A Study of Agent Communication Model in MAS

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Abstract: It is important of Agent communication for the reality of coordination, cooperation and consistency in multi-Agent system. In this paper, an architecture of Agent communication is given. In order to decrease the working capacity to maintain the communication protocol, using the KQML as the basic Agent communication language, the paper proposes an Agent communication model based on dynamic modification to communication protocol where a new protocol is added or modified without changing the protocol software's source code. The model has been applied in a real multi-Agent system. The results show that the model enhances the system's adaptability and stability.

Key-Words: Agent, Multi-Agent system, Agent communication language

1 Introduction

An Agent has the four basic properties: autonomy, reactivity, interaction and sociality. But it can not know all information about the environment and world knowledge. Communication between Agents can help Agent to enhance the ability to exchange information with outsides. It is very important of communication for the reality of coordination, cooperation and consistency in Multi-Agent system.Agent communication means that in order to implement the self goal, Agent must collaborate and be cognitive of the environment through exchanging information and transporting orders.

In paper [1], the communication in MAS be classified as three types: communication directly, strong signal communication and black communication. Paper [2] thought that the communication can be classified as below: no communication, primitive passing, message passing based on the computer, plan passing, blackboard, communication based on speech act theory, Agent communication language(ACL). Agents communicating with each other must based on a certain language or protocol. Many Agent communication languages were introdued in [3] [4] [5]. In order to make such system work more intelligently, artificial intelligence (AI) technologies especially intelligent agent[6, 7] are desired.

The structure of this paper is as follows: In Section 2, we present the conceptions about the Agent and Multi-Agent system. In Section 3, we introduce ACL, KQML and the general architecture of Agent communcation. Moreover, based on KQML, an Agent communication model is proposed. Finally, Section 4 briefly concludes this paper and outline the future work.

2 Agent Technology and Multi-Agent System

2.1 Agent's Conception

There is no universally accepted definition of the term Agent. However, in this paper, Agent is defined as a computer system that is situated in some environment, and that is capable of autonomous action in this particular environment in order to meet its designed objectives [8].

In the course of the research on Agent, the different researchers endowed Agent with different construction, context and capability in their own system. Here we consider that the Agent has four essential characteristics as follows:

Autonomy: Agent controls its action and internal state by itself when they are in motion on some degree and it does not need man or other mechanics' direct control.

Reactivity: Agent could comprehend the circumastance and draw a real time reaction when there is some change in the circumstance.

Interaction: Agent is able to interact with other Agent in order to accomplish and solve a task through a special protocol.

Sociality: Agent is in a social environment which consists of many Agents. It can

cooperate, negotiate or compete with other Agents by using Agent language.

2.2 Multi-Agent System

Agent is defined as software or an entity, which possesses a certain special function, but a single Agent could not solve the complicated and distributed problem in reality. Therefore, one applied system usually is composed of many Agent, these Agent not only have their own's action goal and problem solving ability, but also have the cooperation ability for common goal through a certain organization strategy and protocol. In other words, multi-Agent system (MAS) consists of many self-determinative or semi-determinative agents, each Agent performs its own function, and can communicate with other Agents to accomplish the solution of whole task through cooperation. Contrast with single Agent, Agent in MAS has two main characteristics as follows:

Self-control: In MAS, when an Agent sends out a request, other Agents can accept it under the condition of having the ability and interest of providing service. That is, an Agent can't compel another Agent to provide service.

Cooperativity: In MAS, every Agent which has its own goal must cooperate and negotiate with each other to complete a task.

3 An Agent Communication Model

3.1 KQML and the General Architecture of Agent Communication

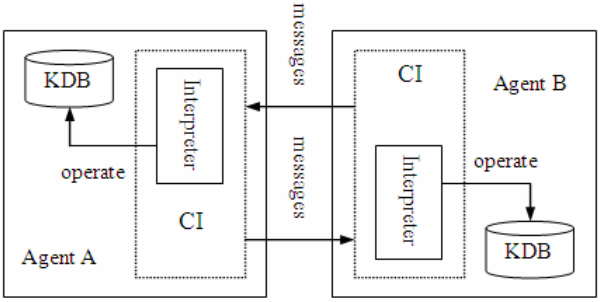
Agent Communication Language is a communication mechanism in Agent based system. DARPA KSE(Knowledge Sharing Effort) group developed protocols for exchange of represented knowledge among autonomous information system from 1990. The principle result of this effort is KQML(Knowledge Query and Manipulation Language) [3]. Another research group in Europe FIFA announced an new Agent communication language FIPA-ACL in 1997. At present, KQML and FIPA-ACL have been accepted widely as the two main ACL standards. They are both based on the speech-act theory. In this paper, the Agent communication model, which is proposed, is based on the KQML. Therefore, here we introduce the KQML.

KQML is a language and protocol for the exchange of information and knowledge between Agents, through message types that express an attitude regarding the actual expression being exchanged. An example KQML message is shown as follows:

```
(ask-if : sender     A
 : receiver    B
 : language    prolog
 : ontology    foo
 : reply-with  id1
 : content     "order" )
```

Ask-if is performative. The value of content is an expression that represents the content of the communication act. The other parameters introduce values that provide a context for the interpretation of the content and hold information to facilitate the processing of the message.

A KQML message is called a performative where the message is intended to perform some action by virtue of being sent. The general architecture of Agent Communication includes the following components shown in Fig. 1: interpreter, communication interface(CI) and knowledge database(KDB). There are some reserved performative sets in KDB. Every Agent needs a KQML's interpreter to interpret and carry out some basic operations. However, the reserved KQML performative in KDB is limited and not satisfied with all applications. So we must extent the performative sets that is supported by the KQML.



