Review

Multi agent system for resource allocation and monitoring

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The objective of this paper is to present a model that uses Multi Agent Technology to assist Fund Allocating Agencies (FAA) to allocate limited funds to most deserving among competing organizations called Fund Seekers (FS) and monitoring the utilization of allocated funds. These funds are given to execute their projects in Research and Development or to impart quality education. In India, the beneficiaries of this system are likely to be those organizations that allocate funds like University Grant Commission (UGC), Department of Science and Technology, Department of Information Technology and FS that avail funds, could be any university or college. To manage decision-making in such a distributed environment, a Multi Agent System (MAS) for resource allocation was designed. Five agents were identified. One agent, called Coordinator Agent has been designed to perform task of helping FS to find sources of funds available depending on nature of projects, second agent called Fund Allocating Agency Agent has been designed to provide the funds, third agent called Fund Allocator Agent has been designed to allocate funds, fourth agent called Fund Seeker has been designed to avail the funds and lastly Monitor Agent has been designed to monitor the progress of utilization of funds. MAS, methodology is used to model the problem. It consists of number of agents that interact with one another. An Agent is an autonomous entity that performs a given task using information gathered from its environment to act in a suitable manner so as to complete the task successfully. This paper describes the steps carried out to model the problem. To implement the model, physical computing and network infrastructure are required.

Key words: Agents, multi agent system, funds allocation, decision making, distributed environment.

INTRODUCTION

Resource Allocation Problem occurs when fixed, limited resources are allocated among competing alternatives. These Resources may be of different types like Manpower, machine timings, raw material and funds. The objective of this paper is to model a resource allocation problem for funds allocations and monitoring the utilization of funds using Multi Agent Systems. This paper focuses on making decision to allocate funds to most

deserving among competing organizations. Decision factors are considered to make decision of allocating funds. These factors used in allocating funds are divided into two categories: quantifiable factor like number of student trained in case of education sector, and non quantifiable factors like impact on society, image of fund seeker.

Funds requirement proposals may be from different organizations and of different nature. Central/State Government agencies provide financial grants to government /government aided institutions to execute their projects. Some of them may be of Research and Development projects while other may be of recurring in nature. In India, there are many sectors where funds are allocated. Education is one such sector in India, where lots of funds are given for Research and Development and to impart quality education. For availing funds to im-

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plement the projects, institutions seeking financial help (funds) submit their proposals to concerned funding organization. Funding organization then evaluates proposal technically as well as financially. After considering decision-making factors, decision is made to allocate funds. Funds are granted from more than one category and range from zero to 100 percent. Currently decision-making with respect to funds allocation is manual or partly computerized. Presently a committee does the job. In some cases, organizations are asked to present the features and execution plan. Based on the recommendation of committee, funds are allocated.

Next part of problem is of monitoring the progress of these projects that is, timely utilization of funds as per schedule. Monitoring is very important factor to know the utilization of the funds, benefits gained from funding and giving further financial help. Project Monitoring is timely gathering on input, output, activities critical for attainment of project objectives with a view to ensure input, work schedule, target outputs are proceeded as planned (Department of Foreign and Budget Monitoring, Ministry of Plan Implementation, Sri Lanka, accessed on Dec. 10,2006).

In India, there are different government agencies giving financial support to different organizations. One such organization is University Grant Commission (UGC). UGC receives financial aids from Ministry of Human Resources and Development and disburses the same to universities and colleges all over India. UGC sanctions grants in plan / non-plan aids. Amount of Rs 1172.14 crores financial aids (plan) was given during session 2004 - 2005 (University Grant Commission, Plan and Unplanned Grants, 2006). Apart from UGC there are other government departments who sanction grants like Department of Information Technology, Ministry of Communication and Information Technology (Department of Information Technology, 2007). National Policy on Education and Science and Engineering Research Council under Department of Science and Technology, Government of India provides funds for Research and Development projects in newly emerging and challenging area of science and engineering. During 2003 - 2004, it has sponsored projects amounting over Rs 43 crores under Basic Science categories (Scheme Research and Development support, 2007). Government of India formulated Tech ED I, Tech ED II, Tech ED III projects to facilitate supply of technical trained manpower to industrial sector and to make the polytechnic more responsive to the expansion to science and technology and need of industrial and rural sectors (national Project Implementation Unit, 2007) . Weight assignment method is used to allocate resource like CPU time (Mumpower at el., 1991). Two main factors in making decision of allocating resources are technical importance and cost effectiveness (Kauffmann at el., 2000).

