithm of resources scheduling, and the function of each agent in system, and the flow of collaborative work among all agents are elaborated, and the software system of resources scheduling is studied and designed in this paper. The testing results show that the principle and method proposed in this paper are correct, and convenient in operation, and strong in practical application, and have high value in application and popularization.

Key Words: *collaborative design, resource scheduling, multi-agents, tasks assignment*

1. Introduction

The rapid development of economic globalization and information technology gave birth to the collaborative design, let different companies develop the same product together through the network, and accomplish the design task by cross-industry and cross-region cooperation. The design tasks and design resources of the design units and groups are all different, so they have to scientifically allocate various resources to each project, in order to fully utilize the design resources for achieving maximum benefit.

Generally, the resources involved in the mechanical product design are divided into three categories: (1) the data information of standard parts, general parts, components and raw materials; (2) technical documents about design standards, design manuals and design drawings; (3)CAD software and other simulation software. At present, for the problem of the collaborative design resources management, experts and scholars mainly study on the digitize description of resources and data information sharing services of them through the network such as releasing, exchanging, quering, browsing, downloading, analyzing and so on. They set up the models of resources by the technology of XML documents, ontology of artificial intelligence [1], and metadata. Due to the particularity of "the human" the problem of sharing designers online has not been considered [2-10].

As we all know, designers are vital resources. The arrangement of designers is very important for the smoothness of the development of collaborative design tasks and for the quality of accomplishment of design takes.

This paper presents a model of collaborative design resources scheduling system based on multi-agents. The technology of agent is used to pack and model the designers (the first three types of design resources are modeled and described by the technology of ontology, own to the limitation of the length, it is not to be addressed here) and then scheduling of remote design resources is achieved on the network through the cooperation of multiple agents [11-12].

2. Design on the Model of Multi-Agents System

Due to that various types of design resources belonging to different design units have a feature of distributed, we use the technology of multi-agents to model the design resources scheduling system, shown in Figure 1.

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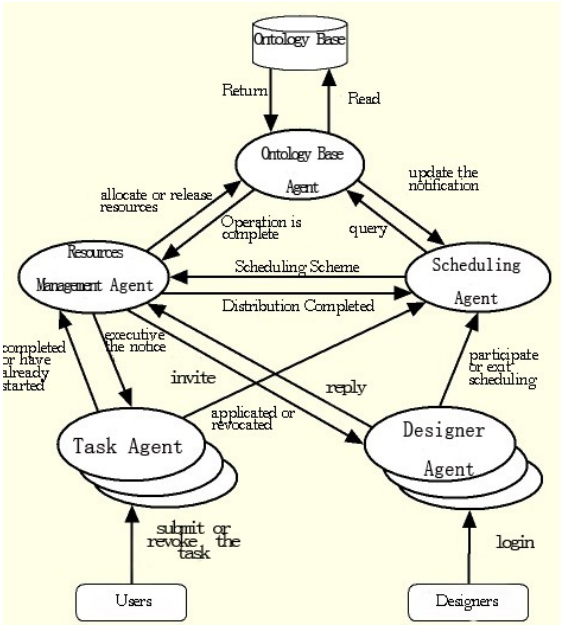

Figure 1. Multi-agent system & flow of scheduling

There are five kinds of Agents [8] in the Multi-agents Scheduling System, the functions of each Agent are listed as follows:

(1) Task Agent (TA, an agent for packing a task). A task corresponds to a Task Agent. When an user propose a task application, the TA of the task will be automatically created, and after the task has been finished or canceled by the user, the TA will be automatically revoked, and then the Service Agent is notified to release resources of the task. The TA will record the task's serial number, construction period, types and quantities of resources needing for it, the maximum waiting time, the current state (waiting or execution) and other basic information. Users can query relative information of the TA. When the users submit an application to modify the task, such as prolonging the construction period, appending resources, and etc., the TA will automatically update its basic information. When the task in a waiting state, TA will apply to the SA for resources; After the RMA has allocated the resources to the task and informed the task to execute, TA will notify the SA to withdraw the resource application and change the current state to a working state and notify the RMA that the task has been started.

