Chapter 1

Introduction
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Resource Allocation Problem occurs when fixed and limited resources are allocated among competing and deserving fund seekers. The different types of resources are manpower, machine timings, raw material, funds etc. The objective of the research is to design and develop multi-agent decision-making system to help in allocating funds to the deserving clients (fund seekers) after considering quantifiable and non-quantifiable decision-making factors in the Web based environment and monitoring the progress thereafter. This chapter describes the existing resource allocation and monitoring procedures, multi-agent technologies, research contributions, problem statement and objectives.

1.1. Resource Allocation and Monitoring

In India, Central and various State Government agencies provide financial grants to the various Government and Government aided institutions to execute their projects. These projects are of different nature. Some of them are of Research and Development nature while others are of specific purpose like contributing to quality education or other social causes. Agencies providing funds are called Funding Agencies or Fund Allocators while agencies availing funds are called Fund Seekers. Fund seeker could be individual or any organization.

Education is one such sector in India where lots of funds are given for Research & Development and for imparting quality education. University Grant Commission (UGC) receives financial aids from Ministry of Human Resources and Development (MHRD) and disburses the same to the universities, educational institutions and colleges of India to provide quality education [1]. This is a government channel to provide financial aid. UGC sanctions grants in plan and non-plan aids. An amount of Rs 1172.14 crore financial aids (plan) was given during session 2004-2005.

UGC provides the funds to fund seekers to carry out research in addition to grant provided for infrastructure such as library books. There are two types of research projects: Minor Projects and Major Projects. It provides grant under five categories: to universities only, to colleges only, to both, to departments of universities and to individuals. The age limit
for retired persons is 70. The UGC allows fund seeker to employ staff depending on the nature of the project and requirement on salary ranging from Rs 6000 to Rs 12000 plus allowances. The fund seeker is supposed to employ staff through open selection method and by constituting selection committee. For minor projects, maximum grant limit is Rs 1 lac and for major projects, the maximum limit is Rs 12 lac for Science/Engineering & Technologies related streams and Rs 10 lac for Social Science, Languages related disciplines. The duration for minor and major projects is 2 and 5 years respectively. The received project proposals are processed in January and July of every year. UGC constitutes a committee comprising experts to review the minor proposals. On their recommendations, funds are given. For major projects, Principal Investigator (PI) is asked to give presentation on the proposal before project evaluation committee. The committee submits reports based on proposal and presentation.

Other funding agencies like Department of Science and Technology (DST) and Department of Information Technology (DIT) also provide funds in research and development sector to come out with new products/technologies. DIT, Ministry of Communication and Information Technology (MCIT) has gained software products by granting funds to various institutions [2].

As a follow up to the National Policy on Education (NPE), Government of India (GOI) formulated Tech ED I, Tech ED II, Tech ED III projects to facilitate the supply of technical trained work force to industrial sector and to make the polytechnic more responsive to promote Science and Technology in industrial and rural sectors. Government has funded Rs 2460 crore for implementation of these three products in different States/Union Territories (UTs) of India and TTTI's (Technical Teacher's Training Institutes, now called National Institute of Technical Teachers' Training and Research) from 1999 to 2005 [3]. National Project Implementation Unit (NPIU) was responsible for implementation of these projects. Science and Engineering Research Council (SERC) under Department of Science and Technology (DST), Government of India (GOI) provides funds for Research and Development projects in newly emerging and challenging areas of Science and Engineering. During 2003-04, it has sponsored projects amounting over Rs 43 crore under Basic Science categories [4]. IIT Bombay has 45 ongoing projects amounting to Rs 60 lac sponsored by organizations like Ministry of Human Resources Development, Defence Research and Development Organization (DRDO) and Department of Science and Technology [5].
DIT also provides funds to carry out research projects and to conduct workshops, seminars and International Conferences. The funded amount depends on proposal categories e.g. Rs 2 lac is given for conducting international conferences. The duration of the project is recommended to be short. There is a standard format to accept proposal and utilization certification. The fund seeker is asked to give presentation before the Expert Committee. Based on the recommendations of the Committee, funds are given. Science and Engineering Research Council (SERC) provides funds to carry out research. The Duration should be 3 to 5 years. SERC has specific format through which proposals can be submitted. Proposal submission is open throughout the year. All India Council for Technical Education (AICTE) also provides funds ranging from Rs 5 lac to Rs 20 lac depending upon the nature of projects like capacity building and patentable technology. Council of Scientific and Industrial Research (CSIR) promotes research work in the field of Agriculture, Engineering, Multidisciplinary projects and Medicine. Preference is given to schemes that have relevance to programmes of CSIR. Proposals can be submitted to CSIR throughout the year. Laboratories of CSIR and Research Committee do the evaluation of proposals. Similarly, DRDO and Department of Atomic Energy provide funds to fund seekers carrying out projects in respective areas.

