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Study on Agent Collaborative Work Model of Aircraft Spares Support Based on CSCW Environment

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Abstract: The aircraft spares support activities involve several support units which are located in different places. For this reason, it is necessary to establish an information network of spares support to coordinate the activity of each support unit. This study focuses its research on creating an Agent collaborative work model of aircraft spares support based on CSCW environment to raise support level and reduce its costs. The author approaches and solves the problem first by designing three-level B/S structure mode for Agent after analyzing the design requirements of it based on CSCW environment and then by exploring the communication mode and collaborative work mechanism between Agent units and probing into the processes of cooperative work group, work flow and formation of support scheme. On the basis of the Agent collaborative work model, the author advances one collaborative control mathematical model under restriction of support level as well and conducts simulating test for the two models by relevant simulation software. The test result is that after collaborative work the support level rises from 93.87 to 97.01% and the total cost per unit time for support costs ($\bar{C}$) falls from 903 ¥RMB to 877 ¥RMB. Thus, the optimization of Agent parameters for aircraft spares comes true and relevance of total support cost and support level is determined.

Key words: Aircraft spares, CSCW, three-level B/S structure, agent

INTRODUCTION

The aircraft spares support involves multiple support action units and multiple rational allocations and cooperative work at different geographical positions and is required to construct a spares support information network environment to coordinate various support units.

CSCW (Computer Support Cooperative Work) environment is a distributed computing environment that can handle multi-media communication, cooperation between users and coordination between various collaborative applications. Agent is a self-operation entity in certain circumstances and possesses some cognition and reaction. Agent's intelligence is revealed on the one hand in its active information extraction from the outside and on the other hand in the reasonable digestion of the passively received information within Agent.

By utilizing CSCW and Agent, the collaborative-support work environment is built up to realize the collaboration and information share among various support units under coordination of the control centre. Experts can undertake remote visualized instruction for the site failures and accomplish remote dispatch and management for the spares. Every support unit, through haring sound, video, graph and picture, overcomes space limits and ensures data information; and it can quickly take action and greatly improve the informatization of aircraft spares.

The aim of this research is to create an Agent collaborative work model of aircraft spares support based on CSCW environment so that the optimization of Agent parameters for aircraft spares will be accomplished and accordingly the support level will be improved and costs will be reduced.

ANALYSIS OF DESIGN REQUIREMENTS OF AGENT UNIT

The design target of CSCW environment is to make every support unit realize the distributed-synchronous collaborative work in the information network of aircraft spares support. Therefore, the support unit Agent should meet the following design requirements:

- The support information can be exchanged and shared in real time; and the technological status, resource allocation and technology support information can be transmitted quickly between different Agents and technological departments
- There is an open integrated platform consisting of basic operation system, application software and

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hardware because the support group having control centre as its core is a dynamic and multivariable support information system (Li, 2004)

- It has a distributed system structure. Because of the territorial distribution of support action and the heterogeneity of support information system, the Agent unit of CSCW environment is employed to handle the support information rapidly and effectively
- The system should be safe. It adopts three-level B/S structure and function server so that the users' computers are not directly connected with the database and the users cannot directly obtain access to the database (Li, 2004). So the illegal access is prevented and the important information of every Agent is protected. In addition, its maintenance and economy, expandability and reliability should be considered

THE AGENT STRUCTURE OF CSCW ENVIRONMENT FOR AIRCRAFT SPARES SUPPORT

Three-level B/S structure mode: The B/S (Browser/Server) mode is supported by TCP/IP, with HTTP as its transmission protocol. The client terminal visits Web server and database by means of Browser. B/S mode comprises browser, web server, application server and database server; and it breaks the limit of conventional document share and C/S (Client/Server) mode and attains a larger documents share. Its working principle is that the client-level browser sends out a request to the application-level server through HTTP and the web server requests data server through application server and returns processed result to the client in the form of HTML (Van Houten and Kimura, 2000). The construction of three-level B/S structure illustrated in Fig. 1 has three features:

- Unified interface and easy operation
- Easy maintenance and expansion
- Good safety. Since it uses intermediate request agency ORB, the client cannot directly visit or modify the database (Carzaniga *et al*., 2001)

Considering the reality of support action, its CSCW environment system is constructed as that in Fig. 2.

