PROJECT MANAGEMENT SYSTEM FOR SMALL-MEDIUM BUILDING CONSTRUCTION PROJECT

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ABSTRACT: An approach is needed in which practitioners learn how to deploy technologies to break through the limited benefits achievable through the substitution of information technology (IT) for existing technologies. This study treats the methodology of business process change in the management of small-medium scale projects. Two case studies of application of IT in building construction examined the feasibilities and the problems of IT adoption, and demonstrated the next challenges of it. This paper focuses on the group management of projects as a future direction of business process innovation for the small-medium scale projects, and discusses the methodology of business process innovation which leads to the group management of them as a possible building production system for IT generation.

KEYWORDS: Project management, business process, small-medium scale project, case study, methodology.

1. INTRODUCTION

After the collapse of the bubble economy in Japan, the number of big building construction projects have decreased, and it has becomes accordingly important for the general contractors how to obtain higher efficiency in the small-medium scale building construction projects. The target of information technology (IT) adoption in building construction has been shifted and expanded gradually form big projects to small-medium projects with the help of widespread use of computers and the Internet.

With this as a backdrop, two case studies had been attempted in which IT was adopted to the management of small-medium building construction projects, and the feasibilities and difficulties of that were investigated.

This paper focuses the target of this study on the small- medium scale building construction projects, discusses the methodology of business process change in the project management on the basis of the considerations of these case studies.

2. METHODOLOGY

The research on which this paper is based followed a four-stage methodology:

(1) Analysis of the problem in the management of building construction projects.
(2) Case studies of IT adoption to building construction management.
(3) Analysis of the feasibility and the problems of IT adoption to construction management.
(4) Discussion on an approach to the business process change in the management of small-medium scale building projects.

3. PROBLEM ANALYSIS

Before devising plans of the case studies, the following items were surveyed and considered: the manager's problems in the small-medium projects, and the features of the building construction.

3.1 Problems in small-medium projects

3.1.1 Manager's problems in small-medium projects

In connection with IT adoption, the following issues are excerpts from a questionnaire of the managers of the small-medium projects (Architectural Product-Engineering 1996).

- There is much overtime work, and that makes managers to stay long at the site office.
- Though amount of work or busyness fluctuates with progression of construction, the number of staff remains few.
- The project management program of small projects is almost same as that of big projects, therefore, they have to make a great number of documents.
- Certain supports from the head office or branches are needed with respect to preparation of temporary work plans, shop drawings, and documents, in addition, cost planning, cost control.
- The managers of small projects remains isolation with respect to the information of project management know-how and new technical issues, and need to access them easily.

3.1.2 Difference between operation of big project and that of small-medium project

The following features are pointed out, which were caused by the difference between operation of big project and that of small-medium project:

- In a big project, resident superintendents communicate with site managers and approve shop drawings, on the other hand, in a small project, superintendents are roving and have a regular meeting for overseeing a construction work. As a result, this causes mistakes in conveyance of information or losses of time in their communication. (Nakao et al. 1997).
- As compared with staffs of big projects, that of small projects have much work and less supports of head office or branches, and cannot afford the time and the money to adopt IT to their work.

To sum up, the managers of small projects are burdened a great deal of work, and have difficulties in obtaining supports from the head office or technical information, that is to say, they would need to enhance efficiency with IT more than the staff of big projects.

3.2 State of affairs in construction execution

3.2.1 State of affairs in site management in terms of IT

From the viewpoint of IT, Kageyama et al.(1998) pointed out the state of affairs of the site management as follows.

Drawings data:

- Drawings is one of the most important and the most inclusive information treated in a construction site.
- The density, the notation, and the way of notification (In case of the CAD, it means application software.) of drawings and specifications vary from project to project.
- Shop drawings and manufacturer's drawings are delivered by package delivery companies in a medium such as papers or cad data.
- The larger a project scale is, the more difficult the management of drawings update is.

Progress data:

- Progress schedules are drawn up by hand or with application software. There is no standardized file format, therefore, it is difficult to make a schedule in collaboration with several staff, and to send it someone in reusable forms.