Second part of the research is aimed at monitoring the progress of these projects after the funds are allocated. Projects are monitored with respect to timely utilization of funds, schedule and achievement of the objectives for which funds are given. Monitoring is a very important factor to understand the utilization of the funds, benefits gained from funding and for giving further financial help. According to the Department of Foreign and Budget Monitoring (Ministry of Plan Implementation, Sri Lanka), Project Monitoring is timely gathering on input, output and activities critical for attainment of project objectives with a view to ensure that the input, work schedule and target outputs are proceeded as planned [6]. For Monitoring purpose, UGC asks fund seekers to submit the progress report within eight months after completion of each year. The recommendations of the UGC Mid-Term Evaluation Committee would decide the continuance of the project. Similarly, for other funding agencies like DIT and DST, a presentation is held where fund seekers present their progress before experts.

After studying the existing procedures of funding agencies, it has been observed that procedures to submit project proposal and funds allocation are lengthy and time consuming.
While making decision, quantification of non-quantitative factors like reputation of fund seeker and social impact is complex in nature. Allocation may not be uniformly distributed. Though fund allocators use Information Technology (IT) to a large extent, the existing tools require decision-making capabilities and integration of monitoring with fund allocation procedure.

1.2. Multi-Agent Technology

Agent is an autonomous software entity capable of performing task independently after gathering information from environment in which it is operating and realizes a set of goals or tasks for which it is designed. It is autonomous in the sense that the agent has control to some extent over its behavior and can act without intervention of human or other agent. Agent acts in order to achieve its designed goal and is intelligent enough to optimize its performance measure. Agent is designed to act on the behalf of the user/other agents and interacts with the others in cooperative manner [7, 8].

Agent operates without the direct intervention of human and has some kind of control over its actions and internal state. Proactive characteristics of agent make agent exhibit its goal directed behavior by taking the initiative. Agent also responds to the changes occurring in the environment. Environment includes human users, information sources like file systems, databases, network, Internet and other agents. Agent interacts with other agents showing its social ability. Apart from these characteristics, agent moves from one location to the other to perform actions.

A Multi-agent System (MAS) consists of a network of agents that can perform actions based on existing resources, knowledge, capabilities and skills they have. Agents in MAS operate in an environment and interact with each other to accomplish their tasks. Agents share information with other agents and request other agents to perform certain tasks [9]. MAS is also modeled mathematically [10].

Agents of MAS work in centralized manner or decentralized manner. In centralized manner, single agent takes complete control while in decentralized or distributed environment; multiple agents are involved in performing tasks. Multi-agent approach is also used to resolve the conflicts between individual and group interests [11]. Interest is in achieving the goal. Multi-agent technology is being used in various decision-making applications like e-tending, scheduling and network resource allocations.
1.2.1. Characteristics of MAS

MAS has the following characteristics:-

i. **Perception**: Knowledge, skills and expertise are distributed among agents operating in multi-agent environment. Different types of data may be at different locations and arrive at different times and may differ in interpretation. Hence, agents in MAS combine their observations in order to increase their collective knowledge about their current state.

ii. **Coordination**: There is no central process or agent that controls all the agents operating in the environment. Agents themselves do the job of synchronization and coordination with each other and avoid conflict.

iii. **Knowledge**: Agents of MAS may be homogeneous or heterogeneous. Agents may have different knowledge in different forms, but to share knowledge, agents have common method.

iv. **Communication**: One of the major components of MAS is Communication Act. Agents interact with each other by means of communication where rules for passing messages in the form of contents and symbols are defined and used.

