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Existing procedures to allocate funds and monitor the progress of the projects were studied in detail along with advances in research and development in the area of resource allocation and monitoring. Resource allocation problem is found to be a Decision-making problem. Decision-making is a mechanism for making a choice among different alternatives during every step of the problem solving and is an integral part of the problem solving. In making decision, an alternative i.e. proposal in case of funding, that meets certain criteria and is better than the others is selected or given preference \[12\]. Based on this concept, a review of related literature and existing procedures is done and classified into two parts: (i) Conceptual Review and (ii) Technological Review. Conceptual Review is based on theory and concepts in this domain. It discusses the methods followed in allocation and monitoring procedures. Technological Review is concerned with the use of technologies in resource allocation and monitoring system like Excel Solver and Multi-agent technology. This chapter details both types of reviews and research methodology adopted to carry out research.

2.1. Conceptual Review

Various approaches have been used in the past to allocate funds to the deserving fund seekers. Jery L. Mumpower et al. have compared three approaches to allocate funds: Incremental, Negotiate and Weight based \[13\]. Incremental Approach to allocate resource (funds) begins with zero allocation and then allocating small resources until resources are exhausted. In Negotiation approach, resources are moved from one place to another depending upon utility function. Weight-based approach assigns weights to allocate resources. Another method to allocate fixed and limited funds is based on the criteria set by allocating agencies \[14\]. For each criterion, definite amount is allocated on the basis of how well each proposal meets criteria. The seekers may have strengths and weaknesses concerning the criteria. There are two main factors in making decision: Technical Importance and Cost Effectiveness. Technical Importance measures the impact of Resource Activities (Work Package) on the objectives of research program like customer satisfaction. Cost effectiveness is concerned with expenditure required to execute the scheme. A proposal with
high technical importance and high cost effectiveness is given highest priority for funding over others [15]. The proposal with low technical importance and high cost effectiveness is also given funds. The proposal with high technical importance and low cost effectiveness is given chance for improvement. The proposal with low technical importance and low cost effectiveness is rejected for funding. While allocating funds, factors like expected profit and probability of meeting targets are also considered [16].

Apart from the above-mentioned resource allocation techniques, mathematical techniques based on Linear Programming, non-linear programming models and Branch & Bound are also being used. These techniques are applied in solving Resource Allocation Problems like production and transportation planning [17, 18]. For the network resource allocation, e.g. processor sharing, congestion control and power control, it makes use of parameters that are usually design variables. Approaches for resource allocation can be Centralized, Hierarchical, Bi-directional or Random Resource Allocation [19].

Robert L. et al. proposed two methods to select alternative while allocating resources: Event and Process [20]. Events perspective focuses on the outcome, but is mostly ignored by industry. Process based decision is concerned with processes involved rather than outcome. In the past, this technique has been used in the selection of R & D projects. S. Coldrick S. et al. defined two stages mechanism to allocate resources to research and development projects [21]. First stage is filtering, that checks the projects against set criteria; in the second stage, non-quantitative criteria are considered. Quantitative factors provide a numeric value for making decision. Such factors are insufficient in decision-making, hence non-quantitative factors like SWOT (Strength, Weakness, Opportunity, Threat) and PEST (Political, Economic, Social, Technology) analysis are also considered in association with quantitative factors. Non-quantitative factors are not easy to measure quantitatively. Quantitative factors are easy to identify and calculate while non-quantitative factors require human knowledge to deal with.

Decision-making problem involving subjective data, which cannot be converted into numeric value, is solved using techniques of Fuzzy Logic, Multi Criteria Decision Making (MCDM) and AHP (Analytic Hierarchy Process). Fuzzy set theory was introduced to deal with uncertainty and vagueness in data. Major advantage of this theory is to represent vague data. It also allows intermediate values to be defined between traditional values like ‘Yes’ and ‘No’. Hence, it is used in quantification of non-quantitative factors. Quantification of
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non-quantitative factors is important to make decision of allocation [22]. The probabilistic tools are also used to deal with such data. This approach has been in use to rank employees' performance using both quantitative and non-quantitative measures.