Index of information or data:

- There are enormous amount of information such as technical information, in-company technical standards, and regulations provided as books or other printed issues. As a result, in looking up such information, they usually depend on the index in their memory.

- Furthermore, the difference of their experiences causes a big difference of accessible information in its quality, quantity, or access speed. For this reason, the younger managers or small project managers may misjudge or find out few alternatives.

Means of communication:

- In checking on the progress of execution, a visual check at the site is the most reliable and speedy way.
- A few means of communication like as digital camera images which include much information become available, but still, the managers often depend on verbal communication or sketches.
- The designers and manufacturers usually stay at remote places, therefore, when the managers discuss with them by telephone, fax, or mail, that may cause losses of time and communication errors.

All these indications makes it clear that there are a big possibility of improvement of productivity and quality with IT.

3.2.2 State of the affairs in construction in terms of logistics

From the viewpoint of logistics control, compared with other manufacturing industries, construction execution has the following features:

- The construction projects are executed at temporary sites which doesn't have a stationary facility like a factory only during the construction time. Furthermore, in the case of small project, it is difficult to make a space for temporarily stocking and working the building materials inside of the construction site.
- The formation of specialist subcontractors vary from project to project.
- For the small projects, there are few resident staffs of specialist subcontractors, and they work at the site only for a period of time when they have their work. Accordingly, before the subcontractors start their work, the agent or the foreman of subcontractors need to check on work progress by phone or attend the daily meeting, and fix the date of their start.
- Each building material manufacturers try to obtain high efficiency in distribution of materials. However, at the time when the trucks reached at a site, the carrying percentages of each trucks are not necessarily high, then several trucks often wait in front of the site. In such cases, space does not permit to unload smoothly the materials from the trucks, and this makes workers to wait the materials and to waste the time. The smaller the building area is, the more serious this problem.

The results of above analysis were taken into consideration for the design of a prototype EDI system applied to the following second case study.

4. CASE STUDIES OF IT ADOPTION TO CONSTRUCTION PROJECT MANEGEMENT

Based on the above analysis of the problems, this study had carried out two case studies for the IT adoption to management of small-medium construction projects.

Hansen et al. (1998) quoted a three-part model of the IT adoption process (Arnold & Gann 1995) in Figure 1, and pointed out that an approach is needed in which firms learn how to deploy technology to move from the limited benefits achievable through the substitution of IT for existing technologies, and that automating individual worksteps needs to expand to a wider transformation of the entire process. This model illustrates the possibilities for firms to improve performance incrementally by moving through each phase, and more radically, by pursuing strategies to transform business processes with the assistance of IT systems. Positioning these case studies on this model, Case 1 locates on the first stage, "Substitution",

and Case 2 locates on the second stage, “Enhancement”. The following paragraphs summarize these two case studies.

4.1 Case 1. Substitution of IT for existing technologies

This case study was applied to a medium scale construction project of a building with 9 storied above ground and 3 storied below which includes offices and a TV studio. The term of this case study was about one year (1996.12 - 1997.11) within the construction time of two years (1996.4 - 1998.3). IT tools ware adopted to the processes of project management. IT tools refer to comparatively low-cost package software or the Internet technology as follows:

(a) Utilization of packaged software
- Software package that includes a word processor, a spreadsheet, and a presentation.
- Digital cameras and a image database software.
- 3D-CAD (For explanation of procedures of tower crane assembly or steel work).
- Painting software (For making original safety signs calling attention to workers).

(b) Preparation and management of documents
- File sharing with the site office LAN.
- Meeting System (In-house software for supporting the daily meeting and creation of instructions and daily reports)
- Liquid crystal PC projector (For safety instructions in daily morning meetings).
- Quality Control System (In-house software for the quality control).

(c) Multimedia and communication
- Personal Handy Phone (PHS) and its base stations on each floors (Both extension call and outside call for enhancement of communication).
- Wireless image transmission system.
- Internet camera.
- PC video conference system.
- Homepage for the owner of the building.

