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Abstract

The increasing intense of the economic constraints forces the manufacturers to share their resources with other organizations [1]. But the management of the available periods of shared resources causes a problem because it is mostly realized in a centralized way [2]. Therefore, distributed scheduling with shared resources is nowadays an important research topic. In this paper, we present a multi-agent model named SCEP (Supervisor, Customer, Environment and Producer). We also introduce the detailed architecture and behavior of the SCEP model in the context of multi-site and shared resources situation. The SCEP application proposed here, aims at improving the scheduling of shared resources in a hospital framework.

1. Introduction

Scheduling is the process of deciding how to assign resources between varieties of possible tasks. It determines the most appropriate moment to execute each operation, taking into account the temporal relationships between acting processes and the capacity limitations of the shared resources [3]. Especially in large and complex systems, the limited resource needs to be shared by several users with customized requirements, during different or overlapped periods.

There are three key points for this problem. First is how to identify the shared resources in distributed scheduling. Each organization wants to plan its own activities with higher priority than others. These actions will lead to the mutual disturbances of shared resources scheduling between each local schedule. Secondly, it is necessary to take into account the interoperability problems. Third one is how to identify the skills of system operators and then integrate them into distributed scheduling.

In this communication, we focus on the first problems of complex system, like hospital, manufacturing factories, etc who adopt distributed scheduling approach to share resource. We use the improved SCEP model to deal with the conflict during the scheduling process for the shared resources.

2. State of art

In decades, the scheduling problem has been widely studied in the literature by various methods.

Shen [4], combines genetic search algorithms based search and agent-based negotiation for the manufacturing scheduling. Since agent-based approaches emphasize on flexibility and responsiveness and genetic algorithms pursue the optimality of solutions, the combination provides a promising way to enhance the performance of manufacturing scheduling systems.

Fuzzy logic [5] allows the modeling of imprecise scheduling knowledge with linguistic variables defined by membership functions showing the degree of preciseness of the data and the reasoning about the imprecise data by using fuzzy rules.

The traditional scheduling methods, as previous mentioned whether analytical, heuristic, or meta-heuristic (including GAs, Tabu search, simulated annealing, artificial neural networks, fuzzy logics), encounter great difficulties when they are applied to real-world situations, as well as simulated annealing, artificial neural networks [3]. This is because they use simplified theoretical models and are essentially concentrated on the sense that all computations are carried out in a central computing unit. However, in complex systems, the facts are always more complicated.

Modern techniques are more effective. The intelligent agent technologies suggest an innovative and lightweight approach on scheduling problem which could support multiple computing units. The distributed approach is more flexible, efficient, and adaptable to real-world dynamic manufacturing environments [6]. The advent and development of network technology and distributed computing provide enabling technology for manufacturing directly at different resource, such as geographically located factories and facilities [7, 8].

Therefore, we believe that using the modern technologies or methods could better identify and solve distributed scheduling problems for shared resources in complex system. In next section, we will introduce a proposed multi-agent model named SCEP.

3. SCEP multi-agent model

3.1. Model description

The SCEP multi-agent model (Figure 1) is a distributed model, which establishes an indirect cooperation between customer agents called C and producer agents called P. This cooperation is performed synchronically through the background environment agent E and is controlled by the supervisor agent S [9]. The detail working procedures and dynamic of the model are introduced in the next part.

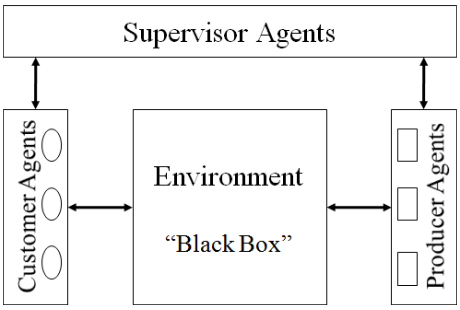

Figure 1. SCEP model

3.2. Dynamic of the model

First of all, the supervisor agent creates the agents society and invites them to generate the inside objects and to initialize the environment. Each object in the environment is associated with an operation which must be achieved to accomplish the project managed by a customer agent [9]. We use four parameters EP (effective position), PP (potential position), WP (wished position) and CP (confirmed position) to identify the temporal and spatial situations of each object.

After the environment initialization, the supervisor agent begins the cooperation process by activating the customer agents and inviting the producer agents to wait. The customer agents require the EP and PP of their associated objects from the environment. The environment send the results back, of course the result is null in the first cycle. Then, the customer agents achieve a CP by taking into account the WP of each object and its perceived propositions (EP and PP). The customer agents also schedule the operations which have not been validated and influence them with the new WP. At the end, the customer agents send the CP and WP of the associated objects to the environment. Each customer agent performs its actions simultaneously which are independent from the behavior of others. It informs the supervisor once its actions are finished.

