The study of natural disasters emergency relief plans deduction conceptual model

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***Abstract* — In this paper, the modeling technology of multi agent in complex system has been employed in natural disaster relief emergency plan deduction according to the existing emergency plan deduction research results and the characteristics of emergency plan system. The natural disasters emergency plans deduction conceptual model based on MAS has been proposed. The proposed model has been tested on JADE platform. The results show that the designed natural disaster emergency plan deduction conceptual model can better address the modeling problem in emergency plan deduction complex system and deduction can achieve the desired results.**

Keywords- Natural disaster; emergency plan; deduction; conceptual model

I. INTRODUCTION

Different natural disasters public occurrences will inevitably happen in human society. These unexpected accidents often lead to serious casualties and property loss. In recent years, different kinds of public emergencies shown the following characteristics including appearance frequency increasing, losses increasing, disasters occurring simultaneously and so on, for example Ocean earthquake and tsunami events in 2004 Indian, "Katrina" hurricane in 2005 USA, China's "512" Wenchuan earthquake disaster in 2008, "112" Haiti's 8.0 earthquake disaster in 2009, "227" 8.8 earthquake in 2009 Chile, "311" northeastern Japan earthquake disaster in 2011 and so on.

Facing all kinds of unexpected natural emergency, reasonable and effective emergency plans can be used to quickly generate treatment decision which can reduce the harm caused by the accidents, when the public occurrences occur. Therefore, the related research of public safety emergency plan is a worldwide research topic both in the field of natural science and technical science [1]-[9].

Emergency practice once again that our ability to effectively carry out disaster relief work, a direct impact on socio-economic development and people's lives and property, improve the public emergency response plan is effective to carry out emergency work on the basis and premise.

Natural disasters relief emergency plan is the basis of public natural disasters events emergency handling, and emergency plan also is the guidelines and programmatic document for government responding to public emergencies. In order to improve the execution and guidance of natural disasters relief emergency plan, it is need to increase the training and exercise of natural disasters relief emergency plan. The existing natural disasters relief emergency plans are mostly text plans and there are many difficulties when the text emergency plan is employed to do emergency drillings. However, the emergency plan deduction system not only can achieve the purpose of emergency drillings but also can test the scientificalness, practicality and operability of emergency plan by using the extrapolating results. What is more importantly, the plan deduction system can generate the comprehensive, specific, targeted intuitive and efficient emergency handling measures according to the occurrence and development process of emergency public accidents and the corresponding emergency plan handling program by using emergency plans deduction technique. The emergency plans deduction system can make the establishment, modification, update and so to be easier and faster so as to improve government handling capabilities for emergency public accidents. So, the emergency plans deduction techniques have been focused on in this paper.

II. EMERGENCY PLANS DEDUCTION METHODOLOGY

Emergency plans deduction techniques can be divided into GIS-based deduction methods [10], analytic hierarchy process methods [11] and complex system modeling methods [12] [13].

The timeliness requirements of handling public emergencies are very high, and the large amounts data involved in public accidents processing have both attributes properties and spatial properties. Geographic information system (GIS) technology can support fast reliable processing of a large amount data and complex graphic symbols visualization, etc. Therefore, GIS technology is an effective support for emergency treatment. With the development of spatial information technology and the stepwise understanding of emergency management, public emergency plans deduction gradually begun to use spatial comprehensive analysis such as

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GIS. The dynamic evolvement simulation technology of emergency plan based on GIS had been established [10].

With the gradual-depth study of emergency system, the analytic hierarchy process (AHP) has been used in emergency relief [11]. The AHP is a comprehensive integrated approach from qualitative analysis to quantitative analysis, and AHP method can decompose complicated problem into several levels and several factors. The emergency plans deduction system is a complex multilevel problem. So, AHP can be used to decompose the emergency plans system into different factors and determine the weight of each factor according to the actual assessment work needs. The weight of factor is the key issue in AHP method.

The emergency plans deduction is a complex system. In order to gain better deduction effect, the multi agents system (MAS) modeling method in complex system modeling can be introduced into emergency plans deduction, and that is one future development directions in emergency plans deduction system under the condition that the interaction mechanism between the components of emergency work is unclear. But up to now, the emergency plans deduction methods based on MAS are in the initial stage.