The investigation was mainly based on the interviews with managers. The author himself had worked as one of project managers in this project, consequently he had two roles both as a development staff and as a user of IT systems. As a result, it included the findings obtained empirically.

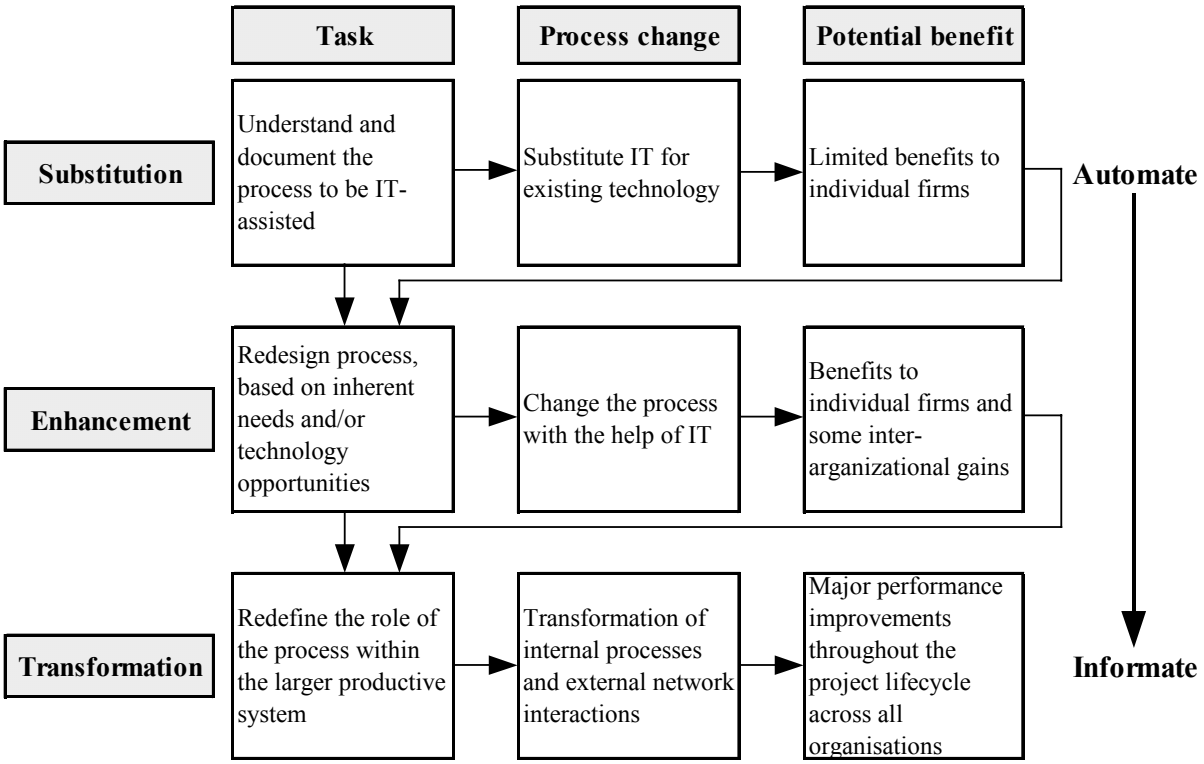

Figure 1. Information technology adoption and business process change (developed from Arnold & Gann 1995)

4.2 Case 2. Process change with help of IT

The second case study focused on the business process change of materials delivery with the help of IT. To be more specific, an attempt was made to adopt a method of delivery which several subcontractors share a truck efficiently. In order to control this delivery system, a prototype of logistics EDI system (Figure 2 & 3) was structured among a general contactor and four subcontractors. This experiment explored the possibility of IT-enabled process change.

This case study was applied to a small construction project of a private residence with 2 storied above ground and 2 storied below. The term of this case study was about three months (1999.7 - 1999.9) within the construction time of one year and half (1998.2 - 1999.10) .