(2) Designer Agent (DA, an agent for packing a designer). One designer corresponds to a Designer Agent. When a designer loges on the collaborative design network, the DA will be automatically created, and after the designer has left the network, the DA will be automatically revoked. DA records the designer's basic information, such as number, major, ability, experience, current state (idle or busy), task involved, and etc. When the current state of a designer is idle, DA will send a message to the SA for asking to participate in scheduling. If the designer is arranged to participate in a task by the RMA, the DA will respond to the RMA and notify the SA to exit out of scheduling.

(3) Resources Management Agent (RMA) is responsible for the allocation and recycling of resources. After the scheduling scheme has been generated by SA, it will be sent to RMA. Then RMA will notify the TA which has got resources to start the task. The negotiation with the designer is to determine the designers which will be involved in the task and notify the involved DAs. When a designer begin working, OBA will be notified the assigned resources for the designer. SA will be notified that it can start the next scheduling as soon as the deployment of resources for the task has been completed. When a task has been completed or cancelled, RMA will notify OBA to release the resources occupied by the task.

(4) Ontology Base Agent (OBA) is responsible for the querying and maintaining the ontology data. When those users modify resources or that RMA notifies to release the occupied resources, the OBA will update the data of the ontology database, and notify the SA. In

addition, it provides ontology data query service for users and other Agents.

(5) Scheduling Agent (SA) is responsible for generating the scheduling scheme. After receiving the application or the notification from TA or DA, it will establish a local data to record the information of waiting tasks and idle designers, and to updated them in time. Whenever that the local data updates or that the notification for OBA update is received, the scheduling algorithm packed in agent will be immediately called to calculate and generate scheduling scheme and then to inform the RMA. SA can accept new application of scheduling after receiving the notification from RMA that the deployment is finished.

3. Assignments of Tasks to Designer Agents

After the generation of a scheduling scheme by SA, the RMA will allocate design software and other resources to the allowed tasks, but what's more important is to arrange designers for the task. Consultation mode is used to assign task to DA, negotiation is realized according to contract net strategy. A task is release by private invitation. Specific consultation steps are listed as follows:

(1) RMA received messages from the SA, including scheduling scheme, information of idle designers and allowed tasks' information. At first, the RMA evaluates allowed tasks and then selects the first priority to allocate the various resources and designers.

(2) Select suitable designers from the idle designers according to the specific demands of tasks, and then make a candidate list, evaluate and sort the designers in the list. The decision-making formula for comprehensive evaluation is as follows:

$$v_i = \sum_{j=1}^{3} w_j x_{ij} \quad (1)$$

Where, v_i is the value of comprehensive evaluation for the ith candidate designers, x_{ij} is the value of the jth attribute for the ith candidate designer, w_j is the weight of the jth attribute. There are three kinds of attributes here: work experience, ability level and responsibility. The three kinds of attributes are described with fuzzy language values. Let its scale as S = {excellent, good, middle, poor, especially poor}, and can be expressed as the number of the corresponding interval: excellent = [0.8, 1]; good = [0.6, 0.8]; middle= [0.4, 0.6]; poor = [0.2, 0.4]; especially poor = [0.0, 0.2]. And then compare the size of the interval number by the possibility degree formula [13] to sort v_i.

(3) After completion of sorting, send invitations to the optimal designers in the list.

(4) After DA has received the invitation, designers can decide whether to accept it according to their preferences and situations.

(5) If the designer accepts the invitation, he will be assigned to the current task. The designer will be removed from de list if he declines the invitation.

(6) Repeat steps (3) - (5) till the needs of the designers assigned to the current task are met.

(7) Repeat step (2) to make the list of candidate designers for the next task, and then repeat steps (3)-(6).

(8) Consultation will end when all tasks have been assigned enough designers, otherwise steps (7) - (8) will be repeated.

4. Multi-Agents Scheduling Process

Shown in Figure 1, the process of multi-agents scheduling system is listed as follows:

(1) Initializing the system, creating RMA, SA, and OBA, establishing DA for logged designer, and putting initial data into the ontology base.