III. THE FRAMEWORK OF NATURAL DISASTERS EMERGENCY PLANS DEDUCTION

Many techniques such as accidents information acquisition, basis calculation, rule reasoning, case reasoning, workflow, intelligent decision-making, emergency decision, collaborative planning, emergency linkage and so on involve in emergency system. On the other hand, different actors and roles also involve in emergency work. The natural disasters relief emergency plan deduction system integrate unexpected accident with the corresponding emergency plan to dynamically deal with the emergency work according to plan treatment process setting. That is to say, the natural disasters relief emergency plan deduction system is a typical complex system. So, the method used in emergency plans deduction system needs to express the complex relationship between different elements in emergency complex system. The plans deduction system can be used to test the rationality of natural disasters relief emergency plan and perfect emergency plan, and plans deduction system also can be employed to train the emergency personnel team through simulation exercised. Under the guidance of the internal rules and mechanism in emergency system, multi agents system (MAS) modeling technology has been employed to establish emergency plan multi agents complex system, then constructs emergency plan deduction technology framework based on MAS in this paper.

A. Theory of complex system modeling based on MAS

Agent is the basic unit in MAS, which is a physical or abstract entity. Agent can act on their own and the environment, and respond to the environment. In general, the agent has the knowledge, goal and ability. Knowledge is the description the world which agent lives in or the solution problem solved by agent. Goal is the aim of all actions of agent. Ability is function such as reasoning, decision-making and control. The MAS is a alliance composed by many different agents, and MAS is an important modeling tool for complex system. The MAS emphasizes particularly on simulation the behavior of the various components in the system and taking into account their interaction from the microscopic. Meanwhile, MAS considers the interaction of the various components in the system and lets them interact. And thus, the macroscopical complexity of the system can be showed. Compared with the traditional methods, this top-down modeling approach can be more intuitively, more realistically performance the complexity of the system. The main contents in MAS include single agent internal structure, communication between different agents, coordination and collaboration among in the agents.

The mainly research issues in emergency plans deduction system based on multi-agent are emergency plans deduction architecture design, different agents internal structure design, agent-agent collaboration mechanism design and the design of communication mechanism between different agents, respectively.

B. The architecture of emergency plans deduction system based on MAS

Utilization the existing study results of emergency plan deduction to construct emergency plan complex system, then selecting MAS modeling technology to top-down model the emergency plans complex system. Meanwhile, the state and behavior characteristics of deduction master module, resource data module, model collection module, process plan program module and plan evaluation module will be abstracted from the microscopic level. Then, the Natural Disaster Relief Emergency Plan Multi Agent Complex System (NDREPMACS), which includes deduction master control agents-alliance, data resource agents-alliance, model set agents-alliance, plan process agents-alliance, and plan evaluation agents-alliance, will be established. There are many agents, such as master control agent, workflow agent, GIS engine agent, decision engine agent, data engine agent and emergency linkage agent, in deduction master control agent-alliance. The data resource agents-alliance includes digital plan agent, disaster case agent, emergency supplies agent, emergency equipment agent, emergency human resource agent and emergency fund agent. The model set agents-alliance is formed by disaster status trend estimate agent, personnel evacuation agent, supply scheduling agent, reconstruction agent, fund scheduling agent and other model agent. National plan process program agent, provincial plan process program agent, municipal plan process program agent, county-level plan process program agent and other plan process program agent are included in plan process agents-alliance. Plan evaluation agents-alliance includes static plan assessment agent, dynamic assessment agent, integrated assessment agent and others assessment agent. Figure 1 is the architecture of natural disaster relief emergency plan deduction system based on MAS.