Due to the above mentioned facts, a need to use multi-agent technology in decision-making problem of funds allocation arises and hence is used in research work. Funding agencies and fund seekers will get benefits with the use of the new decision-making system to allocate and monitor funds to the deserving funds seekers after considering decision-making factors. Advantages are due to the reason that funds allocation procedures adopted by different funding agencies are similar. With multi-agent system, software agents can assist fund allocators, reviewers, fund seekers and experts. Agents will check eligibility criteria, allocate funds and monitor the progress of the projects. New approach brings more transparency in the funds allocation procedure. With the use of Information Technology, time required to process proposals is reduced.

1.3. **Problem Statement and Objectives**

The purpose of the resource allocation and monitoring system is to allocate funds to the deserving and competing fund seekers, bringing more transparency in allocation procedure, being less time consuming, a uniform evaluation policy and distribution by considering both quantitative and non-quantitative decision-making factors. Expert
Committee formed by fund allocator evaluates the proposals. Sometimes, fund seekers are asked to present their proposals before the experts. Funds are allocated after the review of proposals. Once funds are allocated, it becomes essential to know in time, the progress of the project and to monitor the fulfillment of objectives for which funds are allocated. Fund seekers are asked to present the progress of their projects during execution and on completion of the project.

Presently, the process of funding is either manual or makes minimal use technologies. Status of utilization of funds is updated at regular interval of time. Moreover, monitoring is not integrated with allocation procedure, due to which it is difficult to monitor the progress of the project. The proposed system called Multi-agent System for Resource Allocation and Monitoring (MASRAM) is designed and developed. It simulates the behaviors of fund seeker, fund allocator, reviewers and experts into software agents of MASRAM. Resource allocation procedure is made transparent, uniform, simple, cost effective and less time consuming. Integration of monitoring procedure with allocation procedure simplifies the method to monitor the progress of the project and fulfillment of the objectives. It comprises multiple decision-making factors with fuzzy values such as Good, and Very Good for comparing the proposals. Hence, use of MCDM (Multi Criteria Decision Making), Fuzzy set and AHP (Analytic Hierarchy Process) help in simulating the behavior. AHP compares proposals relatively after giving fuzzy values to the decision-making factors.

1.3.1. Objectives

Followings are the objectives of designing and developing MASRAM.

i. The system helps the fund seeker to find the appropriate funding agencies from where funds can be availed based on the nature of projects, funds required and the type of fund seeker. It also helps fund seeker to submit the project proposal.

ii. The system filters the proposals as per minimum eligibility criteria set by fund allocator. Only eligible fund seekers are given funds. It also considers the experts' feedback on presentation given by the fund seeker while short-listing the proposals for funding.

iii. The system makes decision to allocate funds based on rank given to the proposals after evaluating decision-making factors and assigning weights using techniques of MCDM, AHP and Fuzzy logic.
iv. The system periodically monitors the progress of the projects and utilization of funds. It decides the continuity of projects, submits recommendations for further funding and status of projects such as complete, incomplete or terminated.

1.4. Research Contributions

The research contributions includes designing and developing a prototype to allocate resources (Funds) to the deserving fund seekers to execute their projects and monitoring the progress thereafter using Multi-agent technology in the web-based environment. The prototype is implemented using Java Agent Development Framework (JADE), Java Server Pages (JSP) and Oracle database. The prototype is verified against test data generated for this purpose. In an attempt to achieve the desired research goals, the following contributions have been made during the research work.

1.4.1. Identification of Decision-making Factors and their Weights

Resource allocation problem is a decision-making problem and requires decision-making factors to allocate funds. To identify decision-making factors, existing procedures to allocate funds and monitor the progress of the projects of funding agencies like UGC, DIT and DST were studied. Experts in this area were also consulted to get their views. Based on experts’ feedback and existing procedures, twelve decision-making factors are identified. A well-defined questionnaire was prepared. The questionnaire was given to experts and requested to rate the decision-making factors. Their responses were collected and compiled using AHP. With AHP, alternatives are compared with each other using pairwise comparison matrix. It assigns relative scale, importance, or value to each alternative. In our research problem, alternative is project proposals. These factors and their weights are used to rank the proposals.

