An Organizational Decision Support Approach to R&D Project Selection

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Abstract

R&D project selection is an important task for organizations with research and development project management. It is a complicated multi-stage decision-making process which involves groups of decision makers. Current research on R&D project selection mainly focused on mathematical decision models and their applications, but ignored the organizational aspect of the decision-making process. To extend the current research, this paper proposes an organizational decision support framework for R&D project selection. Based on which, an organizational DSS has been developed and used for selection of projects in the National Natural Science Foundation of China. The proposed framework aims at modeling the process of R&D project selection at organizational level. Also, it supports the whole life cycle of the decision-making process.

1. Introduction

R&D project selection is a crucial task for organizations like government funding agencies, universities, research institutes, and technical-intensive companies. It is a complicated decision-making process with features of multiple stages, multiple groups of decision-makers, multiple and often-conflicting objectives, and high risk and uncertainty in predicting the future success and impacts (Ghasemzadeh & Archer, 2000).

Considerable efforts have been made in the past four decades to help organizations make better decisions in R&D project selection (Martino, 1995; Henriksen & Traynor, 1999). Most of them focus on building decision models and developing decision-making methods. (Henriksen & Traynor, 1999) reviews literature and classifies current decision models and methods into the following categories: unstructured peer review, scoring, mathematical programming, economic model, decision analysis, interactive method, artificial intelligence, and portfolio optimization. To improve the usability of these decision models and methods, current research efforts are to employ computer-aided decision support systems to support the R&D project selection tasks (Bard et al., 1988; Liberatore, 1988a, 1988b, 1995; Iyigun, 1993; Kocaoglu & Iyigun, 1994; Ghasemzadeh & Archer, 2000).

However current research on R&D project selection models the process of project selection from a micro point of view. Also, the decision models proposed are usually effective to facilitate single decision-making task with limited participation of decision makers. In practical applications, there is an urgent need to integrate the decision models, methods and decision support systems to facilitate the whole life cycle of the project selection process.

This paper aims to model the R&D project selection problem from the perspective of organizational decision-making. We argue that R&D project selection is a decision-making task of organization-wide rather than any single task with limited decision-makers. Thus organizational decision support system (ODSS) is a suitable architecture to support the decision-making process of R&D project selection.

ODSS is a decision support system, which applies the technologies of computers and communications to enhance the organizational decision-making process (Nunamaker et al. 1992). It is very different from the
traditional DSS and GDSS in aspects such as scope, task scale, organizational complexity, technologies involved, and system architecture. Much research has been done on its conceptualization and system architecture (George, 1992; George et al., 1992; Fedorowicz & Konsynski 1992; Stohr & Konsynski, 1992). Recent advancement includes ODSS design (Howaorka at al., 1995), implementation methodology (Kivijarvi, 1997) and so on (Kaula, 1994; Aggarwal & Mirani, 1995, 1996; Santhanam, 2000). ODSS have been applied to support decision-making in distributed situation (Thomas et al. 1998), telecom (Young-Gul Kim et al., 1997), military (Carter et al.), energy (Sen et al., 2000), and other areas (Perira, 1995; Bright, 1996). However few literature can be found on the application of ODSS in R&D project selection.

An ODSS framework for R&D project selection is presented in this paper. At the conceptual level, modern organizational theory on teams and group cooperation has been used to model the R&D project selection process. At the system design level, work groups are employed in supporting the R&D project selection process. Systems, methods and devices are provided for organizations to manage work groups.

2. Modeling R&D Project Selection Process

Based on an analysis of the case below, we identify some group-based decision-making features of R&D project selection and establish a conceptual model of project selection process.

2.1 A Case of R&D Project Selection

The National Natural Science Foundation of China (NSFC) is the management institution of the National Natural Science Fund with a primary aim to promote and finance basic and applied research in China.

Every year, NSFC receives about 25,000 applications which fall into six categories: General Program (the main part of NSFC's programs with 60% of NSFC's fund with Average Financial Support (AFS) of 180,000 RMB Yuan), Key Program (with AFS more than 1 million RMB Yuan), Major Program (with AFS more than 5 millions RMB Yuan), National Science Fund for Distinguished Young Scholars (with AFS more than 800,000 RMB Yuan), and Special Funds and Programs for International Cooperation and Exchange. For example in 1988-1999, NSFC supported more than 50,000 projects in General Programs, 779 projects in Key Programs, 166 projects in Major Program, and 599 projects in Distinguished Young Scholars.

