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## Distributed Cooperation Solution Method of Complex System Based on MAS \*

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### Abstract

To adapt the model in reconfiguring fault diagnosing to dynamic environment and the needs of solving the tasks of complex system fully, the paper introduced multi-Agent and related technology to the complicated fault diagnosis, an integrated intelligent control system is studied in this paper. Based on the thought of the structure of diagnostic decision and hierarchy in modeling, based on multi-layer decomposition strategy of diagnosis task, a multi-agent synchronous diagnosis federation integrated different knowledge expression modes and inference mechanisms are presented, the functions of management agent, diagnosis agent and decision agent are analyzed, the organization and evolution of agents in the system are proposed, and the corresponding conflict resolution algorithm in given, Layered structure of abstract agent with public attributes is build. System architecture is realized based on MAS distributed layered blackboard. The real world application shows that the proposed control structure successfully solves the fault diagnose problem of the complex plant, and the special advantage in the distributed domain.

Index Terms - Multi-agent system, Distributed Solution, Cooperation, Amalgamation algorithm.

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### 1. Introduction

With large-scale industrial processes and the production of complex devices, traditional control theory and industrial process control technology is faceting with the complexity of the challenge. In a complex environment, the system is not only the traditional spatial distribution, and slow or time-varying parameters. but also have to face many new issues, such as system errors, subsystem status change, sensors and regulator failure, external disturbances and parameter changes or hybrid systems, and industrial processes to adopt continuous process of the past to against the relatively simple part of the conventional control strategy which has been unable to meet the production process need, and the traditional focus on ways to make the entire control and diagnosis system extremely complex and

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difficult to achieve. The other hand, the control system of surveillance, control and diagnosis of interdependent subsystems interaction is an organic whole, which inherent integration requirements. With the development of the smart technology, the need for the entire production process of information integration, make the business decision-making, management, plans, scheduling, process optimization, fault diagnosis, control the scene closely together. This monitoring system for the control and diagnosis system for the integration need higher demand, so we must study new, Industrial production for the complex process of integration and control architecture technology<sup>[1-2]</sup>.

The rise of Agent Research and Development, provide new idea for these issues[3-6]. Agent is based on a distributed computing model which based on the intelligent means of integration method. The objective is to obtain the maximize for the functional entities. MAS (Multi-Agent System. MAS) of the description of the problem domain decomposition and allocation constitute scattered, specific problems facing relatively simple subsystem, and the coordination of the system of parallel and reciprocal cooperation to carry out problem solving, the thinking is very suitable for large, complex problem solving Smart (problem solving). For a dynamic, distributed, real-time and uncertainty in the complex system, Multi Agent System in fault resolution, diagnosis and control shown the greatest advantage. In recent years, many scholars in this field have made in-depth studies. Shahbazian, etc. [1] designed the system which based on the design of the "blackboard and the knowledge-based systems" architecture of intelligent diagnostic system. Jennings[2] make a viewpoint what is the two isolated expert diagnostic system into a multi-agent system environment G. RATE. Hartvigsen[5] put the multi-agent technology in meteorological observation and storm system monitoring, and Jennings Draa, respectively use the agent to achieve the joint intention of the Joint Monitoring mechanisms [6]. Russell[4] use the agent technology to establish a system which is to solve the complex problems of distributed real-time diagnostic system MARV EC. ZHANG, etc. [7] Application use the Agent theoretical to achieve the arms of collaboration assembly, and design corresponding sensor development tools and implementation of systems architecture. HU, etc. [8] designed PLMAS module, Distributed through the use of agent technology to achieve the factors reasoning and decision-making goals of the coordination. DANIEL etc. [9] studied the agent with the blackboard model of interactive forms, and providing a common control model. In the paper of [10], we propose a model for fault diagnosis which based on Multi-Agent-based BP and the dynamic network. In the paper of [11] the combination of genetic algorithms and multi-MAS designed a distributed real-time scheduling algorithm. In the paper of [12] it established a diagnostic agent system architecture and implementation of a prototype system. It based on the above work on the basis of complex industrial process control of the production characteristics and requirements; Based on the establishment of MAS distributed intelligent control and fault diagnosis system. The monitoring system based on the signal Monitoring object characteristics of the structure of the traditional multi-fault diagnosis into the field of object-oriented multi-agent module consultation broken, diagnosis mechanism more flexible, accurate and easy to revise expansion.