1.4.2. Use of Decision-making Factors in Allocation of Resources

A common project proposal submission form to capture the details of project is designed so that the information required to evaluate decision-making factors can be fetched. The quantitative decision-making factors like experience of the staff and non-quantitative factors like impact of the project on society are used to evaluate project proposals with help of MCDM technique. In MCDM, each decision-maker is asked to assign value to each criterion, but in solving resource allocation problem, system itself
assigns value to each criterion after gathering information from the proposals. The values assigned are accumulated using Geometric Mean (GM) to get overall rating. Geometric Mean is better than average since it takes into account the effect of compounding and is better for long term calculations. It is average of logarithmic values of dataset. GM tends to dampen the effect of very high and very low values which may bias the mean if average mean is taken.

1.4.3. Monitoring the Progress

A form to monitor the progress of the project and utilization of funds is designed. Fund seeker provides the information in this designed form. The form contains checklist to get the progress. Depending upon fund category, fund seekers may present the progress of the project before experts. The fund seeker user and experts provide reviews using checklist to fund allocator. This information is used to monitor the progress and utilization of funds. This also helps fund allocator in deciding the continuity of the project and completeness of the projects.

1.4.4. Formalization of Resource Allocation and Monitoring Problem using Multi-agent Technology

The problem to identify agents required for resource allocation and monitoring system is solved based on responsiveness of agents, knowledge available with agents and actions to be performed by agents. Three agents are identified: Fund Seeker Agent (FSA), Fund Allocator and Monitor Agent (FAMA) and Facilitator Agent (FCA). FSA helps fund seeker to submit proposals and progress of the projects. FSA agent is capable of finding appropriate sources for funding depending upon the type of fund seeker (individual or organizational), funds required and the nature of project. FAMA helps fund allocator in evaluating proposals against decision-making factors, assigning weights, calculating overall rating of proposal and ranking the proposals. The proposals are then allocated funds according to percentile policy. Percentile divides the distribution into two or more groups. Each group has its own maximum fund limit and percentage of demanded funds that can be allocated. The group in which overall rating of the proposal falls is identified and funds are given accordingly. FAMA performs actions after observing the change in state of objects in environment, e.g. on getting feedback from experts on proposal presentation given by fund seeker, FAMA starts allocating funds. Before allocation, it ensures that all other criteria meet requirement.
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FAMA also helps fund allocator in monitoring the progress. The solution provided is named as Multi-agent System for Resource Allocation and Monitoring (MASRAM).

1.4.5. Weight-based Distributed Algorithm to Allocate Funds

A weight-based distributed algorithm having five steps is designed to allocate the funds. The algorithm is distributed because the required information and rules to allocate funds are distributed between agents. In the first step (Gathering Initial Values), initial data like fund category, maximum funds, the type of fund seeker and proposal is captured. In second step (Filtering Proposals) proposals are checked against the criteria set by fund allocators. The proposals satisfying the criteria are shortlisted for allocation while others are rejected. In third step (Review of Proposals), the feedback of experts on presentation by fund seeker is captured and analyzed. Proposals getting positive feedback are the only ones which are considered for allocation. In fourth step (Evaluating Proposals), the proposals are evaluated against decision-making factors. The final step ( Allocating Funds) has further three tasks to perform: Assigning Expert Weights, Calculating Cut offs and distribution of funds depending upon weighted values assigned to project and cut offs.

1.4.6. Establishing Communication between Agents of MASRAM

Ontology is designed to establish effective communication between agents of MASRAM along with database. Ontology is used to share knowledge between agents of MASRAM. Various messages like inquiring the status of allocation from FAMA by FSA and request of FCA to FSA to provide list of appropriate sources of funding depending upon criteria are passed using ontology. Agents also use database to share information e.g. FSA agent stores the proposal in database after taking input from fund seeker. FAMA, at a specific time, picks up the proposals and performs further action to allocate funds.

1.4.7. Implementation of Agents of MASRAM in Web-based Environment

To provide a user-friendly graphical interface to the users of the system, a web-based solution was found more effective than traditional client-server architecture. In web-based applications, users need not to install any additional software component except browser at the client sides. The graphical interface also interacts with agents running at server side. Hence, a prototype for web-based environment is developed using multi-agent development tool, Java Agent Development Framework (JADE), JSP and Oracle database. WSIG (Web Service Integration Gateway) provides support