Once the end of the action from the last customer agent has been recorded by the environment, the supervisor agent activates the producer agents and sends the wait signal to the customer agents. The producer agents firstly ask for the CP and new WP of the objects belonging to its intervention domain from the environment. The environment sends the results back, and then the producer agents record the final positions for all tasks associated with CP. For the other tasks, producer agents schedule and influence them by alternative EP and PP. Each producer agent performs its actions independently and informs the supervisor as soon as finish. When the end of the action from the last producer agent is recorded, the supervisor finishes the first cycle and start the next immediately. In each cycle, the final position of at least one object is found. You can find the whole scheduling process in the Figure 2.

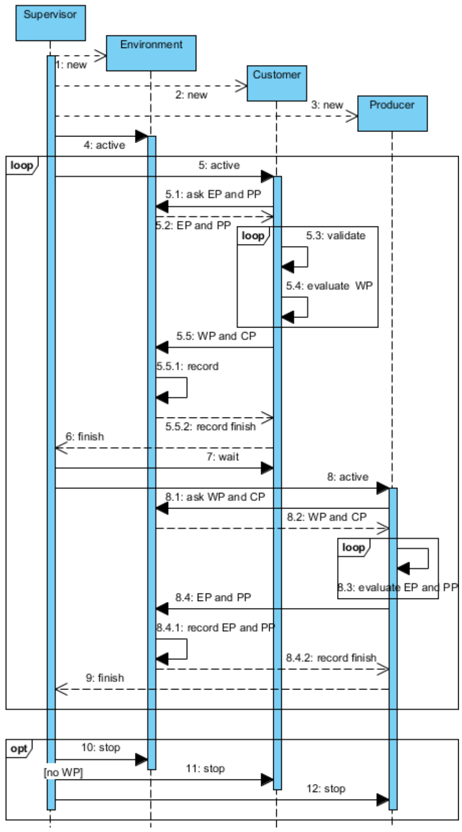

Figure 2. Sequence diagram of SCEP model

The cycle alternation between the activation of the customer agents and the producer agents is repeated until the final position of all the objects is validated. Once there is no WP from the customer agents anymore, the “opt” area will be executed and the supervisor will terminate all the agent society. The whole scheduling process will be finished.

4. Improved SCEP model for multi-site & shared resources

4.1. Multi-site solution

Figure 3 shows a particular network of the SCEP models organized to elaborate plans in a distributed manufacturing domain. This improved network allows establish multi-site plans by cooperate between one client SCEP client and multiple SCEP servers and supplies a support for distributed scheduling.

To establish CORBA connections [10] between various SCEP models, we import a communication module and new concept of ambassador agents. The particularity of the ambassador agent is to get across the boundary of the SCEP models and establish a communication bridge. The number of ambassador agents in SCEP client is equals to the number of the SCEP servers. The ambassador agent in SCEP clients gets information from SCEP client environment about the demands (WP), communicates with associated SCEP server communication module. As soon as the SCEP servers finished their actions, the associated ambassador agents inform the SCEP client that actions are achieved.

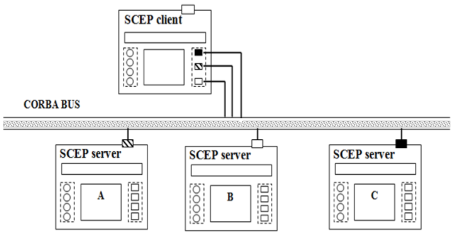

Figure 3. Multi-site SCEP model cooperation

This networked model of SCEP allows the sharing of resources distributed geographically between projects managed by a unique site. The mechanisms must be generalized to allow the sharing of resources between projects managed in multiple sites. [11]

4.2. Shared resources solution

After take into account the shared resources, the proposed solution requires the use of a special register that is only responsible for maintaining all the shared resources activities definitions in multi-site organization. Each server SCEP model which has shared resources must publish all activities descriptions that the shared resources can achieved into the register.

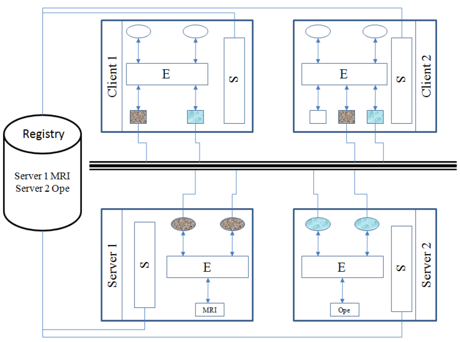

Figure 4. Shared resources SCEP model

If the client SCEP model wants to use a remote activity proposed by shared resource, it must contact the register to obtain the address of all server SCEP models which provides these activities. Then, the client SCEP models contact directly with all these server SCEP models to establish bi-directional communication channels. The supervisor agent, which is in contacted server SCEP models, creates ambassador customer agent for each shared resource providing required activity. Then, the supervisor agent, in client SCEP models, creates ambassador producer agent associated to each ambassador customer agent in server SCEP model side. The ambassador agents are responsible for sending and receiving information to/from the CORBA bus. The whole architecture is shown in the Figure 4. The interior mechanism of each SCEP model has already described in section 3.2. The synchronization of different SCEP models in scheduling process is achieved through a master supervisor agent who is not specified in this paper.