## 2. Diagnosis System MAS structure

Fault Diagnosis System MAS model, the work process is as follows: when it facing with failure, Diagnosis users to take out the fault feature for case at first, and then interface Agent complete description of the problem, at last, the CBR Agent and diagnostic support for the same case. CBA Agent completed similar case retrieval, and the diagnosis of shifting similar cases rewrite the solution to the current problems, Synthesis formed by the current proposed solution to the problem (initial point), While the initial perspective sent to the Diagnosis and Management Agent. During this process, the more synergy with the resources Scheduling Agent, to complete the dispatcher of the data, models, methods, graphics, images call which are needed in diagnostic process. Diagnosis and Management Agent

diagnosis groups to collect the views of the members and submitted to the diagnostic reference materials, Integrated diagnosis users from different angles for thinking envisaged to be some enlightenment, begun to revise and supplement initial view diagnostic support process.

All the more synergy on the basis of the database management system with the right of the overall control, scheduling, mutual communication, share resources and coordinate the operation of the software system, and more synergy with the resources of the scheduling agent for the diagnosis process the required data, models, methods, graphics, images call. It completed two major tasks : According to the diagnosis of learning objectives users develop study plans, and the implementation of the study plan for the diagnosis of learning objectives users develop study plans, and the implementation of the study plan for the diagnosis users with the necessary information and knowledge. It uses goal-driven learning mechanism, based on different target different learning strategies to achieve the knowledge base model library, the methods, databases, and graphics, such as the scheduling. More synergy with the use of various agents completed total control, coordination, scheduling, communication and other functions.

Diagnosis of the structure, which the deliberate and the reaction (reaction) is mixed with the structure. Agent basic structure consists of two parts, one is the field layer, a layer of collaboration. In response to some stimulus, the perception and the actuator are closely integrated together, when Agent identified by a case, the immediate implementation of this situation with the relevant procedures which have been compiled. When Agent facing the same situation, often perform the same action. And partly through prudent based on template matching and consistent with the operation of logic to make decisions. Agent consist of communication interface model from the functional group (the target module, the task decomposition module, planning, decision-making module, the module. Algorithm and functional management module), a knowledge base and beliefs, the local knowledge base, database, the algorithm and internal functional block component. At different levels of different input / output data, which are based on the use of different targets agreement. For real-time control agent, a number of tasks can corresponding to the different model and control algorithm, and under different circumstances for multi-mode switching. The more down layers, the higher real-time have. It mainly shown in response structure, the other hand carefully can consider the greater proportion. At the top agent stressed the autonomy and independence of the agent-through machine learning, which run in it, to gather information with other more rational interaction with others, so that in the process of increasing knowledge, continuously enhancing our ability to have higher intelligence. The entire system highlight the real-time agent, and the cycle response to the change in environment, so each agent has a final deadline for the implementation cycle and to enable it to work in hard real-time environment.

Perception module through a group perception selective percept external environment, Agent revive the other information (notice of the request, etc.)coming from the external environment. Module will change the output signal into actuators required by the format, then the actuator sent the message to the Agent in external environment. Preconditioning module by module basis of a perceived to be the priority tasks and the time of arrival of the decision to task by Rea Merit segment (1), Or through Deliberative segment (2) of this problem into a two classifications problems. Agent knowledge is the basis of agent achievement, as well as a commitment to the outside foundation. That is to examine how to use complex symbols in the world Agent and Agent how various information on Central Habitat for reasoning and decision-making. Feature Extraction Module making the model in knowledge is simplified and streamlined model more localized, and many of the details were removed. Because of the stimulus, details on the relevance can response part of the goal and the state in current. Stimulate some response consist of selector module and module acts. Selector module obtain a high-level logic condition to drive behaviour block on the basis of simplified model. Behaviour module is a finite state machine. Prudent consist of recognition module and consultation modules. Agent is careful monitoring the environment, updating the knowledge base of faith, identifying what happened in the environment and having to do a

particular action aspirations by using the rule what the Regulation is concentrated. Agent desire and intention of balance the various conflicting movements. Below is a description of the reasoning coordination mechanism.