The detail paper has been described in four sections. First section describes the Multi Agent Systems. Second section describes the design of system. Third section describes the implementation tools helpful in implementting system followed by conclusion and finding in the last section.

Multi agent systems (MAS)

A multi- agent System is one that consists of number of agents, which interact with one another. Agents will be acting on the behalf of users / other agents with different goals and motivation. To successfully interact, they require ability to cooperate, coordinate and negotiate with each other. The Agents in MAS work in a team to achieve common goal by interacting with one another. MAS can also be modeled mathematically (Denzinger, 2007).

In past, it has been observed that MAS systems are widely used in resource allocation problems such Transportation Problem, Scheduling, Production Planning and system resources like CPU time. Challenger (Chavez at el., 1997) is based on MAS technology for system resource allocation. MAS Technology is already being used in Scheduling and Shipping Problem (Gorodetski, 2003) . After integrating Funds allocation problem with MAS, the model will be able to:

- Identify the fund allocating agencies based on the nature of project/scheme
- Accept request of fund seeker
- Assign suitable weights to non quantifiable factors
- Select the deserving fund seekers after matching criteria
- Allocate funds
- Monitor the progress of utilization of funds

Developing the system

Overview of the system

The system will have two main components:

- Allocation of funds.
- Monitoring utilization of funds.

The model has been described in Figure 1

Allocation of funds

Coordinator component of the model helps in identifying the suitable funding agencies based on the nature of project. After getting source of funds, Fund Seekers seek-
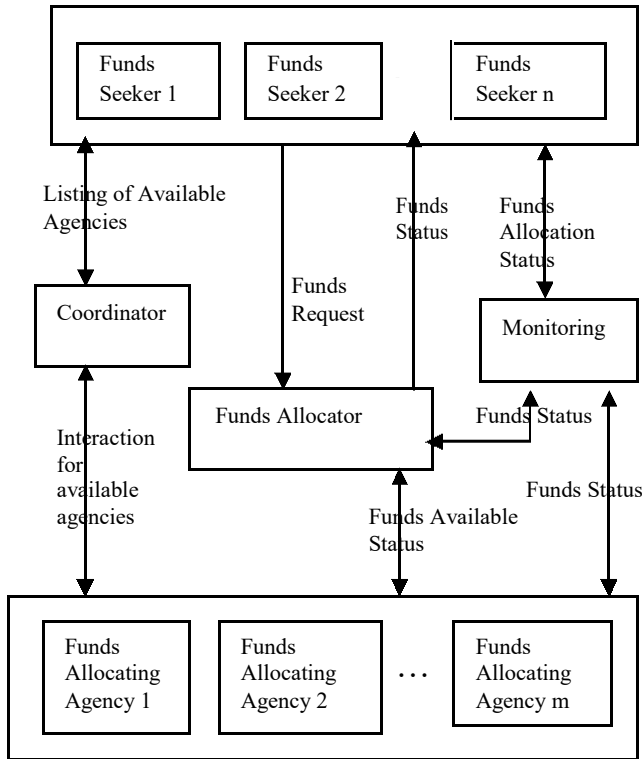
Figure 1. Overview of system.

ing funds would submit their funds requirements to Fund Allocating Agency along with schedule of utilization of funds. The proposal will be checked against set criteria. Funds Seeker's past data helps to calculate probability. In decision making of funds allocation, two possibilities are considered; one, there may be more than one category from which funds would be allocated and secondly, Fund Seeker may apply in more than one category. Main problem in allocating funds comes when limited funds are available as compared to requirement. In these kinds of cases, some weights are assigned to each Fund Seeker. On implementing the model in Multi Agent System, Agents would help in getting Fund Seeker's requirement, evaluating projects, allocating funds and monitoring utilization