(2) A user submits task application, then relative TA is established, and its current state is waiting. The TA applies resources from SA while idle DAs are registering to SA for their participation in the scheduling.

(3) SA records locally the information of tasks applying for resources and that of idle designers, and inquires about other resources information from OBA, then calculate by the local

scheduling algorithm and send the scheduling scheme and its related information to the RMA.

(4) RMA notifies each TA which has got resources. The TA changes its current state to state of execution, and replies to RMA, and revokes the application of resources to SA. The current state of each TA involved in the task after negotiation is changed to state of working, and is given the number of the task, and its application of resources to SA is exited. At last, RMA will notify OBA to change the attribute numbers of resources allocated to its task number. After such operation, OBA writes back to RMA. After receiving the replies from TAs, DAs and OBA, RMA returns s message to SA for the permission of the next schedule.

(5) SA will update the information of waiting tasks and that of idle designers in local record, as soon as it receives the revocation of the application of resources from TA and the announcement of schedule exit from DA. SA will wait for the next schedule after receiving the reply from RMA.

(6) TA will update the information if its task change in its execution process. If it needs additional resources, TA will change to the state of waiting, and apply resources from SA.

(7) After receiving the application of additional resources, SA will update local information and schedule again, and then send the results of schedule to RMA. If there are extra resources to allocate to that task, steps (4) and (5) will be repeated. If additional resources can not be applied in a short time, RMA will notify OBA and DA to release resources and designers.

(8) When the task finished or canceled by user, TA will notify SA to cancel the task and update its local information, and then notify RMA to release the resources of the task, and finally the task is automatically revoked.

5. Design and Implementation of Co-Design Resources Scheduling System

In the presentation layer, technologies such as JSP and Servlet are used to provide presentation interface of data input and output for users and designers. In the business logic layer, technologies such as Java Bean and JADE 4.0 are used to build a multi-agents system on the JADE platform for solving scheduling problems. The JADE platform system has three JADE containers. SA, RMA an OBA are deployed in the main container. Container 1 is used to accommodate TA. Container 2 is used to accommodate DA. When the system initializes, the main container is started and creates SA, RMA, and OBA, then Container 1 and Container 2 are started. When the user submits a task, a new TA is created and deployed in Container 1, and is deleted after its termination or revocation. When a designer login in, a new DA is created and deployed in Container 2, and is deleted after the designer is offline. Java Bean is mainly responsible for the interaction with AMS in JADE in order to manage and maintain multi-agents system. Meanwhile it provides the interface for users and designers accessing to multi-agents. Enterprise information layer mainly uses Jena2.6 framework. The ontology model is stored into the relational database through Jena API. Jena also provides query interface of ontology data for users and multi-agents systems. The system framework is shown in Figure 2.

5.1. Design on System Function Modules

Collaborative design resources scheduling system has such functional modules as user login and registration, designer login and registration, administrator login, user management, resources management, task management and task scheduling. Among them, user management module includes user query, resources management module includes three sub-modules those are resource registration and resource query and resource modification, task management module includes three sub-modules those are task application and task query and task modification, designer management module includes two sub-modules those are designer validation and designer query. The system module structure is shown in Figure 3.

5.2. Show of System Modules

Users can apply, query or modify the task in task management module after their login, shown in Figure 4, where the user is applying for a task called w1. Then users can register, query or modify in resources management module, shown in Figure 5, where the user is registering design software Pro/E.