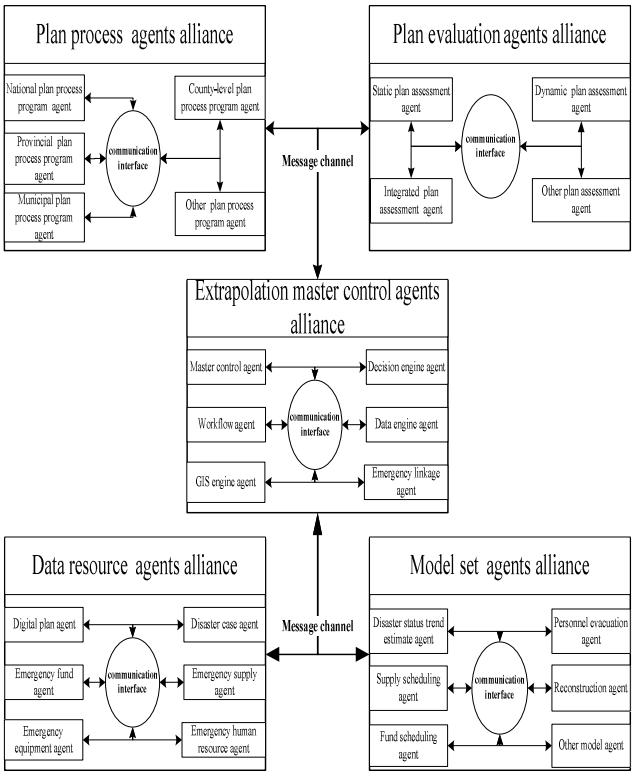

Figure 1 Architecture of NDREPMACS

From figure 1, the different agent alliances including deduction master control agents-alliance, data resource agents-alliance, model set agents-alliance, plan process agents-alliance, and plan evaluation agents-alliance in NDREPMACS use message channel to interact and coordinate. The different agents in five categories agents alliance, i e, master control agent, data engine agent and workflow agent, use communication interface to interact and coordinate. Thus, the communication between different levels agents can achieve the coordination roles among different agents.

The several key issues in NDREPMACS are internal structure design of different agents, communication mechanism design among different agents and coordination mechanism design among different agents.

C. Agent internal structure design

Agent's internal structural designs in NDREPMACS main include the structural design of deduction master control agent-alliance and the other four categories agents-alliance structural design.

The internal structure of deduction master control agent-alliance in NDREPMACS such as Decision engine agent and emergency linkage agent adopts deliberative structure. The reason for that is the deduction master control agent-alliance need to have more learning capability and logical reasoning ability for they need to perform specific tasks in emergency plan deduction. Compared with reactive agent, deliberative agent has more learning capability and complex logical reasoning ability and it emphasizes the intelligence of the agent and has little slowly interactive performance with other agents and environment. Figure 2 shows the internal structure of decision engine agent.

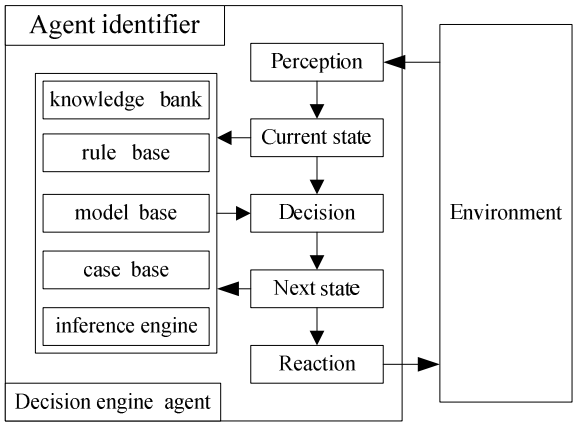

Figure 2 Internal structure of decision engine agent

The internal structure of the other four categories agents-alliance in NDREPMACS adopts reactive structure according to the characteristics of emergency plans deduction complex system and BDI model. Reactive agent is generally based on "perception - action" model. The reactive agent strengthens its synchronous cooperative interaction with environment and other agents, meanwhile weakens its intelligence. The reactive agents are more suitable for emergency plans deduction because they have a faster response rate. The difference of five categories agents-alliance in structural design is that each category agents-alliance has the only agent identifiers, different condition–action rules base and different objective functions. Figure 3 shows the internal structure of data resource agents-alliance.

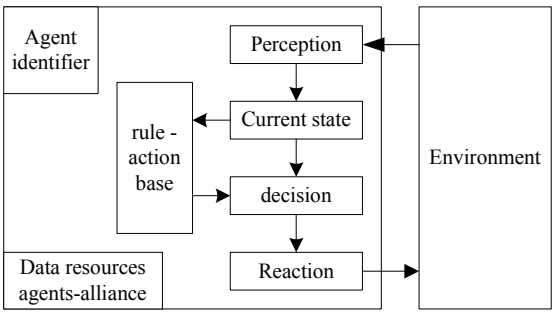

Figure 3 Internal structure of data resource agents-alliance

D. Structural design of agent communication mechanism

Multi-agent coordination is that many agents with different goal coordinate their behavior by making reasonable arrangements for their objectives, resources, etc, so as to achieve maximal their goals. Multi-agent collaboration is that more than one agent cooperate to accomplish common goals by coordinating their behavior. So, in multi-agents coordination collaborative environment, the agent's behavior strategy should not only consider itself behavior, and must conduct itself behavior as the best response strategy for the joint actions strategy of the other agents. Multi-agent communication is the

basis of interaction, coordination and collaboration among different agents.