This prototype system consisted of the following subsystems:

(a) File sharing system between the site office and subcontractors
The file saver manages various kind of project documents and drawings. All the parties concerned the project share the project information each other.

(b) Work progress monitoring system
Internet cameras settled at several points in the site make it easy for the subcontractors and a logistics company to check on work progress from their remote offices at any time when they need.

(c) Materials delivery scheduling system
For preparation for a full-scale EDI system, this system has a simple function of sharing the schedule data of the incoming building materials.

This study consisted of the following activities: interviews with four subcontractors in order to investigate the problems of the prototype and to find out the next challenges; and a experiment on a new quantitative evaluation method of efficiencies of IT adoption. This method was based on, one of cost analysis methods, Activity Based Costing (ABC) that is often applied to the business process restructurings in manufacturing industry.

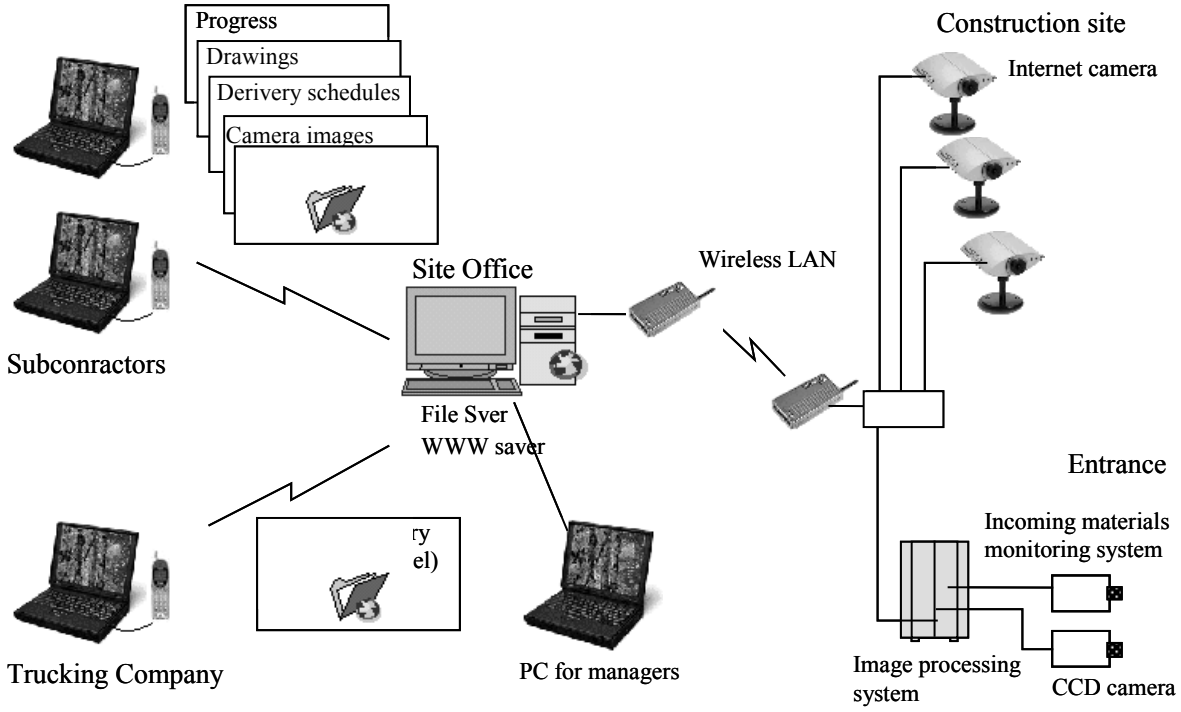

Figure 2. Prototype of Construction Logistics EDI system

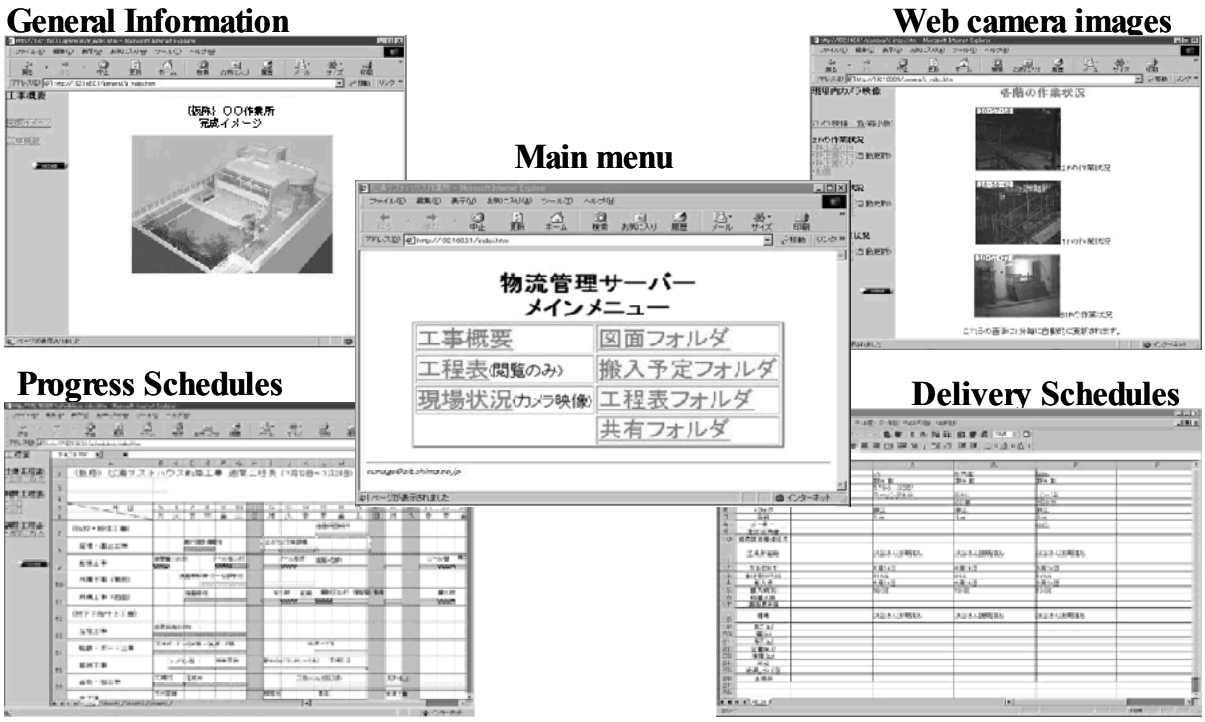

Figure 3. Screen examples of prototype system

5. FINDINGS REGARDING IT ADOPTION AND BUSINESS PROCESS CHANGE

5.1 Findings in Case 1

5.1.1 Profitableness of adopted IT tolls