Non-quantitative factors are also handled with MCDM. MCDM analysis can assist the decision makers to evaluate and rank the project proposals. In this method, each decision maker is asked to evaluate each alternative against set criteria and assign the value [23]. The assigned value is taken from a pre-defined set [24]. Combination of MCDM and fuzzy set theory also tackles the decision issues in the selection of alternatives. This has been in use to solve the problem of infrastructure projects [25]. Projects are ranked and classified into five levels: Urgently Needed, Needed, Much Needed, Rather Needed, and Slightly Needed. First two level projects are satisfied with 100 percent allocation. Remaining projects are ranked. Funds are given according to their respective ranks until funds are exhausted.

Another approach to solve decision-making problem involving multi-criteria is Analytic Hierarchy Process (AHP). It has now become most widely used decision-making technique. It involves six steps: (i) Defining Unstructured Problem, (ii) Planning Hierarchical Structure, (iii) Applying Pairwise Comparisons, (iv) Use of Eigen Values, (v) Checking Consistency and (vi) Aggregating Relative Weights. In the original model, AHP is based on four steps: Problem Solving, Weight Valuation, Weight Aggregation and Sensitivity Analysis [26]. These four steps have been re-grouped into six steps. AHP is also useful when non-quantitative factors are further divided into sub factors and is depicted as decision-making problem of multi criteria. The idea behind making hierarchy of criteria is to depict top-down managerial concepts and bottom-up evaluation of criteria. Lowest level factors are calculated first and then accumulated at higher level. While fuzzy logic is suitable for evaluating factors, AHP is suitable for comparing alternatives among criteria rather than merely ranking. Integration of fuzzy logic with AHP gives advantage of making subjective factors more quantifiable [27, 28, 29, 30]. Integrated approach of AHP and Fuzzy is also used in making decision to select alternatives. Mohamad Ashari Alias et al. used Fuzzy-AHP to rank choices for best use of river system [31]. Integration of these techniques results in making good choice among multiple alternatives.

Decision-making models proposed in past have been classified into three categories: Decision Theory Approach, Economic Analysis, and Operations Research Approach [32]. Decision Theory models rely on subjective or qualitative input variables. Economic Analysis
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is based on probability in terms of investment required and expected revenue. It makes use of methods like NPV (Net Present Value) and Discounted Cash Flow [33]. It also assumes that profit is the only objective. NPV and other discounted cash flow methods are found inappropriate in research and development project selection as they favor more for short-term projects and not the long-term projects where market is uncertain [34]. Problem arises when non-economic benefits are considered. The Operations Research approach is characterized by the use of mathematical programming techniques to optimize selection of alternatives, provided constraints and other resources are available.

According to Asit K. Biswas, monitoring is defined as “Continuous or periodic surveillance over the implementation of an activity to ensure that input deliveries, work schedules, targeted output and other required actions are proceeding according to the plan” [35]. The main issues are frequency, timing, depth (formal or informal), and breadth (beyond cost and time). To monitor the progress of projects and utilization of funds, two monitoring tools such as PERT and Gantt chart are useful [36].

2.2. Technological Review

During the research work, use of the technology in resource allocation has been studied. Work already done in the area of resource allocation and monitoring systems using different technologies from time to time is reviewed. Basic computation tools like Excel Solver have been found useful to implement the resource allocation and monitoring concepts especially in Economics Analysis and Operations Research Problems. Financial methods like NPV and Cash Flow are easily found in office automation tools. However, drawback of these tools is that they take only defined and quantitative input. EGSA (Educational Guidance Service for Adults) organization has developed a project monitoring system to provide statistical information to the government agencies [37]. It is a web based e-monitoring system currently having 100 projects and their status. This e-monitoring system provides basis of managing, planning and evaluating data on the funded projects. Association of Southeast Asian Nations (ASEAN) is responsible for promoting higher education [38]. The aim of this organization is to promote human resources for development and enhance the quality of education. As on 1\textsuperscript{st} September 2006, ASEAN has 132 projects for which funds have been received from different countries like Indonesia, Malaysia, and Singapore. Need for monitoring the projects arises because projects are dynamic in nature and are carried out in changing environment [39]. Fund allocating agencies and fund seekers are making use of
their web sites. These are not integrated with core problem of resource allocation and monitoring. Status is uploaded at a regular interval of time.