Agent definition for all Agent pool ,PERCEPT for all perceptual information collection, BEL for all information collection, DES set for all desire,

INT set for all intent, ACT for all atoms act sets,  $\prod$  said Power Set, T indicated that the schedule.

$a_i \equiv (P, B, D, I, ACT, see, bf, option, filter, excent)$

$a_i \in AGENT$

$P \subset PERCENT$

$B \subset BEL, D \subset DES, I \subset INT, Agent, said three mental state. Among them, I = \{x | x = (\prod rx, px, gx), rx \in BEL\}$  intention to achieve the prerequisite,  $Px \in (ACT, t)$  to achieve the intent of the planning,  $gx \in DES$  intent to eventually achieve the goal.

See: STATE  $\rightarrow$  PERCEPT, said Agent perception process.

Brf :  $\prod PERCEPT \times B \rightarrow \prod D$ , expressed the belief that agent process.

Option :  $\prod \prod I \times B \rightarrow \prod D$ , said the process of determining the wishes.

Include two aspects : First, the recursive found more specific desire that the formation of sub-targets; Second, it ensures that desire and belief the same intent.

Filter :  $\prod \prod I B \times \times D \rightarrow \prod \prod I$  expressed intention of choice, the process of determining that there are three possibilities; abandon reached or not incompatible intent; keep up not prove intent or incompatible; adding a new intention.

Except :  $I \rightarrow \prod ACT$ , said Agent implementation process.

Algorithm 1. Reasoning Algorithm

- (1) given  $g_i, g_i \in D$ , which can be communication, perception, the internal reasoning and so on.
- (2) If  $X, x \in X, gx=gi, X$  might be set.
- (3) If the  $Y, Y X$ 's. Not.  $Y \in Y, ry, ry \in B, Y$  intention to set realistic possibility.
- (4) If  $xm \in Y, x \in Y, F(xm) \geq F(x)$ , then the commitment to  $xm$  intent  $F()$  function to a policy choice.
- (5) If the implementation failed  $xm$ , from (2) re-run.

### 3. MULTI Agent decision-making mechanism

To address the uncertainties of the sequential determination. We used an arbitrary time algorithm (Anytime) and the decision tree method to solve such problems better.

The core idea of the Anytime algorithm is that the quality of solution go with the increase in computing time and continues to increase. Algorithm for each input and specific mapping computation time for a group of output. Anytime algorithm has a well-defined multi-level quality indicators for monitoring the entire process and there efficient allocating resources. For each result has a quality grade with counterparts.

We used Maps, Agent of the decision-making process of various state of the environment and the consequences of the program and its message loud and clear expression, and accordingly, choose the best programs. That the arbitrary time can be a solution, which solution quality over time increased. Maps is a non - cyclic graph. From the perspective of policy-makers subjective belief, desire and action can be taken of the set model.

Algorithm 2. Uncertainty of the decision-making algorithm diagnosis

- (1) Initialization (Initialization) : initialization process to  $D_n, \dots D_1$  in order to consider a policy for every node. Determining a decision node probability distribution.

(2) Choose a policy function Refining (Choosing a decision function to refine  $n$ ) : All can be expanded leaf node to determine a priority queue, leaf node inspired by value ranking. Queue is a group of arrays  $(D_i, l)$ , which  $D_i$  decision-making nodes,  $l$   $D_i$  is the decision tree leaves. So this is not only instructive value of a tree to determine the peak leaf expansion order, but also the decision-making function to determine the order of refining. In which case, decision-making function to inspire value for ranking the importance of refining rather than a pre-defined order of refining.

(3) The extension of leaf nodes (Extending a given leaf) : For example, can choose the greatest probability of leaf node expansion, this one, most likely the first search.

(4) Update the whole strategy (Updating the global policy) : Update each decision tree  $D_{i+1}, \dots, D_n$  the conditional probability. Each node a recalculation  $P(X|YX)$ .