5. Application on improved SCEP model

5.1. Case study description

In this case study, we have three departments (A, B and C) in a hospital who can achieve several activities like medical diagnosing, magnetic resonance imaging (MRI), surgical operating, etc. Since the MRI machine located in department C is very expensive, department A and B share it as a shared resource.

In order to keep this case simple and understandable, we assume that no transport time for patients between different departments. For the resources, no set-up time is considered. Once an operation has started on a resource, it will finish on the same one. The disturbances frequency of resources is low during the operation processing, and there is no closure time for the resources. The resource only has three possible statues: available, in processing, or in failure after a disturbance.

5.2. Illustrative example

All the detail of resources in these three departments can be found in Table 1. Each resource can achieve several activities with different capabilities and costs.

Table 1. Resources in all Departments

Resource	Rule	Activity	Color	Capability	Cost
A1	FIFO	Medical diagnosis	red	1	1
		Establish a prescription	green	1	1
A2	FIFO	Medical diagnosis	red	1	1.5
		Surgical operation	blue	1	1
B1	FIFO	Medical diagnosis	red	1	1
		Establish a prescription	green	1	1
B2	FIFO	Medical diagnosis	red	1	1.5
		Surgical operation	blue	1.5	1
C	FIFO	MRI	purple	1	1

Table 2. Care Orders in all departments

CO	Objective	Quantity	Order date	Due date	Routing
COA1	Delay	1	0	7	1
COA2	Delay	1	1	9	2
COA3	Delay	1	2	10	3
COB1	Delay	1	0	7	1
COB2	Delay	1	1	10	2
COB3	Delay	1	2	12	4

In each department there are three requirements from the patients, we call them Care Orders (COs). The detail characteristics of all COs are given in Table 2. Because of the specialization in medical organization we suppose that all COs are required to satisfy their due date firstly.

We also suppose that the dispatching rule used for management is FIFO (first in first out).

COs follows the linear routing defined in Table 3. The operating times are defined for the most capable resources.

Table 3. Routing

Routing	Operation	Activity	Operation time
1	1	Medical diagnosis	3
	2	Establish a prescription	2
2	1	Medical diagnosis	2
	2	MRI	3
3	1	Medical diagnosis	2
	2	Surgical operation	2
4	1	Establish a prescription	2
	2	Surgical operation	2

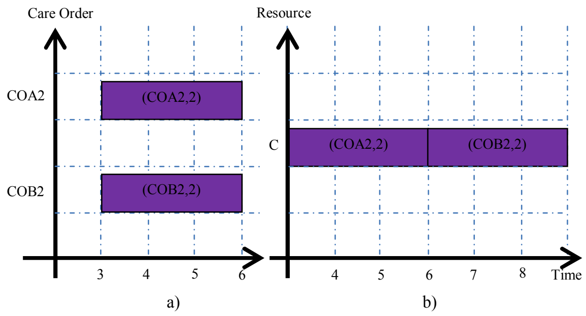

Figure 5. Scheduling for resource C

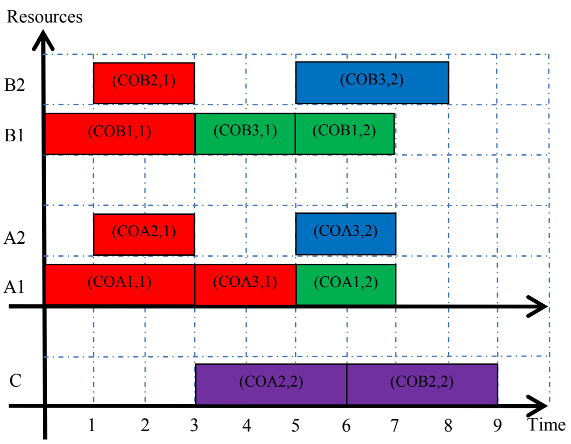

Figure 6. Result in all departments

This case study requires negotiation between SCEP model A and SCEP model B for the shared resource. The ambassador producer agents AMRI and BMRI send the wished position of object COA2.2 "([3, 6], 0)" and COB2.2 "([3, 6], 0)" to the ambassador customer agent MRIA and MRIB. The producer agent MRI finds a conflict here. Base on the FIFO rule it prioritizes these two objects and sends the effective position back: COA2.2 ([3, 6], C) to agent AMRI and COB2.2 ([6, 9], C) to agent BMRI. The detail scheduling process is shown in the Figure 5.

After all the scheduling process is finished, we can see the Gantt result in the Figure 6.

6. Conclusion & Perspectives

We introduce an improved SCEP model in this paper, aiming at solving problems of distributed scheduling on shared resources in complex system. We adopt a simple example in a hospital to illustrate how the improved SCEP help multiple users to schedule their local resource and also support sharing resource.

Indeed, there are some hypotheses in our illustration, such as disturbance of resources is set to low, routing rule of resource are only limited on FIFO. In the future we will continue discuss the scheduling behavior of the improved SCEP model under uncertainties. We will take into account the disturbance at different levels. The further work may help to model more actual situations and lead to an automatic implementation of the improved SCEP model.

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