According to the three-level B/S structure, the construction of CSCW environment Agent of aircraft support is required to sufficiently combine the features of

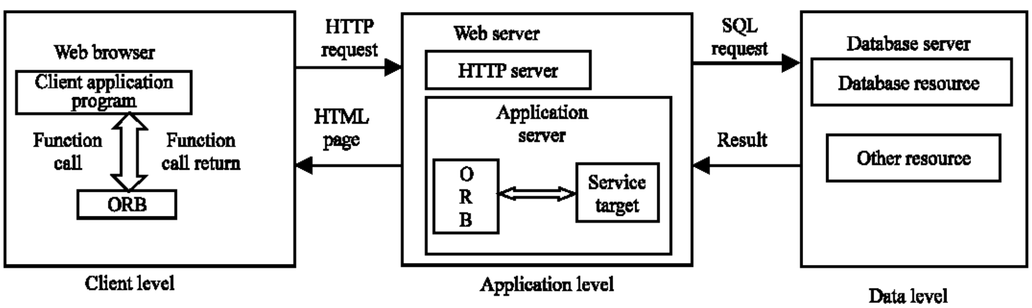

Fig. 1: Construction of three-level B/S structure

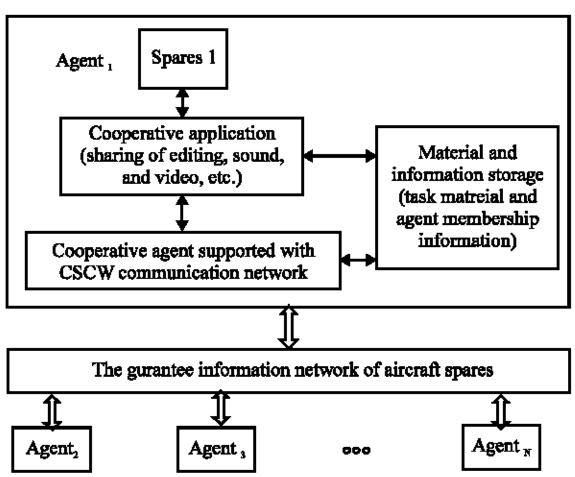

Fig. 2: CSCW environment system

support centre Agent and the other Agents. The collaborative technology support between support centre Agent and spares Agents faces the entire process and meets the requirements of aircraft support. The unified standards and strategic planning should be made; and the information and resources of various Agents can be shared and spares support information can be transmitted promptly, effectively and accurately (Martins *et al*., 2002).

Agent structure of CSCW environment: According to the three-level B/S structure in Fig. 1, the Agent structure of CSCW environment is built up. This system adopts three-level B/S structure mode (Fig. 3): Access level: The Agents at different locations and the support centre Agent can get access to the system via Web Browser whenever and wherever possible; Application level: The object-oriented distributed technology, web service and EJB (Enterprise Java Bean) business management are adopted or used to realize the integrated interface between various Agents and support centre Agent (Zhao and Xiao, 2004); Support level: The software and hardware environment for operation of the support