#### 4. Application Analysis

According to the method, the development of the prototype system is used in sophisticated centrifuges, which achieve a sophisticated centrifuge fault diagnosis and monitoring system. The system can complete the task of diagnostic tests and meet the required performance indicators, and the whole system of systems maintenance, Real-time fault diagnosis and monitoring capabilities have been greatly improved. Sophisticated centrifuge system is a large electromechanical systems, which consists of Dynamic radius and inaccurate measurement system, temperature control system, Spindle control system, dynamic balancing system birdcage control system, the centre monitoring system components.

As sophisticated centrifuges in all of the subsystems are independent of the computer system and function relatively independent, We used a MAS plane a structure, that is, each subsystem as a MAS, According to the diagnosis targets and diagnostic services, the diagnostic agent was designed and confabulated in the MAS platform, and all subsystems finally passed 100Mbps network switches centrifuge components in a sophisticated multi-agent Fault Diagnosis and Monitoring system.

Because sophisticated centrifuge work in the high-speed rotation, personnel and equipment to the security, the entire centrifuge was closed in the protective shield of steel, and monitoring agent centre platform and fault diagnosis agent platform user agent can achieved Remote control for the above subsystems, and sent control instructions. The user can user agent of the new diagnostic tasks transmitted to the monitoring agent, and then task decomposition, sending to the diagnostic agent to enforce. Supervisory Agent eventual diagnosis through user agent in the form of a graphical interface, and visual display to users.

Diagnostic agent for the operation process : At first the diagnostic agent has a function of the initial internal  $f_0$  ( $f_0 \in F$ ), in a moment, it obtain the diagnostic agent by observing the external environment which would be visually see the state  $(s_i)$  ( $s_i \in S$ ), It combined this visual state function at this time  $f_0$  for thinking and reasoning, so that diagnosis function is ( $f_0$ .see ( $s_i$ )) According to the amendment before the decision diagnosis function object of achieving the ultimate goal of state mode result ( diagnosis ( $f_0$ .see ( $s_i$ ))). When one agent sent message to another agent, first defined an object ACL Message msg, then assigned value, finally called Agent category send () method. The following code shows the diagnosis of spindle balancing agent to agent sent an error signal on the control of the diagnostic results of the consumer income.

```
ACLMessage msg=new ACLMessage(ACLMessage. INFORM); msg.addReceiver(new
AID("Dynamic Balance", AID. ISLOCALNAME));
msg.setLanguage("English");
msg.setOntology("MainAxis-diagnosis-ontology");
msg.setContent("Error signal is normal");
send(msg);
```

Artificially created three different types of fault simulation in experiments, rotor. rotor and the rotor misalignment loose parts, while adding equipment to trouble-free circumstances. It is four models.

Through speed and acceleration sensors, respectively rotor test various fault conditions the parameters. The using of trapezoidal function can obtain the fault mode Eigen value membership function, calculated for each sensor to the failure mode of the value of the distribution function (for the failure mode really credibility), As shown in table 1, the specific signal processing see [7]. This data using fuzzy diagnosis Agent[8] integration and the integration of this diagnostic agent, respectively Diagnose, the maximum reliability and fault principle function of the type and the results are as shown in table 1. Among them, two fuzzy sensor fusion when the weight of the 0.5.

## 5. Conclusion

Dynamic ever-changing environment of complex policy issues, such as the Distributed Fault Diagnosis System fields, as complex causal relationship. Information and randomness, such as fuzzy uncertainty, to express their knowledge, the causal relationship is difficult to grasp. Based on the past, intelligent diagnosis based on the method of application and related intelligent agent technology, Based on the Multi-Agent System for Distributed Intelligent Diagnostic decision-making model The model number distributed in the different regions of the agent work composition is a Distributed Multi-Agent Remote Diagnostic System, overcome the traditional rule-based reasoning system of knowledge and reasoning difficult to access the fragile nature of defects. Sophisticated centrifuges in fault diagnosis and monitoring system, the model can quickly and accurately cause of the fault analysis provided reasonable and constructive decisions, and experts have made similar findings. improving the safety of the system operating efficiency.

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