Anthony Chavez et al. designed a multi-agent system to allocate CPU timings in distributed environment [40]. They developed Challenger Simulator with graphical interface written in Java to know the states of agents. The agents communicate with each other to share their resources particularly CPU (Central Processing Unit) time. User Agent is responsible for broadcasting request for bids to all agents over network. The message contains job ID, priority and expected duration to complete the job. It also evaluates all the received bids. It assigns task to the best bidder. Another agent, a service agent, responds with bid giving estimated time to complete the job. It is based on Market Based Control System, in which buyers and sellers always try to maximize their own utilities. It describes three objectives: maximizing processor utility, minimizing mean flow time and minimizing the response ratio. Mean flow time is average time when a job is originated to when it is completed. Processor utility is percentage of CPU time allocated. Mean response ratio is the average ratio of actual time needed to complete the job divided by the time required to run that job on unloaded benchmark processor.

Gorodetski et al. used Multi-agent Technology in resource allocation problem of scheduling within shipping logistics problem [41]. It is based on Auction based resource allocation approach because in most of the planning and scheduling tasks, restricted resources cause the constraints. There are two types of agents: Auctioneer and Contractor. Auctioneer Agent is responsible for meta level management (Choosing processor), order sequencing, analyzing quality of standard offered by contractor and resource allocation management. Contractor Agent uses shortest route and participates in whole/part of the order. The algorithm uses heuristics technique to find the winner. Chevaleyre Y. et al. discuss use of multi-agent system in allocation of different types of resources like networking connection among agents [42]. While allocating resources, the agent responsible for distributing resources considers the preferences given by agents who avail resources. Multi-agent technology is being used in wide range of applications like industrial, manufacturing, networking scheduling and scheduling.

Peng Y. et al. proposed multi-agent system of Intelligent Enterprise Integration to cover business applications of procurement, manufacturing scheduling and network routing [43]. Any entity receiving resource is referred to as an agent. Receiving agents may have
preferences and allocation is done according to their preferences. Specialized agents are
developed to gather required information and knowledge spread over multiple legacy
systems. They cooperate with each other and interact with the users to make decision in
dealing with various enterprises level tasks. It uses six agents to integrate all the legacy
systems: Gateway Agent, Broker Agent, Monitor Agent, Parameter Agent, Analysis Agent,
and Coordinator Agent.

Combination of multi-agent, fuzzy sets and MCDM is used to develop intelligent
systems like e-SCM (Supply Chain Management) [44]. This model is based on multi-agent
architecture whose function is to map buyer-seller considering quantitative and qualitative
attributes using fuzzy logic. The model uses two matrices: one for supplier and another for
buyer to store fuzzy values for different attributes. Qualitative attributes of buyers were
identified as service level, aesthetics etc. and for supplier, attributes like customer
satisfaction, geographical benefits etc. are considered.

In designing and developing multi-agent systems, emphasis is given to
communication that takes place between agents. Communication is a form of interaction
between agents [45]. Though agents are autonomous entities capable of doing tasks
independently, yet they need help of other agents operating in the environment in multi-agent
system to accomplish the overall goal. Agent either shares information produced by it with
other agents or requests other agents to perform some task related with it. Former is called
Information Sharing and later is called Task Sharing. They generally do this using common
language known as Agent Communication Language (ACL). ACL is declarative in nature so
that the agents can understand the messages exchanged. FIPA (Foundation for Intelligent
Physical Agent) - ACL is widely used MAS in which agents coordinate with each other.
Other used ACL in MAS is KQML (Knowledge Query Markup Language) [46].