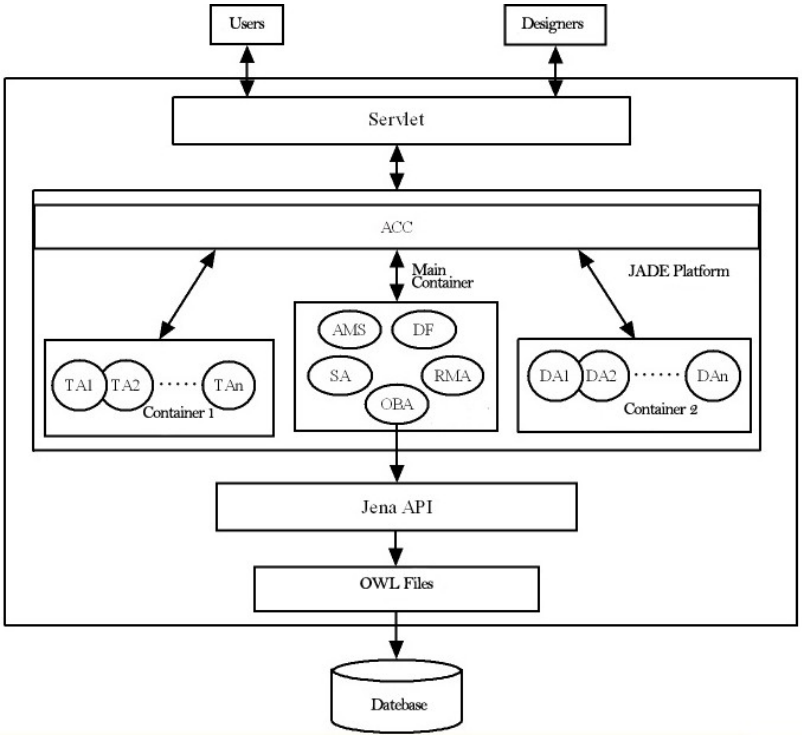

Figure 2. Frame of resources scheduling system

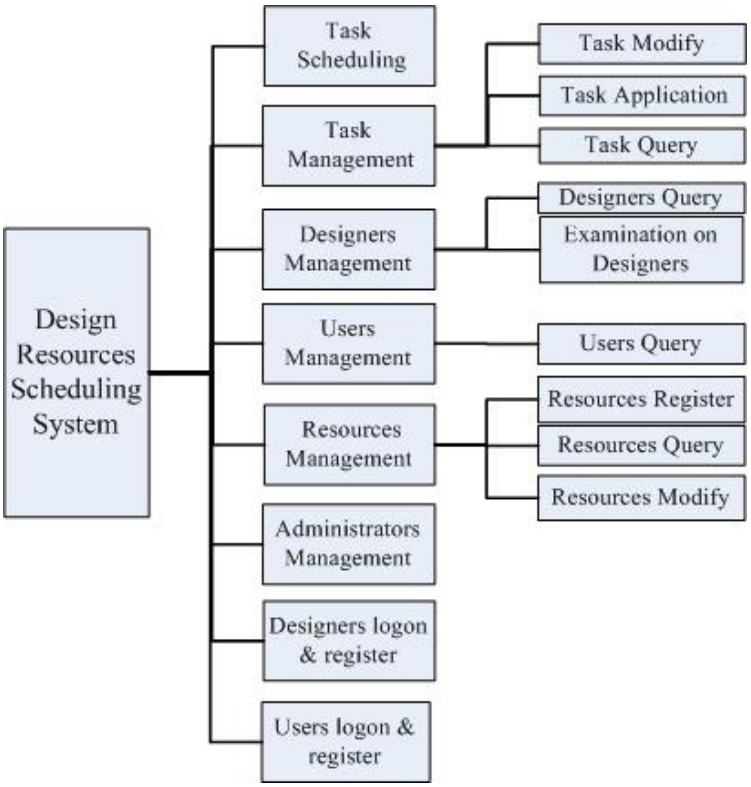

Figure 3. Blocks of system function

Figure 4. Application of tasks

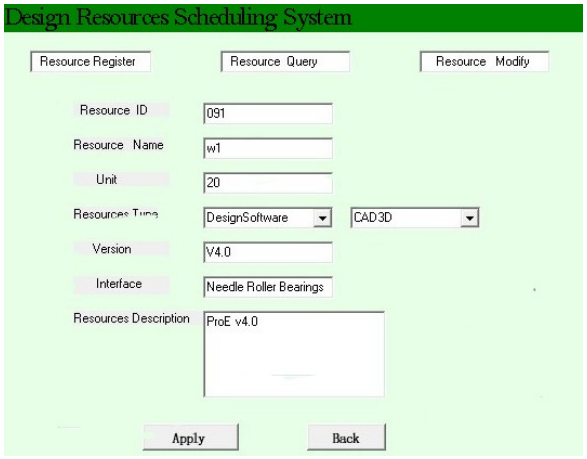

Figure 5. Registration of resources

After registration, you can inquire about that resource shown in Figure 6. The design software Pro/E just registered can be inquired about by its name, and the results are that two different versions of Pro/E are found shown in Figure 7.