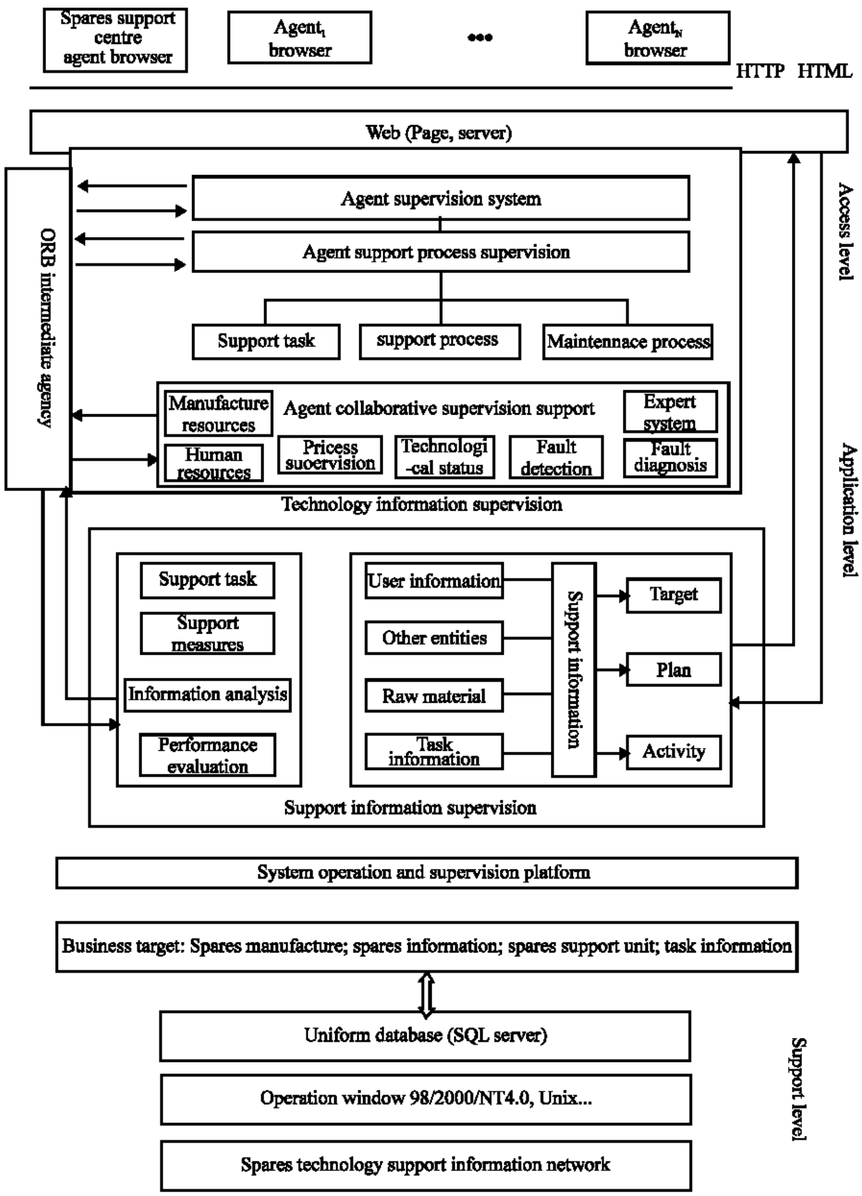

Fig. 3: Agent structure of CSCW environment

system is provided, for example, hardware environment of computer and network, software environment of operation system and unified database.

Communication mode of Agent unit in CSCW environment: From Fig. 3, it can be learnt that the support system is composed of information detections of technology and support. The technology detection receives information of support activities and formulates action plan, technology reserve of support detection and Agent's maintenance scheme according to support objectives and requirements. The Agent detection will detect the manufacture and manpower resources of each Agent and detect the technological status of aircraft spares. When the system to which Agent belongs has fault, the intelligence diagnosis system will be used to make urgent repair for it and restore its technological status. The fault, which cannot be immediately repaired, should be fed back to the support centre in order that the support centre Agent can adjust support action plan at once. The information is private to the Agent system and is stored in the databases and knowledge bases of various Agents. The support information detection is mainly utilized for the exchange of external support information. It collects information of utilization, aircraft, planning, project objective and support plan. Moreover, every Agent sends out information of project objective and support plan so that the system adjusts Agent's technological status according to support information. The information is shared and stored in the Agent database and knowledge base of the support centre. By the intermediate agency, this system can protect the technology information and allow the authorized access. The intermediate agency can help realize the access to the technological information in the case of cross-platform and heterogeneity.

Characteristics of the system structure: The system adopts three-level structure of B/S mode, which is illustrated in Fig. 3. It consists of access level

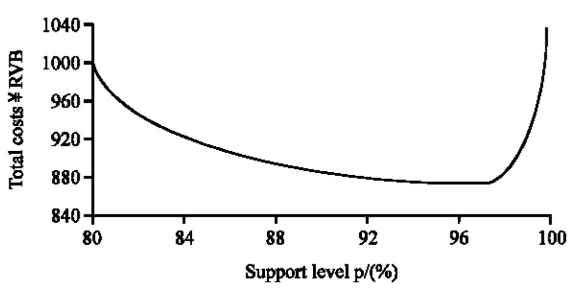

Fig. 4: Relation tendency of support level and total cost

(client level), application level and support level (data level). The access level system users, including detection centre and Agents, can be developed through web-type system. The support level offers detecting technology and gets access to the system via browser. The application level, by means of object-oriented distributed technology, Java ORB technology and web service, achieves system operation for the heterogeneous distribution system and the unified database and ensures completeness and consistency of the technological data's exchange (Lee *et al*., 2001). This structure owns characteristics as below:

- It has the descriptive function of stratification-gradation technology information. The treatment and description for detection centre and Agents include information of technology and support. The overall arrangement and reasonable planning can be ensured
- It has the feature of objective-oriented distributed management. After the detection centre determines the support objective in accordance with the requirement of support technology, every Agent and support centre Agent make up concrete support measures
- The system has dynamic Agent detecting and coordinating capability. The support centre Agent can promptly adjust each Agent's technological support actions in light of each Agent's technological status
- It has the capability of exchanging and sharing data under heterogeneous condition. Thanks to the intermediate agency (ORB), the data's exchange and share between different systems of operation, database management and management information are improved