Monitoring progress of project

Once the funds are allocated, next phase is of monitoring timely utilization of funds allocated. Proper utilization of funds shows the fulfillment of objective for which funds were allocated. After implementing the model in Multi Agent System, an Agent will help in getting the data on utilization of funds according to schedule submitted by Fund Seeker. For monitoring projects, project-monitoring techniques like Gantt chart are to be used (http://www.ganttchart.com, 2007). PERT Chart is another tool to analyze the tasks involved in completing a

given project, especially the time needed to complete each task, and identifying the minimum time needed to complete the total project (Hira and Gupta, Problems in Operation Research Principles and Solutions, 1995).

Analysis phase

Use Case diagram is used to model the system. Use Case Diagrams are effective way to capture the potential functional requirements of system (Si and Oram, 1998); Bergenti at el., 2001). Use case diagram for Resource Allocation and monitoring is shown in Figure 2. Use of AUML, modeling technique helps in analyzing the system (Odell at el., 2000; Janlma at el., 2005).

Design phase

After analysis phase, design phase was carried out. The aim was to specify the solution domain. The steps carried out in design phase are summarized below (Nikraz at el., 2007):

- Agent splitting/merging / renaming
- Interaction specification
- Messages templates
- Description to be registered/searched
- Agent-resource interaction
- Agent-user interaction
- Internal agent behavior
- Defining an ontology
- Content language selection

Agent diagram of the system is shown in Figure 6. Figures 3 shows the Interaction Diagram for finding suitable funding agency, Figure 4 shows the Interaction Diagram for allocating funds and Figure 5 shows the Interaction Diagram for monitoring utilization of funds.

Agents and their

responsibilities Agent diagram

Figure 6 shows the various agents involved in proposed model and their interactions with other agents. Responsibilities of each agent are discussed below:

Coordinator agent: This agent will be responsible for following services:

- It serves request of Fund Seeker Agent to provide a list of suitable funding agencies based on nature of project

Funds allocator agent: This agent has following responsibilities.