NSFC has a unique evaluation system for facilitating project selection process. More specifically, NSFC maintains a peer reviewer database with more than 30,000 records, and employs more than 700 experts from 59 disciplines for panel evaluation. Although the evaluation process is somewhat different for projects in different program categories, the basic steps for project selection are similar. The basic steps include: Research Proposal by Applicants, Issued by their Affiliated Institution(s), Preliminary Evaluation by NSFC Departments, Peer Review, Panel Evaluation, and Approval by NSFC.

2.2 Group-Based Decision-making Features of R&D Project Selection

Analyzing and designing organization processes around groups (teams) has been widely addressed in modern organizational theories (Nunamaker et al., 1992). R&D project selection can be regarded as an organization-wide decision-making task, which is actually accomplished by a set of independent decision-making groups (see Table 1 for a number of possible decision-making groups for R&D project selection and their associated responsibilities). Although there are different decision objectives, decision task complexity, decision models and methods employed, group size, proximity, communication channel and interaction protocol between the independent decision-making groups, these independent groups works together towards the common organization goals, and coordinate with each other by performing their tasks in a certain sequence in which the outputs of one tasks (performed by a group) must be used as the inputs to another task (performed by another group).
<table>
<thead>
<tr>
<th>Group No.</th>
<th>Group Name</th>
<th>Group Members</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>proposal preliminary evaluation</td>
<td>1. department as well as the division managers of the found; 2. applicants; 3. research office coordinators of the institutes the applicants affiliated.</td>
<td>1. Ensure the completeness of proposal  2. Ensure the applicants and the proposal meet the requirements.</td>
</tr>
<tr>
<td>2</td>
<td>proposal assignment</td>
<td>1. division managers; 2. managers of other divisions.</td>
<td>1. Assigning each proposal to one or more peer reviewers in the same domain; 2. For those across disciplines, may transfer to another division.</td>
</tr>
<tr>
<td>3</td>
<td>peer review</td>
<td>1. division managers of the found; 2. peer reviewers.</td>
<td>1. Peer reviewers evaluate the proposals assigned; 2. Division managers coordinate the process as coordinators.</td>
</tr>
<tr>
<td>4</td>
<td>review results validation and summary</td>
<td>1. division managers.</td>
<td>1. Validate the peer reviewer’s results; 2. Make decision for those un-valid review results; 3. Recommend proposal list for panel evaluation (margin proposals selection)</td>
</tr>
<tr>
<td>5</td>
<td>panel evaluation</td>
<td>1. department and division managers; 2. domain experts employed.</td>
<td>1. Portfolio to be founded proposals; 2. Make decisions for margin proposals; 3. Format final recommendation of funded list.</td>
</tr>
<tr>
<td>6</td>
<td>Issue the funded list</td>
<td>1. top managers; 2. department and division managers.</td>
<td>1. Confirm the final recommendation list; 2. Treat exception cases.</td>
</tr>
<tr>
<td>7</td>
<td>Selection and evaluation peer reviewers</td>
<td>1. department and division managers; 2. domain experts employed.</td>
<td>3. Made reviewer selection and management rules; 4. Evaluate the reviewers based-on their evaluation history.</td>
</tr>
<tr>
<td>8</td>
<td>made the evaluation systems</td>
<td>1. Managers of the found; 2. domain experts employed.</td>
<td>1. Made evaluation systems for different kinds of programs; 2. Adjust the evaluation systems based on practice and environment changes.</td>
</tr>
</tbody>
</table>
In (DeSanctis & Gallupe, 1987), a taxonomy of decision-making group is proposed with the following three dimensions: group size (smaller vs. larger), member proximity (face-to-face vs. dispersed), task type (mixed motive, cognitive conflict, preference, intellectual, creativity, or planning). In (Bui & Jarke (1987), another taxonomy is presented, based on group’s communication patterns, with the dimensions of spatial distance, temporal distance, centralization of control, and degree of cooperation. In this paper, we consider the following four dimensions to categorize decision-making groups for R&D project selection:

- **Task nature**: structured, semi-structured, and unstructured
- **Temporal distance**: real-time, days, months, and long term
- **Degree of cooperation**: cooperation, semi-cooperation, non-cooperation
- **Members’ accessibility to group’s information**: fully accessible, and partially accessible.