Table 1 shows a summary of interviews on adopted IT tools in term of initial cost, merit, and demerit. Initial costs were judged whether it could be reasonable for small-medium projects within 2 or 3 years. Almost every IT tools show the possibility of profitableness for site managements. Furthermore, each tools seems to be affordable. However, if they plan to introduce several tools at once, the initial cost may swell, and not be affordable for small-medium projects. The number of IT tools that they could introduce is limited within a few.

All these issues made it clear that IT tools needs to be provided in lower prices. Furthermore, the problems of computer literacy was founded. When there is a trouble with a printer or the LAN, most of managers could not fix it up. Even if he knows how to treat, he would not have enough time for it. At times the temporary power supply of the site failed, and the PHS base stations had troubles.

5.2 Findings in Case 2

5.2.1 Interviews with users of subcontractors

The key points of interviews with users of the subcontractors are shown as follows:

- The data transfer rate was 32Kbps for this study. However, a higher communication speed is needed in having access to information.
- It is very useful that the update of information such as progress schedules or drawings are available from the saver. It is needed to expand the range of contents which could be used in various purposes, and improve paperless.
- Not only information sharing, certain interactive collaboration systems are required, that put the conventional work procedures on the net, and obtain more efficiency of work.
- In the subcontractors, there are few computers or network infrastructures, and the user's computer literacy rate is not so high.