- It serves request of Fund Seeker Agent to provide interface for funds request submission.
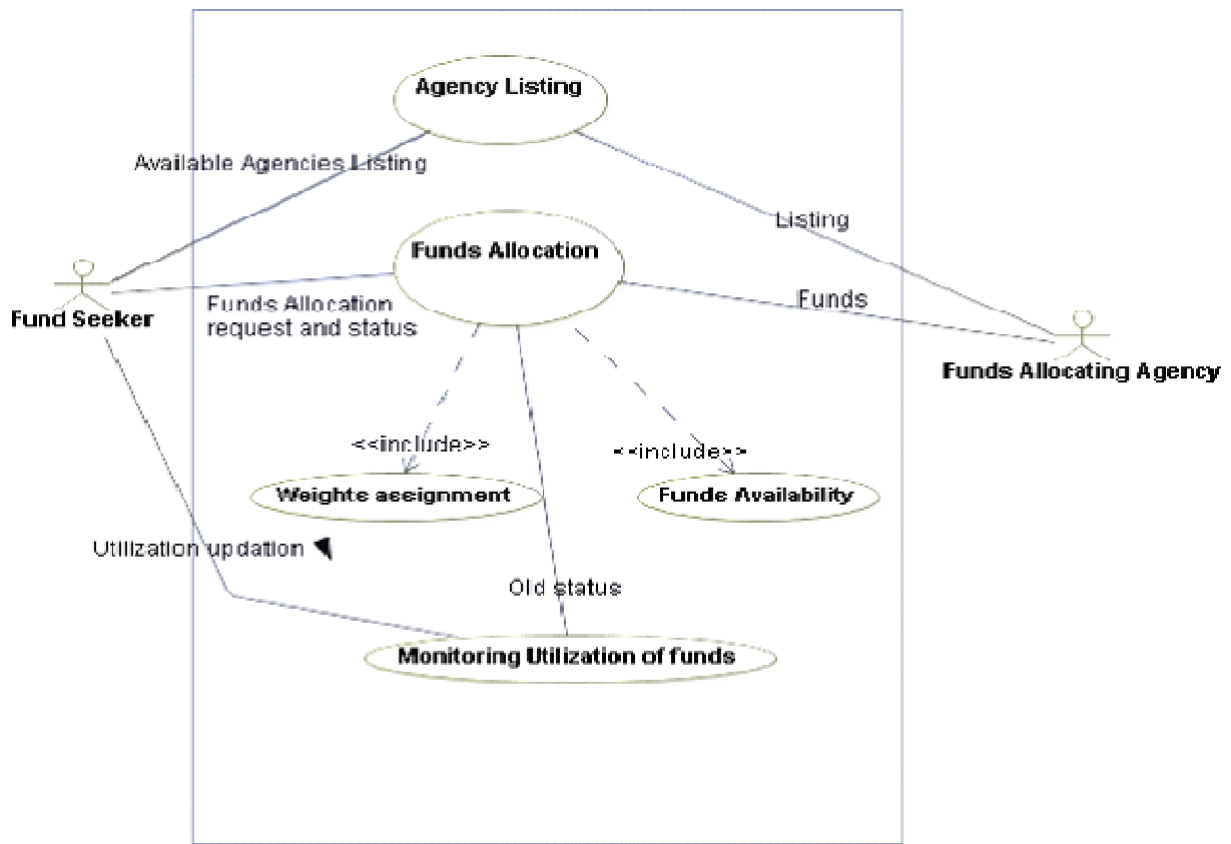
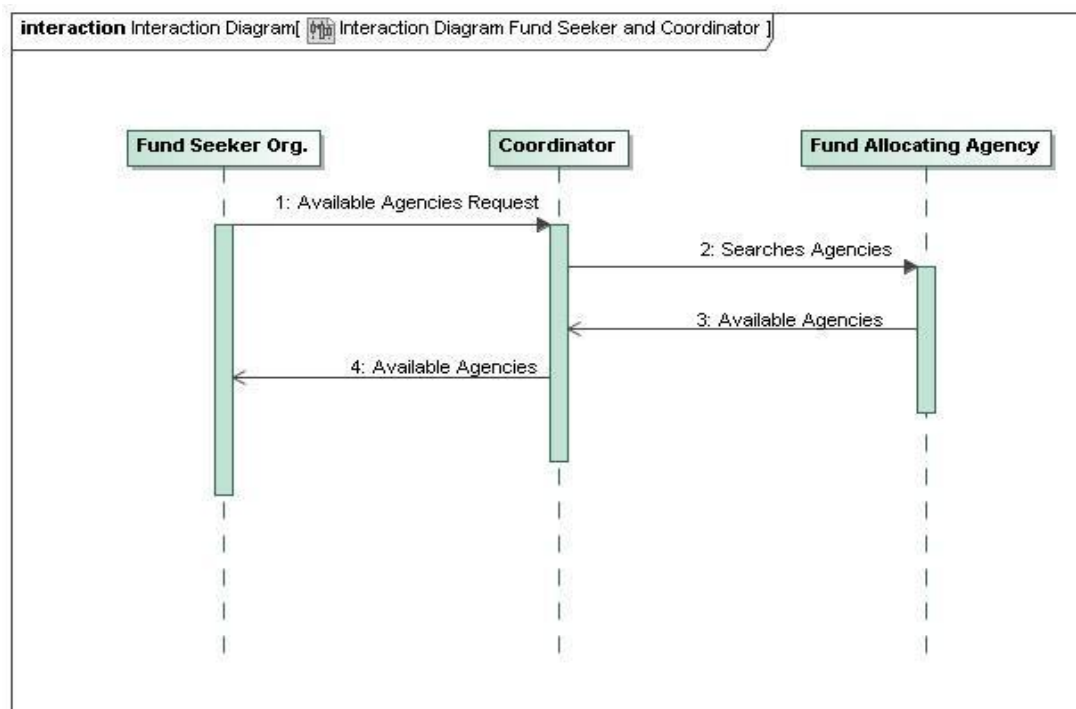**Figure 2** Use case diagram of Resource allocations and monitoring