Against the above four dimensions, the decision-making groups (proposed in Table 1) involved in R&D project selection are presented in Table 2. Based on the proposed decision-making groups and their features in R&D project selection, a project selection process is proposed and presented as shown in Figure 1.

3. An ODSS Architecture for R&D Project Selection

3.1 Architecture Overview

Following modern organizational theories of analyzing and designing organization processes around groups (teams), ODSSs have be viewed as the support tools for interacting groups (Nunamaker et al., 1992). From this perspective, an ODSS is to support the overall life-cycle of each group as well as its interactions with other groups of the organization. The major functions of ODSS are to manage group activities such as group creation, communication, and coordination. Based on this perspective and the process model of R&D project selection (see Figure 1), we propose an ODSS architecture (see Figure 2), which focuses on the basic group management functions.

The overall architecture of the ODSS falls into the browser/server paradigm. The system at the server end consists of three parts:

<table>
<thead>
<tr>
<th>Group Name</th>
<th>Task Nature</th>
<th>Temporal Distance</th>
<th>Degree of Cooperation</th>
<th>Information Accessibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>proposal preliminary evaluation</td>
<td>semi-structured</td>
<td>days</td>
<td>cooperation</td>
<td>fully</td>
</tr>
<tr>
<td>proposal assignment</td>
<td>semi-structured</td>
<td>days</td>
<td>cooperation</td>
<td>fully</td>
</tr>
<tr>
<td>peer review</td>
<td>structured</td>
<td>months</td>
<td>cooperation</td>
<td>partially</td>
</tr>
<tr>
<td>review results validation and summary</td>
<td>semi-structured</td>
<td>days</td>
<td>cooperation</td>
<td>fully</td>
</tr>
<tr>
<td>panel evaluation</td>
<td>unstructured</td>
<td>real times</td>
<td>semi-cooperation</td>
<td>fully / partially</td>
</tr>
<tr>
<td>issue the funded list</td>
<td>unstructured</td>
<td>days</td>
<td>cooperation</td>
<td>fully</td>
</tr>
<tr>
<td>selection and evaluation peer reviewers</td>
<td>unstructured</td>
<td>long term</td>
<td>semi cooperation</td>
<td>fully</td>
</tr>
<tr>
<td>made the evaluation systems</td>
<td>unstructured</td>
<td>long term</td>
<td>semi-cooperation</td>
<td>fully</td>
</tr>
</tbody>
</table>
experts for evaluation systems

Applicants and its affiliated institute RO coordinators

department & division managers of the found

Proposal DB

evaluation systems rule base

peer reviewers DB

proposals with their peer reviewers and evaluation systems

peer reviewers

division managers of the found

division managers (as coordinators)

peer reviewed proposals

division managers

validation, summary and aggregation to each projects

pannel experts

department & division managers

final recommendations

top managers & department, division managers

lists for funded projects

Legend:

DB/KB
experts / agents
decision-making output
decision-making group with no. m

Figure 1. R&D project selection process model
Organizational Information Resources Management System: it manages the overall information resources of the organizations, including organization rules guiding project selection, submitted proposals, data of people involved in project selection (staff of the organization and all domain experts), and decision models facilitating project selection decision-making.

Group Management System: it is responsible for managing the overall life-cycle of decision-making groups. It can be understood as a gateway between the groups as well as between the groups and the organizational information resources. Specifically, it plays the roles of generating groups, maintaining groups, coordinating group activities, and terminating groups.

Living Environment of Groups: Groups can exist in many ways, including web-based systems, email-based systems, electronic meeting systems, workflow systems as well as text/video-based conferencing systems. The living environment provides technique infrastructure for running local systems of individual groups.

The Organizational Information Resource Management System and Group Management System are global and are shared by all the groups. However, they cannot be configured by any single group. Nevertheless, each group is allocated a local server, which can be configured by the group according to its intentions, but only provides services for members of the group.

At the end user side, users are categorized as internal and/or external.

