MULTI-AGENT DECENTRALISED SYSTEM OF MEDICAL HELP

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Abstract: Among numerous names connected with classic models of agents (BDI, Agent-0, M-agent) a notion of ”operational agent” has appeared recently. An operational agent is a certain virtual being acting most often in a computer system or network system, able to realize certain functions. The paper will present a description the operational agent acting in the decentralized network environment. A concept of using this class of agents in creating a network support system of organizing medical help will be drawn up. Copyright © 2000 IFAC.

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1. INTRODUCTION

Intensive research conducted in numerous world centers in the field of decentralized systems of artificial intelligence, often called agent systems, has brought this scope to the next stage of development.

Apart from the studies concerning the description formalization of creating models of those systems and pilot applications, there appear proposals of certain standards (e.g. FIPA) and methodology of designing agent systems.

Universal platforms are created which enable the implementation of agent systems and specification of certain types of agents (Cetnarowicz and Nawarecki, 1995), (Demazeau and Muller, 1990), (Rao, 1996), (Rao et al., 1992). Among numerous names connected with classic models of agents (BDI, Agent-0, M-agent) a notion of ”operational agent” has appeared recently (Cetnarowicz and Nawarecki, 1995).

To express it in a plain and simple way, an operational agent is a certain virtual being acting most often in a computer system or network system, able to realize certain functions. In general, these are information functions, however, such an agent is often equipped with an ability to conduct negotiations, and in time, undertake decisions and initiate complicated actions (Ambroszkiewicz and Cetnarowicz, 1999), (Cetnarowicz and Nawarecki, 1995).

The paper will present a description of a certain version of the operational agent acting in the decentralized network environment, and then a concept of using this class of agents in creating a network support system of organizing medical help will be drawn up.

2. CONCEPT OF THE OPERATIONAL AGENT

Operational agent defined with the use of the M-agent architecture (Ambroszkiewicz and Cetnarowicz, 1999) may be a very useful and universal element of multiagent systems. A virtual operational agent with the following qualities is considered (Ambroszkiewicz and Cetnarowicz, 1999), (Zabiska and Cetnarowicz, 1995):
- mobility, that is an ability to move around in its environment, which in the given case is the network environment;
- ability to communicate with other agents remaining in the given environment and servers which are the network nodes;
- ability to negotiate, understood as going beyond passive issues of messages, that is making proposals (offers, demands) and concluding agreements (in particular, working out a compromise in conflict situations);
- ability to make decisions of its own, that is initiating activities (actions) which are within the competence of the given agent.

In the network environment conditions, the difference between moving around of the agent and establishing communication means that in the first case the whole software package describing the given agent is sent to a proper node, whereas in the second case only a message (question, answer, decision) is sent. Negotiations can be carried out from a distance /by remote control/ (through messages in the network) or within the network where the given agent remains. It is the agent who decides which way to choose with regard to the situation. Similarly, actions which result from the decision undertaken by the agent can be realized in the place of its presence or the nodes where the agent has the right to act. The concept presented in this paper uses the M-agent architecture as a basis for a description of the operational agent (Ambroszkiewicz and Cetnarowicz, 1999), (Cetnarowicz and Nawarecki, 1995). The essence of the concept of M-agent is expressed by the following statement: In order to design a multiagent system we have to state what the agent is or is not in the system. Therefore, the system can be divided into two parts:

- Environment which can be observed by the agent and represented by the given model \( m \).
- Agent with its mind in which it builds and modifies the said model of the environment around it.

Creating a multiagent system, we have to consider that the given agent (\( a \)) remains and acts in a certain environment (\( V \)). For each agent created in this environment the following must be defined:

- Set of strategies \( S \) (\( s \) - strategy, \( s \in S \)), set of goals \( Q \) (\( q \) - goal, \( q \in Q \)) models of environment \( M \) in which the agent remains (\( m \) - model of a certain environment, \( m \in M \)).
- Observation operation (\( I \)) and strategy execution operation (\( X \)).

The principle on which such an agent works can be presented as follows:

- The given agent \( a \) observes the environment around and builds a model \( m \) of this environment in its mind using the observation operation (\( I \)).
- The agent predicts the changes of the environment as a result of execution of (one or two) the strategy \( s \). For this purpose it modifies model \( m \) in its mind using the strategy \( s \), thus obtaining a new model of environment predicted and changed \( m' \) (\( m' = s(m) \)).
- Next, using the goal function (\( q \)) it compares the models \( m \) and \( m' \) (assessing the value \( q(m, m') = q(m, s(m)) \)) and chooses the optimal strategy \( s^* \) which changes the environment (for its goals) in the best way.
- The agent realizes the selected strategy \( s^* \) in the environment using operator \( X \), thus obtaining the changed environment \( V' \) (\( V' = X(s, V) \)).

Summing up, the whole decision process is on the one hand separated from the real world (it takes place in the agent’s mind), but on the other hand it is connected with reality through observation operation (\( I \)) and strategy execution operation (\( X \)). A model of M-agent presented above can be used for building a more complex architecture of a multi-profile agent. In the multi-profile architecture the given agent consists of a certain set number of profiles \( a_i \) (\( i = 1, 2...n \)) Each profile \( a_i \) is built on the principles given above. The agent \( a \) observes the environment around (using operator \( I \)) and builds its model \( (m_i) \) in each profile. Then it chooses the optimal strategy in each profile, afterwards it works out a coherent strategy which is executed using the operator \( X \). Each profile is responsible for the agent’s behavior based on another specific point of viewing the world (e.g. a profile responsible for the agent’s survival, a profile responsible for the execution of a concrete group of tasks, etc.). A scheme of multi-profile agent is shown in Fig. 1.