Table 1. Evaluation of IT systems

IT tools		Initial cost	Merit	Demerit
Packaged software	Package including a word processor, a spreadsheet, and a presentation	Affordable	Usefull for helpng the file sharing.	
	Digital cameras and a image database software	Affordable	Making it easier to handle image data.	Data management needs much expence in time and effort.
	3D-CAD (For explanation of procedures of tower crane assembly)	Affordable	Helpfull for workers to understand their work easier.	Cad data input needs much expence in time and effort.
	Painting software (For making original safety signs calling attention)	Affordable	Effective for calling attention to workers	
Documents	File sharing with the site office LAN	Affordable	Helpful foreffective use of files, printers, and PCs.	It is a little bit difficult to deal with network problems.
	Meeting System (For meetings and creation of instructions, daily reports)	Affordable	Saving in time and effort for creating documents.	It has a lean inport / export function
	Liquid crystal PC projector (For safety instructions in daily meetings)	Very expensive	Helpful for effective presentations to many people.	Initial cost is expensive.
	Quality Control System (In-house software for the quality control)	Affordable	Helpful for the management of the ISO documents	It is difficult to understand the operation.
Multimedia & communication	Personal Handy Phone (PHS) and its base stations	Affordable	Actualizing communications througouth the site.	It is dificult to recover after power failures.
	Wireless image transmission system	Very expensive	Easy to get images from remote locations.	Initial cost is expensive. Lisence is required.
	Internet camera	Expensive	Easy instration. Helpful for transmiting images on the net.	Wiring needs expence in time and effort.
	PC video conference system	Expensive	Providing various kind of usefull communication tools.	Initial cost is expensive.
	Homepage for the owner of the building	Affordable	Helpful for improving services for the building owner.	

5.2.2 Problems in prototype system

The major problems in this prototype system are shown as follows:

- This delivery system which share the trucks among subcontractors requires many firms to join this system in order to perform effectively.
- At times the temporary power supply for the site failed, and the saver or the wireless LAN had troubles. It is difficult for small projects to keep stable power supply.
- In fixing the delivery schedules, the conventional communication way such as a telephone or a fax was still remained, then, the managers had an unexpected load inputting these schedule data with the keyboard.
- In consideration of security, two networks, the Intranet and the LAN for experiment were separated in a site office. For this reason, at times the managers had unexpected loads moving data one network to another with a floppy disk.

5.2.3 Evaluation of effectiveness of IT adoption

At first, an activity list was made by analyzing the business processes. Based on this activity list, with interviews and questionnaires, a cost analysis, the ABC was executed. As result, it was found that the ABC could be applied as an method of evaluation, but needed enormous expense in time and effort.

6. APPROACHES TO BUSINESS PROCESS CHANGE IN CONSTRUCTION

Based on the considerations of two case studies that were respectively positioned at the ”Substitution” stage and the “Enhancement” stage in the three-part model of the IT

adoption process (Figure 1), this section discusses how to attack the next challenge of the "Transformation" stage for the management of small-medium scale projects.

6.1 Next challenges in IT adoption found in Case studies

The following three challenges in the IT adoption were derived from above two case studies:

(a) Minimization of cost and maintenance of the IT systems
It is needed to minimize the costs and the maintenance. This problem can be solved in certain ways as follows: introducing a group management of small projects with a group saver; providing the business applications with certain systems like as an application service provider (ASP).

(b) Business process change
It is difficult to obtain high efficiencies of IT adoption without the business process change. Add to this, the change needs to expand to a wider transformation of the entire process.

(c) Evaluation of effectiveness of IT adoption
Many reports of practical application of IT in construction show only qualitative or subjective estimation of effectiveness. In Case 2, an evaluation method was applied, however it required enormous expense in time and effort, and is not practical yet. A simple, practical evaluation method of effectiveness of IT adoption needs to be developed.

In order to achieve the "Transformation" level, above challenges should be considered.

6.2 Business process change in construction

This paper discusses the main subject, the methodology of a business process change in the management of small-medium projects.