Figure 3. Interaction diagram: Identification of funding agencies.
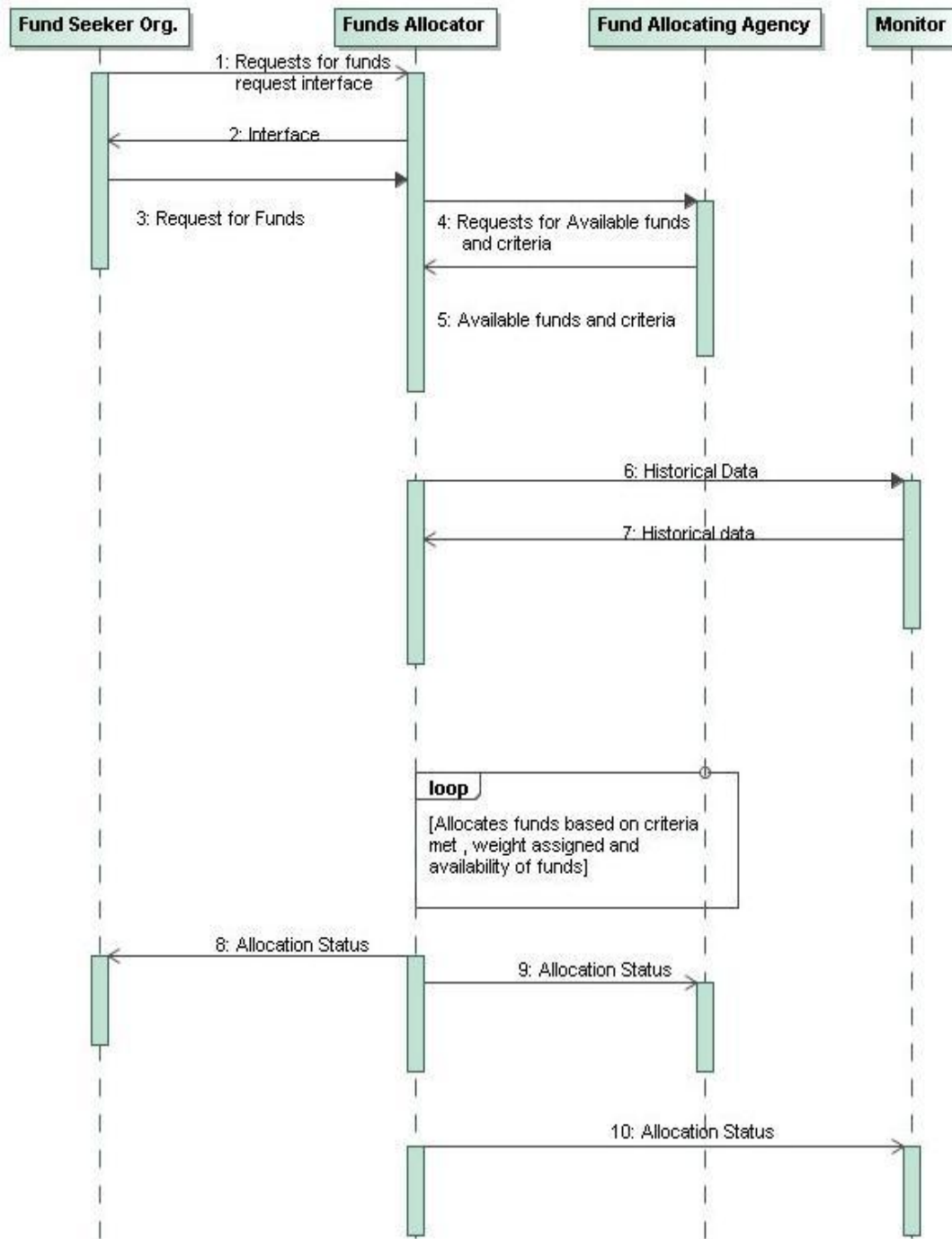
Figure 4. Interaction diagram: Funds allocation

- It accepts the fund request form from Fund Seeker Agent.
- It makes decision regarding funds allocation after matching the criteria set by Fund Allocating Agency Agent
- It intimates status of funds allocation to Fund Seeker Agent, Funds Allocating Agency Agent and Monitor Agent.

