Stage Gate Analysis in Business-Academia Collaborative Project

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Abstract—This paper analyzes an actual business-academia collaborative project from the viewpoint of stage gate approach (we call this approach "*stage gate analysis*"). Stage gate analysis is a method of reviewing a finished project and summarizing it, whereas conventional stage gate management is used to control an on-going project. The case study analyzed is a project undertaken over a period of 6 years by Tokyo Institute of Technology, Toshiba Corporation and other companies to construct credit information infrastructure. The stage gate analysis clarifies success and failure factors of the project with a cause-and-effect relation map which can be utilized by other business-academia collaborative projects.

I. INTRODUCTION

Since success or failure of R&D projects largely depends on quality of management, project managers should learn and share best practices from previous projects. Although many success stories have been reported, it is difficult for managers to accumulate and enhance knowledge and skills from these stories. In these cases, we believe that analyzing and summarizing frameworks are required for knowledge reuse. The stage gate approach [1, 2, 3, 4] is one of the popular and effective frameworks to manage ongoing R&D projects. However, no one has shown a concrete procedure based on stage gate for backward review to analyze past projects and formalize knowledge and practices from them. In this paper, we introduce one concrete stage gate analysis specialized for software and service R&D projects in which activities of each stage and conditions of each gate are organized by a cause-and-effect relation map. We analyze an actual business-academia collaborative project based on our stage gate analysis, and extracts best practices from the analysis which can be utilized by other business-academia collaborative projects.

II. STAGE GATE ANALYSIS

Stage gate methods [3] are used to manage, direct, and accelerate R&D processes in many companies (e.g., 3M, Kodak, General Electric, Motorola, DuPont, Toray, Asahi Kasei). The main purpose in applying the stage gate method is to provide guidelines for project managers. The method suggests what the manager should do at each stage and what the important goals (gates=checkpoints) of the stage are. Although these guidelines of the stage gate method are of help, we still recognize the need for backward review after finishing projects (*"stage gate analysis"*), and aim to store practical tips of R&D project management in a reusable form for subsequent projects. The terminology "*stage gate analysis*" is used in several papers. However, none provides a concrete backward review from the stage gate viewpoint. Therefore, the following stage gate analysis method is proposed to satisfy the above requirements.

We adopt a customized stage gate method to software and services R&D projects. Our method consists of 7 stages and 6 gates (Table 1).

TABLE 1: STAGE GATE PROCESS FOR STAGE GATE ANALYSIS

Stage/ Gate	Activities and Conditions
Stage0	**Idea Discovery:** Pre-work designed to discover and uncover opportunities and generate ideas.
Gate1	Idea screen from 3 viewpoints: (G11) Strategic fit, (G12) Market attractiveness, and (G13) Technological competitive edge. In this gate, it is not necessary to satisfy all viewpoints, but one of them should be outstanding.
Stage1	**Concept Development:** Activities to make an R&D project plan including initial marketing and technology survey.
Gate2	Decision to start the R&D project from 3 viewpoints: (G21) Strategic fit, (G22) Market attractiveness, and (G23) Technological competitive edge. In this gate, it is not necessary to satisfy all viewpoints, but one of them should be outstanding.
Stage2	**Feasibility Study:** Development of key technologies forming competitive edge and establishment of intellectual property. Activities to secure the commitment of the business sectors that will start the business based on this project in future.
Gate3	Decision to develop detailed plan, investigate, and develop from 3 viewpoints: (G31) Are key technologies forming competitive edge established? (G32) Is there a business sector that makes a commitment? (G33) Are a target and goal, tasks and roadmap to the goal clear and concrete?
Stage3	**Development:** Detailed planning, investigation, and development with the business sectors, especially strengthening of competitive edge and reinforcement of weak points. Activities to acquire an early customer.
Gate4	Decision to progress to testing and validation in the marketplace from 2 viewpoints: (G41) Do an early customer and a business sector exist? (G42) Can the total quality of the system satisfy the customer's requirements?
Stage4	**Testing & Validation:** Tests or trials in the marketplace, especially for early customers. Settlement of problems that appear in the trials.
Gate5	Final approval for production and launch from 2 viewpoints: (G51) Is the business profitable? (G52) Are problems settled?
Stage5	**Product production and launch:** The business sector launches the business, and the R&D sector develops additional attractive technologies to deal with competitors.
Gate6	Decision to continue production and expand the business from 3 viewpoints: (G61) High profit performance, (G62) Increasing marketability, and (G63) Product competitive power.
Stage6	**Product Support and Program Review:** The business sector elevates it to be one of the backbone businesses (shining stars) of the sector.