Construction of collaborative control mathematical model for aircraft spares: Optimization mathematical model of collaborative control Agent for aircraft spares is as below:

$$\min \bar{C} = \bar{C}_I + \bar{C}_T + \bar{C}_e = (Q-\alpha)\sum_{DL'=s'}^{N}\{[(\sum_{i=1}^{N} D_i)L' - s']$$

$$f(DL')\} + \alpha\sum_{i=1}^{N}[\sum_{D_iL_i=s_i}^{N}(D_iL_i - s_i)f(D_iL_i)] +$$

$$\sum_{i=1}^{N}\{A_i\frac{\bar{D}_i}{S_i - s_i} + r_i(\frac{S_i + s_i}{2} - \bar{D}_iL_i) + [\frac{\bar{D}_i}{W} + \delta(\frac{\bar{D}_i}{W})]C_{0i}\}$$

$$\text{s.t.}\begin{cases}\sum_{i=1}^{N}\bar{D}_i = \bar{D}, S_i \le S_{i,e} \\ p_i \ge p, \bar{D}_i \ge 0, s_i \ge 0 \text{ and to be integer}\end{cases}$$

where, in equation, $(\bar{C})$ stands for average total cost per unit time; $(\bar{C}_I)$ for cost of inventory Agent; $(\bar{C}_T)$ for transport cost of Agent; $(\bar{C}_s)$ for scheduling cost of Agent; Q for loss fees of shortage. And α stands for scheduling cost of aircraft spares maintenance per unit during supply inventory Agent; D for total demand in a certain period; D_i for demand of supply inventory Agent i; L' for lead time at shortage considered from the system, of which the value is equal to the shortest lead time of supplier's setting Agents; ś for re-ordering point at shortage seen from the system; L_i for lead time of supply Agent i; A_i for single order fee; r_i for single-piece storage fee; W for single-vehicle transport capacity; C_{0i} for single-vehicle transport cost from one Agent to another. And p_i and p represent the practical support level and specified support level, respectively.

The restriction condition $S_i \le S_{i.e}$ illustrates that the maximum nominal inventory can not be more than the Agent's rated inventory. The restriction condition $p_i \ge p$ shows that the practical support level will be greater than or equal to the specified one (Si *et al*., 2007).

EXAMPLE SIMULATION

One aircraft company (a collaborative control centre) forecasts one user's landing gear sleeve demand per unit time in a relatively long period complies with Poisson distribution of λ = 12. For the landing gear sleeves of the required type, there are four Agents to meet the supply requirement and the user insists that the support level is not lower than the value p = 95%. The relevant information of the four Agents are shown in Table 1 (Suppose the scheduling cost per Agent is α = 20; single-vehicle transport capacity is one piece).

Every Agent adopts $^{(S,s)}$ control strategy, in which ^{S} stands for post-ordering inventory and ^{s} for minimum inventory. According to the mathematical model, let the basic information of each Agent in Table 1 be the model's inputs; and use MATLAB program to realize the designed calculation; then the optimal control parameters of each Agent under the restriction of minimum total cost and guaranteed support level can be achieved. They are supply Agent 1 (30, 13), supply Agent 2 (9, 3), supply Agent 3 (20, 7) and supply Agent 4 (17, 8). The support level of collaborative Agent system is 97.01%.

Table 2 describes the support level change of each supply Agent and system after and before collaboration.

Figure 4 indicates the relation tendency of support level and total cost in aircraft spares collaborative control system. In this coordinate chart, the horizontal axis represents support level and the vertical axis shows total cost. Through collaboration of Agents, the support level can be raised and total cost can be reduced in a certain range. If the support level of each Agent is known, the optimum combining point of total cost and support level will be determined. It can be seen that when the support level rises from 93.87 to 97.01%, the total cost per unit time $(\bar{C})$ for support falls from 903 ¥RMB to 877 ¥RMB.

Table 1: The relevant parameters of supplier's setting agents

Agent	1	2	3	4
Rated inventory (p)	30	20	24	20
Lead time (day)	2	1	3	2
Ordering cost/time (¥)	100	80	150	100
Storage cost/piece (¥)	5	10	5	8
Shortage cost (¥)	100			
Single-vehicle transport fee (¥)	40	80	50	30

Table 2: Change of support level before and after collaboration

	Agent 1	Agent 2	Agent 3	Agent 4	Support level
Before	94.10	97.30	94.70	94.40	93.87
After	96.26	95.89	98.88	100.00	97.01

CONCLUSION

By utilizing CSCW and Agent, the collaborative-support work environment is built up to realize the cooperative work and information share among various support units (Agents) under coordination of the control centre. Experts can undertake remote visualized instruction for the site failures and accomplish remote dispatch and management for the spares. Every support unit (Agent), through sharing sound, video, graph and picture, overcomes space limits and ensures data information; and it can quickly take action and greatly improve the informatization of aircraft spares. On the basis of the Agent collaborative work model, the author advances one collaborative control mathematical model under restriction of support level as well and conducts simulating test for the two models by relevant simulation software. As a result, the optimization of Agent parameters for aircraft spares is realized and relevance of total support cost and support level is determined.

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