. Fig. 1 The general architecture of Agent communication

3.2 An Agent Communication Model based on Dynamic Modification Protocol

In MAS, the communication protocols need frequently to be modified and added in order to fulfil the different transmission services. In real appliaction, it must spend a lot of time in changing the ptotocol software's source code to maintain the communication protocol. Therefore, it decreases the system's adaptability and stability.

Communication language and protocol are the basis to exchange information and knowledge effectively among Agents. KQML is a widely used communication language, which defines the

representation style of message and mode of work and supports the knowledge sharing among run-time agents. A KQML-based communication model is proposed where Agent can add new protocol or modify protocol without any modification of the protocol software's source code. The working capacity to maintain the communication protocol can be decreased, thus the adaptablility and stability are enhanced. This communication model has been applied in design of protocol interface for a multi-Agent based digital agricultural spatial information management system in a province of China.

A communication protocol is considered that it is consists of some CFSM (Communication Finite State Machines) [9] and messages which are exchanged by FIFO (first-in-first-out) queue. Therefore, it can be looked upon as a series of received and dispatched message sequences. Essentially, Agent communication is a state transfer mode where messages are mapped into Agent's state transfer relationship.

Assuming an expression of a state transfer process is defined as follows:

Tk(Ink, Prock, Rek)

Where Ink is a message, which comes from the other Agent. Prock is a process according to the Ink.Rek is a message responsing to the Prock.

Agent communication process is based on a standard communication protocol, could be regarded as Agent's state transfer process. Therefore, a standard communication protocol can be mapped into state transfer rule database which is made up of the state transfer condition table and state transfer process table. In real application, we can modify the state transfer condition table and state transfer process table when an Agent communication protocol needs to be added. The inner communication protocol interface of Agent is shown in figure 2 which is composed of five elements, which are controller, evaluation machine, state transfer condition table, state transfer process table and current state transfer process table. Their working processes include three steps shown as follows:

Step 1: Controller checks the current state then informs the evaluation machine.

Step 2: Evaluation machine selects a process of the state transfer according to the current state and state transfer condition.

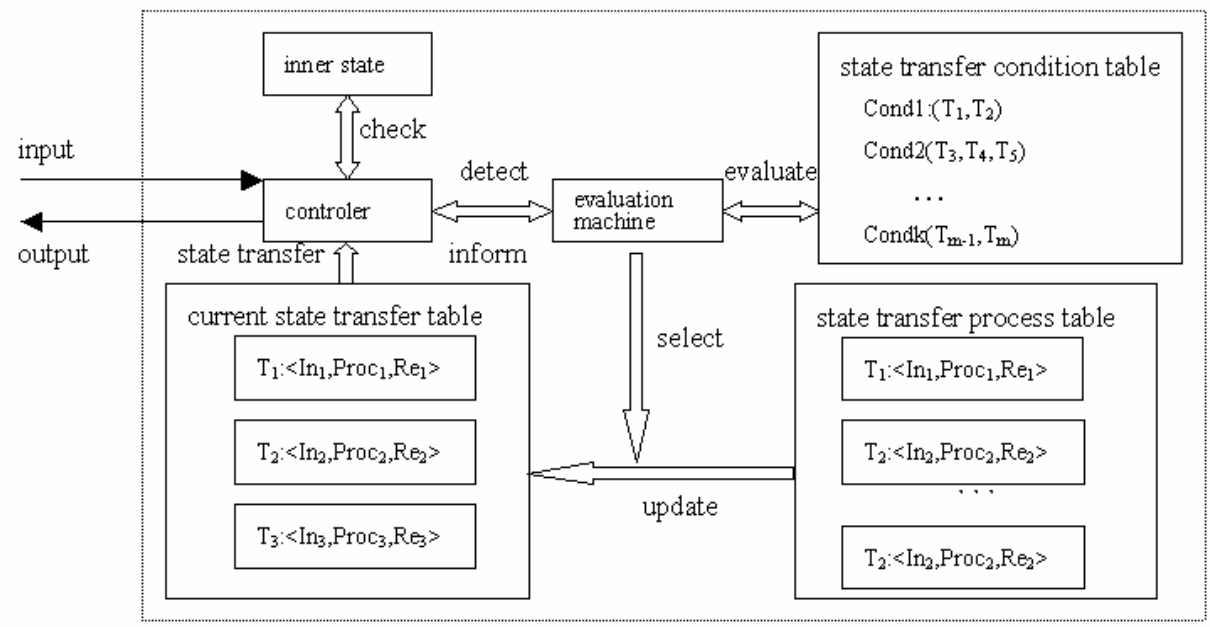


Fig. 2 The inner protocol interface of Agent

Step 3: Controller triggers off a process of the state transfer according to imported messages and the current state transfer process.

The untrue code for the process of Agent communication is shown as follows:

```
While((msg=GetMessage())!=NULL){
    if((T=GetCurrentTransfer(msg)!=NULL){
       T->Proc(T->In);
       SendResp(T->Re);
       State=GetCurrentState();
       CheckCurrentState(State);
       UpdateCurrentTranferTable();}
    }
```

WebGIS(Web-based Geographic Information System) is developed rapid and applied widely. In paper [10], a WebGIS based on multi-Agent is presented which has been applied in a real digital agricultural spatial information management system in a provice of China, order to solve the main problem that Agents communicate and collaborate in the distributed system, the communication model based on dynamic modification protocol has been applied in the MAS and the results are shown the model decreases the working capacity to maintain the communication protocol and enhances the system's adaptability and stability.

4 Conclusions

Communication is representation of Agent social property. Based on KQML, the paper proposes an Agent communication model where a new protocol is added or modified without changing the protocol software's source code and the model has been are successfully used in a real MAS. The next step of the work is to use the model into more detailed applications and study the multi-Agent cooperative problem solving.

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