The proposed stage gate analysis consists of the following 4 steps. As we only explain its outline, please refer to the case study in the next section.

- **Step1:** Story telling
  Make a full story of the project according to historical records and decompose it into 7 stages.
- **Step2:** Template matching
  Associate activities and conditions with norms of stages and gates specified in Table 1.
- **Step3:** Analyzing
  Analyze success and failure factors using a cause-and-effect relation map (Fig. 1). In the cause-and-effect relation map, the positive relation (solid line) means that there is actual positive causality between activities and conditions on the target project. The negative relation (dotted line) means that causality exists between weak/poor activities and unsatisfied conditions. For example, a gate G33 is unsatisfied because an activity S33 is poor in Fig.1.
- **Step4:** Summarizing
  Summarize analysis and store findings in the project case database.
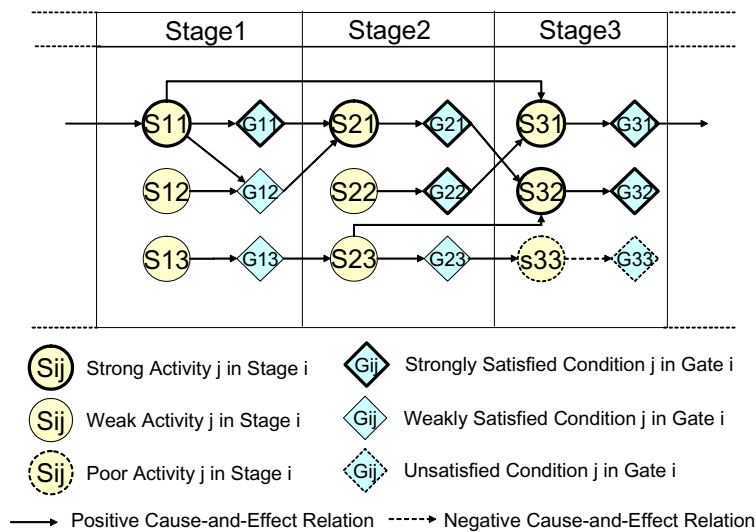

Figure 1: Cause-and-Effect Relation Map

III. CASE STUDY: CREDIT INFORMATION INFRASTRUCTURE PROJECT

A. Project Overview

The credit information infrastructure project, called "*CII Project*", was launched in April 1999 by the late Professor Hiroshi Shirakawa who was one of the most active researchers in Japan and also a core member of Center of Research for Advanced Financial Technology (CRAFT), Tokyo Institute of Technology. Purpose of the project includes R&D of credit information infrastructure by combining financial engineering and information technology [5, 6]. Figure 2 shows the basic structure of the credit information infrastructure, which consists of a credit information database and services to utilize the database.
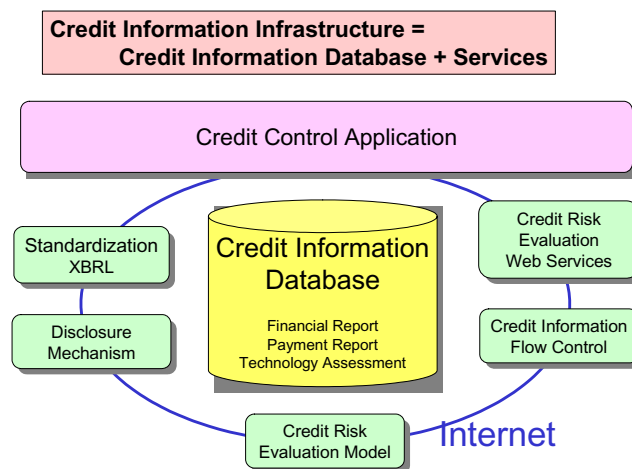

Figure 2: Credit Information Infrastructure

B. Stage Gate Analysis

1. Story Telling and Template Matching
According to the stage gate analysis procedure, a history of the project is broken down into the following stages.