Therefore, the agent built according to the M-agent architecture aims at changing the environment undertaking the decisions based on predicting the effects of applying strategy \( s \), using the model \( m \) of the environment. Consequently, the
Fig. 2. Scheme of a displacement profile (M-agent architecture).

Fig. 3. Scheme of a processing profile (M-agent architecture).

Effects obtained result from an analysis of possible changes of the model \( m \), whereas the modifications of the model \( m \) as such can be achieved by the agent by means of two ways:

- changing the kind of environment
- changing the agent’s point of view (e.g. by moving around in the environment).

The above-mentioned action can be realized in terms of the M-agent architecture in the following way:

- The agent moving around in the environment changes its point of view and consequently, changes the model of the environment built in its mind. Thus the agent which has at least one profile connected with mobility, is a mobile agent (Fig. 2).
- The agent can change the chosen parameters of the environment. These parameters can be considered as a certain kind of resources available in the environment which are changed by the agent while consuming or producing the given resource. The change of the resources in the environment (i.e. parameters of the environment) changes its model in the agent’s mind. The changes of resources in the environment are realized by a proper profile, called the processing profile (Fig. 3).
- A lot of agents can act in the environment. A group of agents having the same (or similar) point of view on the change in the environ-

Fig. 4. Scheme of a grouping profile (M-agent architecture).

Therefore, it can be stated that in terms of the M-agent architecture described above, the operational agent will be an agent which has mobility profiles, grouping profiles and resource processing profiles.

**3. CONCEPT OF A DECENTRALIZED SYSTEM OF MEDICAL HELP**

The system of medical help considered has a task to choose the best center which undertakes an action (providing help) based on the integrated but decentralized computer system. The realization of the system proposed is based on the application of a properly organized group of operational agents. The concept of the system structure and the principles of cooperation of each agent is reduced to the following postulates:

- Hospital (wards) are represented as nodes in the network. The possibilities of a hospital in the given node are represented by a Ward Agent (\( AO \)).
- The patient (sick, injured person) is represented by a Patient’s Agent (\( AP \)). It has information about the examination results/treatment and the present symptoms of the given patient.
- In the system there are nodes authorized to create the Patient’s Agent. These nodes are accessible to general practitioners and emergency services (e.g. firemen, police, etc.) by means of overhead or radio network.
- In the system there is a unified multiagent platform which enables \( AP \) agents to move around in the network and hold negotiations between \( AP \) agents and \( AO \) agents concern-
Fig. 5. Scheme of actions of the decentralized multiagent system of providing medical help.

In the system there are (can be generated) Patient’s Information Agents (AIP) which look for information about the given patient in medical centers (outpatient clinics, hospitals) to provide it to AP agent in order to create the patient’s full picture (epicrisis) enlarged by dispersed archival data.

The following version of the system’s activity is predicted:

1. The patient (sick, injured person) is attended by first contact service (GP, paramedic, etc.).
2. By means of entering the multiagent system (precisely, a proper node), a patient’s agent (AP) is created and equipped with current information about the patient’s state.
3. The agent AP moves around in the system (from node to node) and negotiates a possibility of providing help with ward agents (AO).
4. During negotiations the agent AP with the help of patient’s information agents AIP, whom it generates, looks for archival data about the patient’s health in order to create his epicrisis adequate enough to start negotiations and undertake decisions about providing help.
5. In the case of positive results of negotiations between AP and AO in the given node, a suitable ward admits the patient.
6. A full epicrisis of the patient is created with the help of AIO and help is provided.

The structure of the above actions is illustrated in Fig. 5. Operational agents which have the qualities described above, are able to execute tasks ascribed to agents AO, AP and AIP. Obviously, each of them must be ascribed an adequate set of strategies, goals and actions, and especially a certain way of depicting real situation in the inner mode (i.e. the agent’s mind) of the given agent. This stage of the system designing, however, can only be realized in a close cooperation with medical circles.

4. GENERAL EMERGENCY HELP

The medical help organization proposed, may be extended to polyvalent emergency help. In this case there is a host (node) in the network (called Emergency Center - EC) where a number of different agents are created. There are agents to organize medical help, fire service and the police or any other kind of necessary help (Fig. 6).

In the global network specialized subnetworks may be defined. The use Information Centers that provide information about emergency help service centers (such as: price, quality, delay time, etc.) makes it possible for the CIfH agent to find appropriate service for the help needed.

5. CONCLUSIONS

The search for appropriate help realized via the network by the use of decentralized multiagent system gives the following advantages:

- The search process may be realized in the real time mode.
- The search may verify a great number of the services which can improve the quality of the offered service.
- Particular exigency help may be guaranteed
- New help providers may join the system in the real time.
- Market oriented rules may be used to select an optimal appropriate help service provider.

Experimental realization of different M-agent versions, as well as pilot solutions of platforms for
creating multiagent systems have been a subject matter of research studies (Cetnarowicz and Nawarecki, 1995), (Nawarecki and Cetnarowicz, 1993), (Zabiska and Cetnarowicz, 1995).

The progress in these studies seems to give the right to acknowledge a statement that the grounds for undertaking the realization of agent systems intended for concrete applications have been created. The application, whose concept has been drawn up in this paper, both satisfies real needs and keeps up with the present development trends, specified as a creation of information society.

REFERENCES