Internal Users usually are staff of the organization and play the role of the controllers or coordinators. They usually are assigned a group task, and then use the Group Management System to create a group, define the goal, and coordinate the work process until reaching the final decisions.

External Users usually are the peer reviewers, research office coordinators of other organizations, and experts invited to join in the project selection process. They are usually with lower information accessibility. They do not interact with Group Management System and their work processes are coordinated by their group’s controller(s) or coordinator(s).

Under this architecture, the organizational decision-making may proceed as a decision-making group creation process according to the decompositions of decision-making tasks (see Figure 3 for details). As illustrated in figure 3, for a given organization-wide task Task-1 of A-1, A-1 decomposes the task into several subtasks, say Task-11, Task-12, Task-13, and creates a group, say group-1, including members, say A-11, A-12, and A-13. Each member is assigned to a subtask, say Task-11 to A-11, Task-12 to A-12, and Task-13 to A-13. If a member cannot complete the assigned subtask by himself/herself, he/she has to decompose it into pieces, create a new group, and assign each piece of the subtask to a member. The process will be repeated until every task piece can be handled by a single decision-maker.

3.2 Alternative Configurations for Groups in R&D Project Selection

According to features of the decision-making groups identified for R&D project selection (see Table 1 and Table 2), alternative configurations to support each of the group’s decision-makings are suggested as shown in Table 3.
3.3 Comparison with other ODSS Architectures

Several system architectures of ODSS have been proposed in the last decade (see (George, 1992) for a summary of most of them). Some of these architectures keep the basic components of personal DSS which mainly contains database, model base, and user interface. Examples include those of Walker, Pagni and Bellucci, Dondi et al., Philippakis and Green, and Miller and Nilakanta (George, 1992). There are some others, which address the new situations ODSS confront and possesses much more new components, and examples include those of Swanson and Zmud (George, 1992), Watson (George, 1992), and Holsapple and Whinston (Holsapple & Whinston, 1996). Coincidently, all of these architectures have addressed certain features of organization decision-making. Those inheriting the traditional DSS architecture address that ODSS is a kind of DSS, Holsapple and Whinston’s and Watson’s address the feature of multiple-person have been involved, while Swanson’s addresses that the decision-makings are distributed. However, our proposed architecture follows the tradition of modern organizational theory of analyzing and modeling organizational processes around the concept of group (team), and addresses the support and management to decision-making groups and their interactions.

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Members</th>
<th>Goal Descriptions</th>
<th>Communication Technologies</th>
<th>Support Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>proposal preliminary evaluation</td>
<td></td>
<td></td>
<td>Email</td>
<td>Electronic forms processing, intelligent agent</td>
</tr>
<tr>
<td>proposal assignment</td>
<td></td>
<td></td>
<td>Email, web-based collaborated operation to database</td>
<td>matching algorithm, NSS</td>
</tr>
<tr>
<td>peer review</td>
<td></td>
<td></td>
<td>web-based collaborated operation to database, Email,</td>
<td>Electronic forms processing, intelligent agents</td>
</tr>
<tr>
<td>review results validation and summary</td>
<td>Same as in the Table 1.</td>
<td>rules and other documents related to the responsibilities list in the table 1.</td>
<td>Structured workflow, email, electronic meeting</td>
<td>MADM models</td>
</tr>
<tr>
<td>panel evaluation</td>
<td></td>
<td></td>
<td>Electronic Meeting</td>
<td>NSS, Portfolio models, statistic models</td>
</tr>
<tr>
<td>issue the funded list</td>
<td></td>
<td></td>
<td>Electronic Meeting</td>
<td>Statistic models, visualization tools</td>
</tr>
<tr>
<td>selection and evaluation peer reviewers</td>
<td></td>
<td></td>
<td>Email /BBS</td>
<td>Data mining tools</td>
</tr>
<tr>
<td>made the evaluation systems</td>
<td></td>
<td></td>
<td>Email /BBS</td>
<td>Statistical models, Intelligent agents</td>
</tr>
</tbody>
</table>
4. Applying the ODSS Architecture in Real World: the ISIS Case

As the biggest natural science foundation in China, NSFC (the National Natural Science Foundation of China) has launched a five-year IT strategy to build a national-wide information system to support the project management and research disseminations. Internet-based Science Information System (ISIS, http://isis.nsfc.gov.cn) is a step to the goal.