Monitor Agent

This agent will be responsible for:
- Serving the request of Fund Seeker Agent to update status of utilization of funds
- Serving the request of Funds Allocator Agent to provide past data of Fund Seeker User
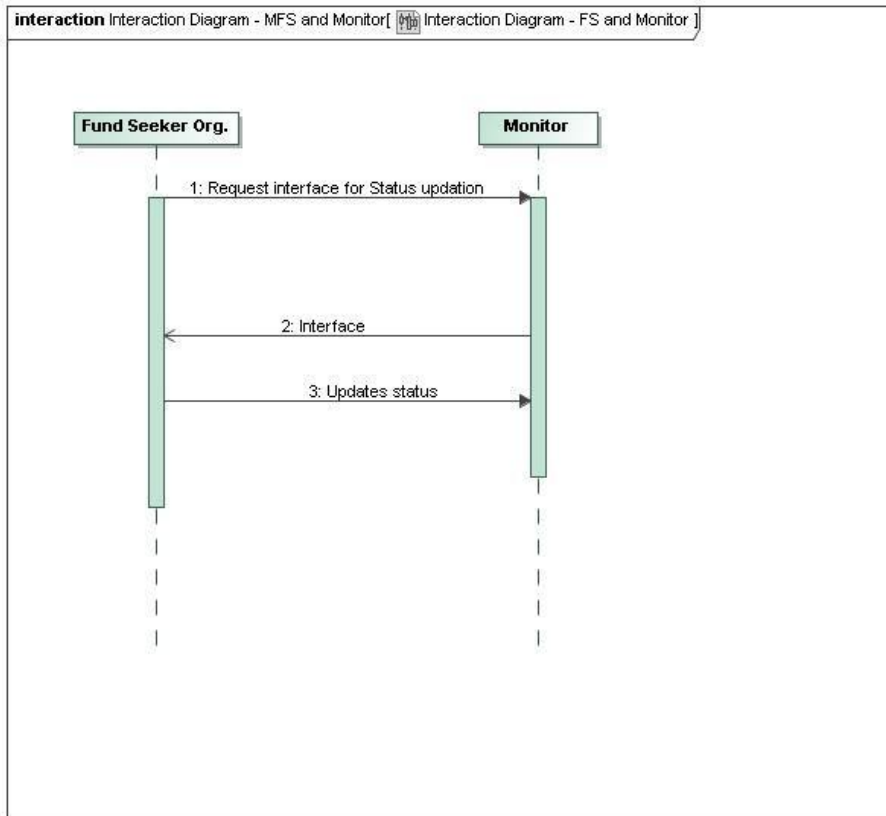- Serving the request of Funds Allocator Agent to
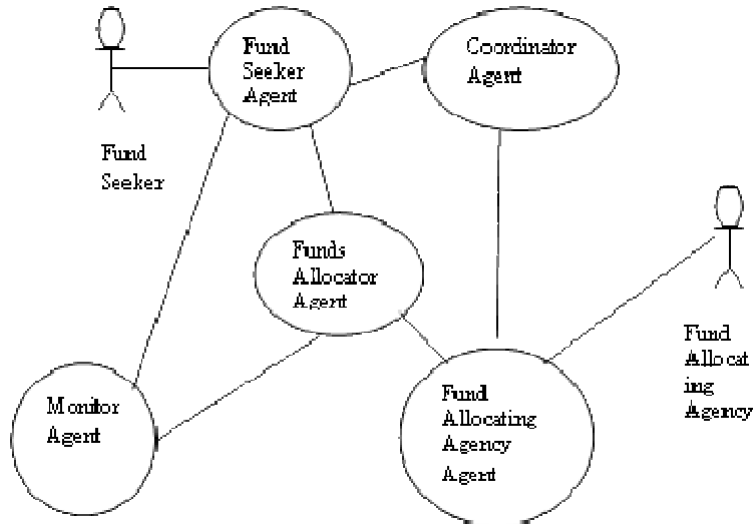
Figure 5. Interaction diagram: Monitoring.