Stage0 (- 1998):
(S01) In his capacity as the chairman of an academic study group on financial technology, Professor Shirakawa of CRAFT developed a basic idea and concept through dialogue with key people in banks and government.

Gate1:
(G12) Market attractiveness was strongly satisfied in the initial idea and concept.

Stage1 (1998):
Prof. Shirakawa prepared a business-academia collaborative project in CRAFT. (S11) He designed the detailed project plan and explained his concept and plan to Toshiba and several companies.

Gate2:
As a result, (G22) Toshiba and 3 companies agreed to Shirakawa's concept and decided to invest human and financial resources to a joint project.

Stage2 (1999):
The project started in April 1999. After one year's intensive research, (S21) an original and attractive credit risk scoring method (The CRAFT scoring method) had been developed [4]. Concurrently, a concentrated effort was made to secure national project funds. After many twists and turns, (S22) we secured national project funds (1 million dollar) from the Information-technology Promotion Agency (IPA), one of agencies of the Ministry of Economy, Trade and Industry (METI).

Gate3:
(G31) The CRAFT scoring method was developed and (G32) National project funds were secured. (G33) A plan was clear concerning a national project fund, but unclear after finishing it.

Stage3 (2000):
Using national project funds, (S31) we developed an internet finance system which is a web-based financing support system including a new credit scoring model (Fig. 3). Here, we rebuild the practical scoring model by analyzing a huge amount of credit information covering twenty thousand companies. In March 2001, (S32) we made an announcement concerning our system and scoring model in both a symposium and in the press, which had a significant impact on the financial industry. We received many enquiries from interested parties throughout Japan and finally accepted an order to build an in-house scoring model from a credit guarantee company. (S33) We also organized monthly regular seminars with the business community and academia. These meetings were supported by METI and many key people participated who were attracted by Professor Shirakawa's vision.

Gate4:
(G41) An early customer appeared and (G42) the practical scoring model performed well in benchmarking.

Stage4 (2001):
A credit-scoring model was developed for the credit guarantee company. Through this project, (S41) we got valuable experience and obtained know-how concerning actual credit control management. After finishing the job, (S42) we received an order to build a credit control system from a general trading company. That system was several times larger than the previous job. In parallel, (S43) an IT vendor proposed development of package software development adopting the CRAFT scoring method. Toshiba and the IT vendor jointly developed the software and issued a press release announcing its commercialization. During this stage, (S44) we submitted a bid to the public bidding for constructing a scoring model used in the pubic credit database, but failed to receive an order.

Gate5:
(G51) a second job was economically feasible and, (G52) enabling us to build on the confidence we had gained through the first job.

Stage5 (2002-2004):
(S51) Large-scale credit scoring model and system were developed for the general trading company. We gained a good reputation with the customer and received subsequent jobs. In parallel, (S52) the package software were sold steadily. On the other hand, since these business-based activities seemed to gradually diverge from the original vision, (S53) we developed an experimental system (credit information supply chain system) using XBRL (eXtended Business Reporting Language) and Web services together with two companies in the XBRL community in Japan. This was an academic and volunteer-based subproject. (S54) We have been also developing technologies to sophisticate the credit scoring model. Although the project has been under way for 3 years, we are encountering difficulties in proceeding to the next stage.
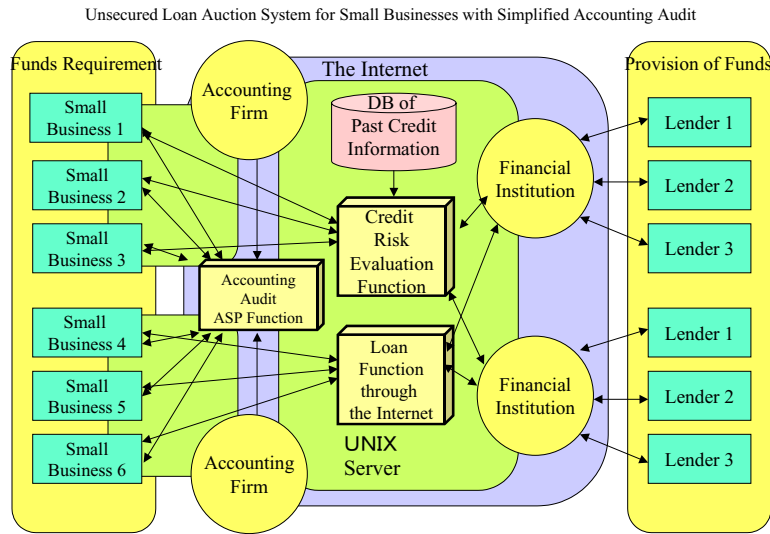
Internet Finance System