4.1 ISIS Implementation

ISIS implemented the proposed ODSS architecture on Internet using the n-tier distributed computing technology (Scott, 1998). Moreover, unified approach of object-oriented software engineering is applied (Bahirami, 2000). Also, the Unified Modeling Language (UML) (Booch et al. 1997) has been chosen as the basic modeling language during the development phase. The matrix between the ODSS architecture components and the ISIS software components is shown in Table 4.

At present, ISIS supports four decision-making groups, which include the proposal preliminary evaluation, the proposal assignment, the peer review, and review results validation and summary.

ISIS supports group management by defining different type of users which include top manager, department manager, division manager, organizational user, principal investigator, external reviewer as well as project administration. Each user group has different information accessibilities. Top manager, department manager, and division manager have different permission to create their own decision-making groups. Figure 4 shows an interface, which allows division manager to create group and assign reviewers for proposals, while Figure 5 illustrates how group members/reviewers evaluate proposals.

4.2 Performance

As mentioned before, NSFC receives more than 25,000 research proposals every year. For each proposal, NSFC will assign five external reviewers to give assessments. In total, there are more than 75,000 peer review works. Before ISIS system has been developed, snail mail and telephone/fax system were used to support the reviewing process. Data accuracy and data capacity were comparatively low. It was difficult to support decision-makings effectively and efficiently. After ISIS has been launched, through Internet, the managers can manage decision-making groups dynamically and exchange information with their group members at any time and any place. Comparing with the performance before and after ISIS, Table 5 provides some findings for reference.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Processing Time</td>
<td>Two and a half months</td>
<td>One month</td>
</tr>
<tr>
<td>Valid Percentage of Total Evaluation</td>
<td>80%</td>
<td>94.5%</td>
</tr>
<tr>
<td>Electronic Processing Record Size</td>
<td>900 Bytes</td>
<td>More than 32K Bytes</td>
</tr>
<tr>
<td>Un-reaching Cases</td>
<td>27%</td>
<td>5%</td>
</tr>
</tbody>
</table>

Table 4 The matrix between the components of ODSS and of ISIS

<table>
<thead>
<tr>
<th>ODSS Architectural Component</th>
<th>System Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational Information Resources Management System (OIRMS)</td>
<td>&lt;&lt;Type Library&gt;&gt; Common Type Library for Universal Resource Request</td>
</tr>
<tr>
<td>Group Management System (GMS)</td>
<td>&lt;&lt;Sub System&gt;&gt; Group Management Sub-system</td>
</tr>
<tr>
<td>Group Living Environment (GLE)</td>
<td>&lt;&lt;Sub System&gt;&gt; E-Commerce Groupware</td>
</tr>
</tbody>
</table>
Notes:
♦ Overall Processing Time: The time cost on processing the overall round of evaluation. Generally, evaluation period has the starting date and end date that NSFC officially distributes evaluation form to external reviewer and reviewer return filled evaluation form respectively. This time period is the overall processing time of all evaluations.
♦ Valid Percentage of Total Evaluation: For those submitted evaluation, some of them is invalid due to the insufficient information provided or ill-fill data. Invalid evaluation should be returned back to reviewer for correction accordingly. Those can’t be returned or corrected before end date of evaluation will be void. Valid percentage can be counted by studying how many evaluations are not void in terms of all evaluations.

5. Conclusion

The purpose of this paper is to approach R&D project selection problems from a macro rather than a micro point of view, i.e., from the perspective of organizational decision-making rather than the perspective of single decision maker or unit. This approach aims to develop a framework to facilitate the whole life cycle of project selection process.

The major contributions of this research are as follows. First, a new ODSS framework for R&D project selection was proposed with the goal to extend the current literature of the field. The framework includes a group-based modeling method that facilitates R&D project selection process, and a corresponding ODSS architecture that support and coordinate the work of decision-making groups. Second, this paper presents an application of the proposed ODSS framework to a real project selection system. In conclusion, this research contributes a new ODSS architecture, which differentiates itself from the existing ones in addressing the support to decision-making groups of organizations for R&D project selection process.

References