Figure 6. Agent diagram

keep record of allocated funds

Fund Seeker Agent

This agent will be responsible for

- Requesting Coordinator Agent to provide list of suitable Fund Allocating Agencies
- Requesting Fund Allocator Agent to provide interface for submission of funds request.
- Submitting funds request

- Providing status of utilization of funds

Funds Allocating Agency Agent

This agent is responsible for:

- Getting amount of funds to be allocated under different categories from Fund Allocating Agency user

- Serving request of Funds Allocator Agent to provide information about available funds.
- Updating the status of funds allocated
- Interacting with Funds Allocator Agent regarding allocation of funds

Design and Implementation tools

Java Agent Development Framework (JADE) is helpful to construct the system. JADE platform is a popular FIPA-compliant platform for the development of Multi Agent Systems (The Foundation of Intelligent Physical Agents, available at http://www.fipa.org, accessed on 14th Sep, 2006). JADE is software framework fully implemented in Java language. It simplifies the implementation of MAS. The only system requirement for JADE is Java Run time version 1.4 or higher [Java Development Framework, http://jade.tilab.com/, accessed on 14 Sep, 2006; JADE Administrator's Guide, available at http://jade.tilab.com/do/administratorguide.pdf, accessed on June 30, 2007). Other tools like JACK and JESS are also helpful. Any database supporting relational/object oriented features like Oracle / SQL Server for back enddata storage can be used. Alternatively, a simulator tool of MATLAB (Simulink) from MathWorks can be used to simulate the system. (http://www.mathworks.com, 2008).

Example

Suppose an education institute wants to avail funds of $0.1 million for setting up of new Computer Laboratory. There is also another scientific organization that wants to develop a tool that helps in transmitting secured information on Internet (Information Security) and requires $5 million. Both want funds to implement their respective projects. To allocate funds, let there are two different agencies: Department of Science and Department of Human Resources. These are the sources of funds. In the proposed system, Fund Seeker Agent (on the behalf of the institutes who want to avail funds) seeks help of Coordinator Agent to find fund allocating agencies, i.e. the sources of funds. On the request of Fund Seeker

Agent, Coordinator Agent lists out the available sources of funds, names of organizations based on nature of project. Department of Human Resource is suitable for education institution and Department of Science for scientific organization.

On getting list, Fund Seeker Agent selects the appropriate source of funds and submits project proposal online to Fund Allocator Agent along with schedule of implementation. Fund Allocator Agent matches the criteria set by Fund Allocating Agency Agent. Let only criteria is experienced manpower and is fulfilled in both the cases. Funds Allocating Agency Agent provides the availability of funds ($ 10 millions in case of Department of Human Resources and $100 millions in case of Department of Science). Funds Allocator Agent allocates funds based on availability of funds in respective categories. Since sufficient funds are available, 100% allocation can be made. Fund Allocator Agent then intimates information regarding allocation of funds to Monitor Agent to monitor the progress of utilization of funds. It also intimates to Fund Seeker Agent and Fund Allocating Agency Agent regarding amount of funds allocated. Monitor Agent then keeps track of the funds sanctioned and utilization of funds by the Fund Seekers from time to time depending upon schedule given at the time of proposal submission. This helps in analyzing the appropriate utilization of funds.

Conclusion

In this paper, we have modeled Multi Agent Based Resource Allocation and Monitoring by suggesting the development methodology. UML diagrams of Use Case, Interaction Diagrams were used to model the system. In identification of Agents along with their roles and responsibilities, UML approach was used. Ongoing work includes development methodology. We regard our research as starting point in developing methodology for Resource Allocation and Monitoring problem. We will extend out research to other phases of Agent Oriented Software development methodology as the systematic approach.

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