Agents use database at backend in complex business applications. Agents in MAS
cannot work without cooperating with each other despite the fact that they are autonomous
and capable of solving complex problem independently. In both the cases, database is used
[47]. Task sharing is related with requesting the agent to perform task (complete/partial).
Information sharing is concerned with sharing information with other agents. Databases are
widely used in various agent-based applications such as Cross Enterprise Resource Planning
for small and medium enterprises, Airline Operation Control System and health sectors [48,
49,50]. Use of databases in these applications has made the communication between agents
simple and more effective. Availabilities of technologies and techniques such as Broadband Networks, Virtual Realities and Artificial Intelligence techniques have increased the interest in web-based applications [51]. Decision-making capabilities are also embedded in web-based systems such as Tender Evaluation, e-learning and class scheduling plan using multi-agent systems [52, 53]. Various agent-oriented tools are available to develop intelligent agents that include basic services like Communication Act. One of them is JADE (Java Agent Development Framework). It is FIPA compliant tool. JADE simplifies the implementation of MAS through middle tier. Messages in JADE can be passed through string data type, Java object or ontology [54, 55]. JESS is another widely used agent development tool [56].

The characteristics of Object Relational Database Management System (ORDBMS), Oracle encourage the developers to use it as backend support in multi-agent based applications. The capabilities of such databases to store attributes and methods of class as User Defined Type (UDT) and to use them further as column data type in table is another reasonable factor to support agents of resource allocation problem. Moreover, normalization is not used in object-oriented concept [57]. ORDBMSs are widely used for data storage and manipulation, as these are strong on handling real world application and in this category, Oracle 9i is popular ORDBMS database [58]. Oracle has collection objects like nested table and Varrays. With nested tables, it is easy to store information of one object in a single table.

To model and design, multi-agent based applications, Agent Unified Modeling Language (AUML) technique is used. AUML is a graphical modeling technique that is standardized by Technical Committee of FIPA. AUML is a system specification technique covering the whole software engineering process- from planning, through analysis, design, implementation including code and deployment [59].

Presently, the process of funding is either manual or makes minimal use of technologies. Status of utilization of funds is updated at regular interval of time and is not integrated with allocation. There is no system available to allocate funds and monitor the progress using multi-agent technology with the support of database. This motivated the present researcher to design and develop a Multi-agent System for Resource Allocation and Monitoring (MASRAM) in the web-based environment.
2.3. Research Methodology

After conducting the conceptual and technological reviews of resource allocation and monitoring problem, a well-defined and effective methodology consisting of the following steps was adopted to complete the research work.

2.3.1. Modeling Multi-agent System for Resource Allocation and Monitoring

Resource Allocation and Monitoring System is modeled using multi-agent technology. During modeling the system, procedures for fund seeking, fund allocation and monitoring are defined. In addition to procedures, three software agents: Fund Seeker Agent (FSA), Fund Allocator and Monitor Agent (FAMA) and Facilitator Agent (FCA) are also identified. Roles and responsibilities of each agent are defined. FSA acts on the behalf of Fund Seeker, FAMA acts on the behalf of Fund Allocator and FCA acts as a facilitator between users of system and agents. Four types of users are identified who interact with system: Fund seeker, Fund allocator, Reviewers and Expert. Agent Unified Modeling Language (AUML) is used to model the system [60].

2.3.2. Designing Multi-agent based Solution

The communication between agents takes place using ontology with back support of database. With the help of well-defined Ontology, messages are passed from one agent to other. Agents in Multi-agent environment communicate with each other as information/rules required to take actions are distributed among them. Database stores the data like fund categories, proposals, progress reports, experts’ feedback and other parameters required to allocate funds. Agents use this data and share with each other. Apart from ontology and database, design also covers detailed pseudo codes of the actions performed by agents at different stages.

2.3.3. Implementation of MASRAM

The complete designed MASRAM was implemented using JADE and JSP with back support of Oracle as database. A three-layered web-based architecture is proposed comprising Presentation Layer, Agent Layer and Database Layer. Presentation Layer is used to provide interface to the users. Agent Layer implements three defined agents and Database Layer stores the information for sharing among agents.
2.3.4. Verification of the System

The prototype developed was verified against test data set generated for the purpose of verification. Fourteen test cases are used to verify the system completely.

Based on conceptual and technological reviews related with resource allocation, monitoring and multi-agent technology, a Multi-agent System for Resource Allocation and Monitoring is modeled, designed, implemented and verified by adopting the research methodology as discussed in this chapter.