Unsecured Loan Auction System for Small Businesses with Simplified Accounting Audit

Figure 3: Internet Finance System

2. Analyzing and Summarizing

Why could the project successfully survive to Stage 5? Why was the project stalling in stage 5? We analyze and summarize the project from 3 viewpoints using the cause-and-effect relation map (Fig. 4):

[Viewpoint 1] Vision and Publicity

Prof. Shirakawa's attractive vision (S01 and S11) in Stages 0 and 1 and the subsequent timely and active publicity (S32 and S33) served as the driving force of the project. Especially, these activities contributed to acquisition of a national project fund (G32) and an early customer (G41).

[Viewpoint 2] Technological Competitive Edge

An original scoring model based on analysis of *"financial data"* (S21) had competitive power in 1999 and contributed to acquisition of a national project fund (G32). However, several rivals appeared in Stage 5. Additional new scoring technologies should be earlier developed in Stages 5 (S54) to satisfy a gate G63.

[Viewpoint 3] Commitment to National Systems

In order to achieve Prof. Shirakawa's vision, the credit information database should be constructed. However, it is not feasible for private companies to do this. It should be done by the government and that is what happened. We submitted bids several times to the government's general public bidding, but were unsuccessful (S44), which may have been due to our lack of a track record of successes concerning national financial systems. If we had won the bid, we would have progressed to Stage 6 (G63).
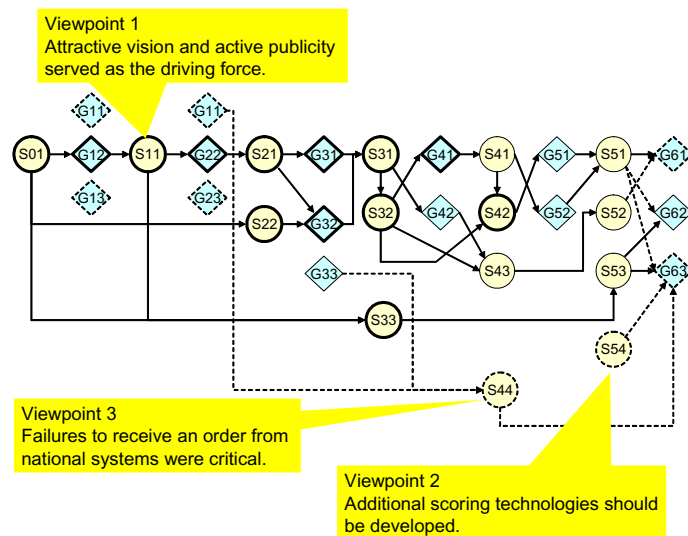

Figure 4: Cause-and-Effect Relation Map of CII Project

IV. DISCUSSION

The case study of stage gate analysis has 2 practical implications: (A) success and failure factors in business-academia collaborative projects are indicated, and (B) stage gate analysis is one of the promising approaches extracting knowledge useful in subsequent projects.