The statement method can be used to realize the communication among different agents for the communication among the agents is bidirectional communication. The statement method achieves communication by exchanging the statement such as definitions, assumptions and other statements sentence. The widely used agent communication language is agent communication language (ACL) or Knowledge Query and Manipulation Language (KQML). After completion design the internal structure of different agents in NDREPMACS, ACL has been selected as the communication language for different agents in NDREPMACS, and SL has been employed as the criterion format of communication content between agents.

Five categories agents-alliances, including deduction master control agents-alliance, data resource agents-alliance, model set agents-alliance, plan process agents-alliance, and plan evaluation agents-alliance, in NDREPMACS can achieve interaction coordination by the message channel using ACL. Different agents, such as national plan process program agent and provincial plan process program agent, in five categories agents-alliances use communication interface to interact coordinate. The agents and agents-alliances can achieve coordination and collaboration through the communication between different agents, thus the agents and agents-alliances in NDREPMACS can interact. And then we can complete emergency plans deduce by using NDREPMACS.

IV. EXPERIMENT

In order to test the validity of the proposed model, the JADE platform based on FIPA (the Foundation for Intelligent Physical Agents) standard has been employed to do emergency plans deduction experiment. JADE is a software platform that provides basic middleware-layer functionalities which are independent of the specific application and which simplify the realization of distributed applications that exploit the software agent abstraction [14] [15]. A significant merit of JADE is that it implements this abstraction over a well-known object-oriented language, Java, providing a simple and friendly API. Figure 4 shows the main architectural elements of a JADE platform.

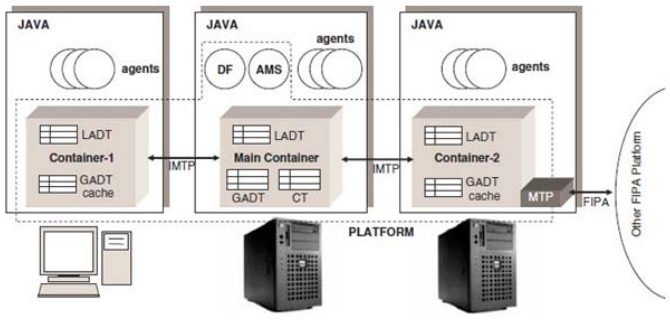

Figure 4 Relationship between the main architectural elements

Above we have designed the architecture of natural disaster relief emergency plans deduction system based on MAS. In the experiment, According to the characteristics of jade plat, we design the five corresponding agent containers: master-control-container (MCC), data-resource-container (DRC), model-set-container (MSC), plan-evaluation-container (PEC), plan-process- container (PPC). These containers are responsible for loading the corresponding five collections of agent showing on Figure 1.

The experiment results show that the MCC was responsible for loading master control agent, work flow agent, GIS engine agent, emergency linkage agent, decision engine agent, data engine agent, and the DRC was responsible for loading digital plan agent, disaster case agent, emergency equipment agent, emergency fund agent, emergency human resource agent, emergency supply agent, and the MSC was responsible for loading disaster trend estimate model agent, fund schedule model agent, personnel evacuation model agent, reconstruction model agent, supply schedule model agent, other model agent, and the PEC was responsible for loading dynamic plan assessment agent, integrate plan assessment agent, static plan assessment agent, other plan assessment agent, and the PPC was responsible for loading county plan agent, municipal plan agent, national plan agent, provincial plan agent, other plan agent.

V. CONCLUSION

In this paper, the deduction conceptual model of natural disaster relief emergency plan based on MAS has been focused. The architecture of natural disaster relief emergency plan deduction based on MAS, agent internal structure and agent communication mechanism have been designed. The proposed deduction model has been tested on JADE platform. The results show that the designed natural disaster emergency plan deduction conceptual model can better address the modeling problem in emergency plan deduction complex system and deduction can achieve the desired results.

The natural disaster relief emergency plan deduction model is just starting and there are still many problems need to be resolved. Such as, the agent internal structure design in NDREPMACS and this issue is related to the agent modeling theory in artificial intelligence and the action mechanism of natural disaster emergency relief complex system. The coordination and cooperation between different agents in NDREPMACS is the another problem. To solve the above problems, it is need depth joint research of emergency management, artificial intelligence, disaster science and other areas.

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