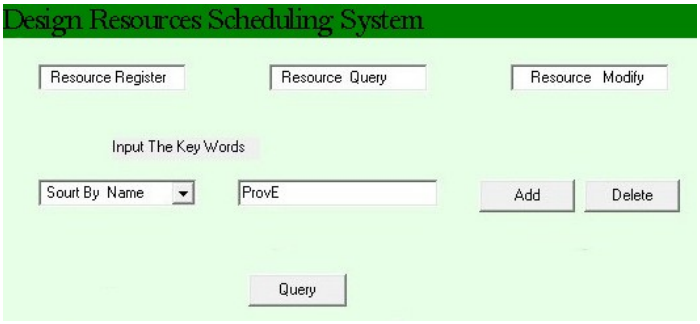

Figure 6. Querying of resources

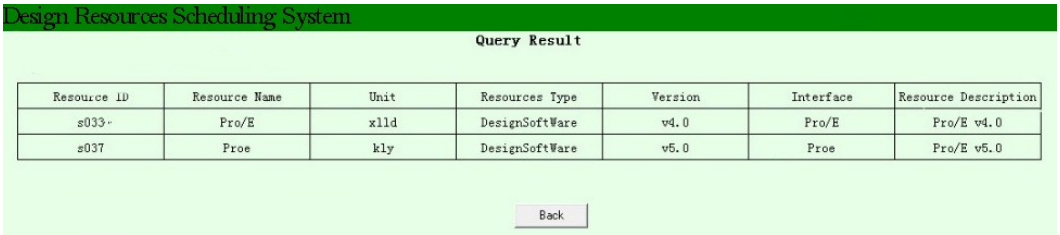

Figure 7. Results of querying of resources

After login in the system, administrator can schedule and validate the designer's qualification. Designer's three attributes which are experience, ability and responsibility are set by the designer's personal information. These three attributes will be used to evaluate the designer in the consultation between RMA and DA. As shown in Figure 8, after a designer called zya has registered, his experience, ability and responsibility are set as good by administrator. The appropriate data is input in the system, and then schedule is started, its results are shown in Figure 9.

Figure 8. Examination on designers

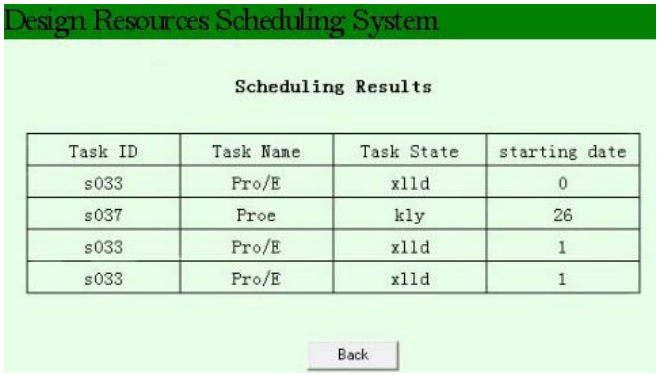

Figure 9. Results of scheduling

6. Conclusions

This paper offers a model of resources scheduling system based on multi-agents in order to solve the scheduling problems of distributed resources in the process of networked collaborative design, and sets up the agent models of collaborative design resources and that of collaborative design scheduling process, and designs the negotiation algorithm for assignment of tasks to designers, and then uses JADE framework to design this multi-agents system for resources scheduling, thus the software system of collaborative design resources scheduling is accomplished.

The results when the system is running testify its operability and utility. This method also has a good reference value in developing similar resource scheduling management systems.

Acknowledgements

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