A. Practical Implications for Business-Academia Collaborative Projects

Generally, it is not easy to manage a business-academia collaborative project involving more than two companies. This case study indicates that an attractive vision and concept responding to social needs are very important. In our project, Prof. Shirakawa's vision was attractive and high-minded, that is, he sought to address the weak points in Japan's financial system following the financial Big Bang. Furthermore, our strategic publicity and monthly open seminars proved to be effective in attracting new project members who shared Professor Shirakawa's vision. Figure 5 shows changes in the membership of the project. Only Tokyo Institute of Technology (Titech) and Toshiba has been members throughout the entire period. When the project progressed to a new stage, some members may have found it difficult to continue because of mismatch between their own benefit and the project's benefit and moved apart from the project. However, attractive vision and publicity helped us to secure new members, especially in Stage 3 (2000) and Stage 4 (2001).

Investment and revenue sharing pose difficult problems in collaborative projects. In our project, the national project fund in Stage 3 (2000) was particularly helpful in resolving such problems. After 2001, we divided our activities into business-based activities and academic-based (volunteer-based) activities. Academic-based and volunteer-based activities continue to pursue the original high-minded vision. However, in Stage 4 and 5 we needed an opportunity to participate in another national project, but did not gain such an opportunity. This is one reason that we are unable to proceed to Stage 6.
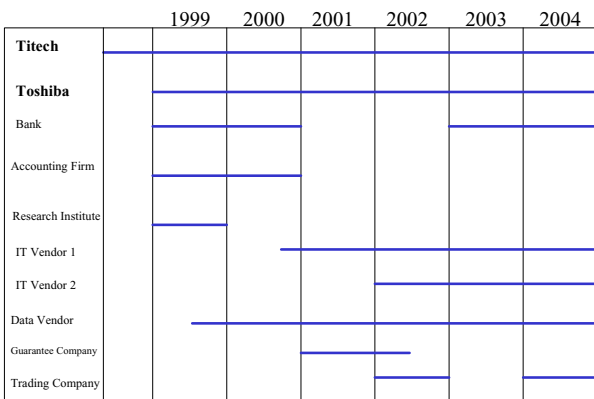
Project members

	1999	2000	2001	2002	2003	2004
Titech						
Toshiba						
Bank						
Accounting Firm						
Research Institute						
IT Vendor 1						
IT Vendor 2						
Data Vendor						
Guarantee Company						
Trading Company						

Figure 5: Changes of Project Membership

B. Practical Implications for Stage Gate Analysis

This paper shows that the stage gate approach is useful not only for on-going project management but also for backward project review and knowledge extraction through the case studies. Although concrete procedure of stage gate analysis is not mentioned in the previous papers, it is clear that these two aspects of stage gate utilization should interact fruitfully and thus play an important role in the improvement of overall project management. Figure 6 shows an image of a future stage gate management system with a project database. In this system, many cases are stored in the database and cases are formalized and structured based on the stage gate analysis. Each case consists of an attribute (project type, scale, target business domain, etc.), a cause-and-effect relation map, and a detailed project story. When planning a new R&D project, the project manager can design the project according to the stage gate template which is reinforced by useful cases. Through the cases, the manager can concretely understand the significance of activities of stages and conditions of gates. Compared with flat text-based cases, formalized and structured cases will be useful for searching efficiently for relevant cases from the database.
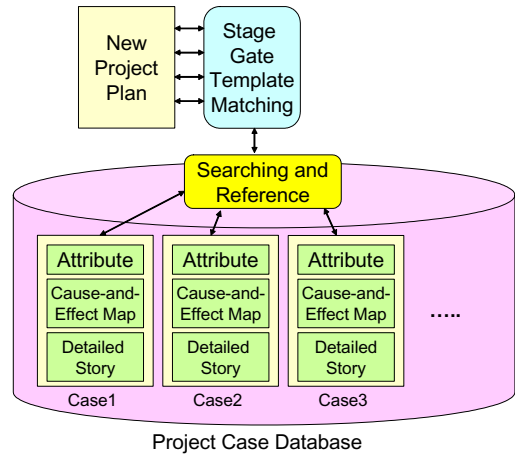

Figure 6: Stage Gate Management System with Project Case Database

V. CONCLUSION

This paper presented the procedure of stage gate analysis and applied it to a credit information infrastructure project. This procedure is useful to extract the characteristics of a project, notably the success and failure factors. Extracted knowledge is expected to provide useful suggestions for similar projects. In future work, we intend to refine the procedure by referring to other case studies and to construct the project case database.

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