Looking back the history of building construction in Japan, several examples of the group management of projects can be found. The group management had been one of solutions to enhancing efficiency of management. However there has not necessarily been powerful means for connecting the scattered project sites, then the management style have flip-flopped between individual management and group one. Now the Internet and various kind of IT can be just the powerful means for connecting the scattered project sites, and the group management of small projects become feasible. On the contrary, the consideration of 6.1(a) indicates this solution could help the IT adoption for small projects.

6.2.1 Vision of business process change

Several images of the group management are derived form the above consideration and the examples of business process innovation in manufacturing industries as follows:

- In this paper, the organization that has a function of group management is provisionally given the name of "the group management center". Centralizing tasks which could be moved from each projects to the group management center, each projects increases the time for strategy planning or decision making.
- Typical steps of business process innovation consists of the following four steps: simplification, standardization, centralization (or sharing), and outsourcing. In this case, the centralization might be the most important and enable not only to improve the effectiveness but to accumulate the know-how.
- The centralization of tasks from the sites has several patterns as follows: a centralized management, a regional distribution, and a functional distribution. In addition, the difference of operations or control balance of this center brings various combinations of these patterns.
- The group management center has a function as a kind of shared service center that provides various kind of services to each projects and receives the money for it. Therefore, The center behave as a profit center.

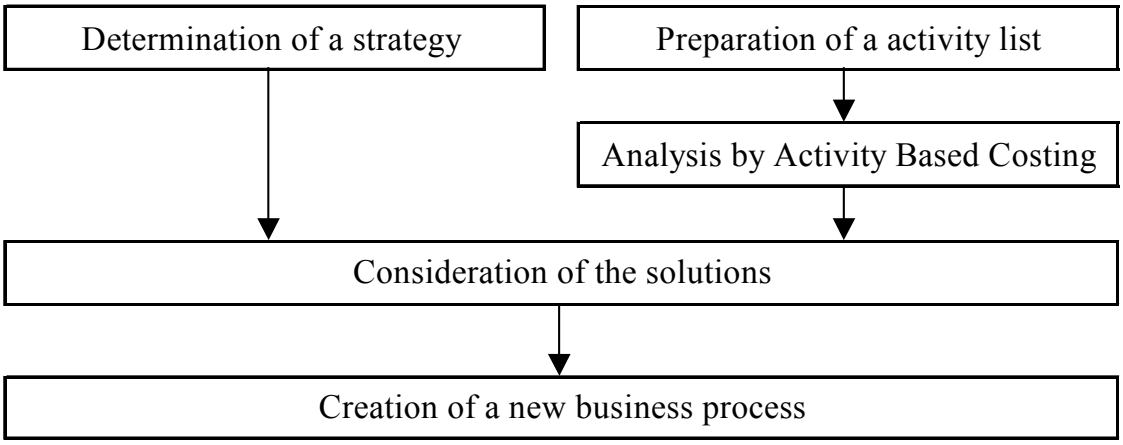

Figure 4. Procedure of business process restructuring

- The Internet connects among the scattered project sites and this center, and IT systems improve the efficiency of business.

6.2.2 Procedure of business process reengineering

The procedure of business process reengineering in this study incorporates the concept of the Activity Based Management (ABM). Figure 4 shows this procedure. On the one hand, a strategy is determined, on the other hand, a activity list is created on the basis of analysis of actual business processes, and using this list, the ABC, a cost analysis, is executed. These activities leads to consideration of the solutions, and a new business process is finally created.

7. CONCLUSION

This paper showed two case studies of IT adoption to the small-medium building projects. These case studies investigated the feasibilities and problems of IT adoption, and lead to the next challenges as follows: (a) It is severely needed to minimize cost and maintenance of IT systems; (b) In order to obtain high efficiencies of the IT adoption, the business process change needs to expand to a wider transformation of the entire process; (c) A simple, practical evaluation method of effectiveness of IT adoption needs to be developed.

On the basis of these consideration, focused on the group management of projects as a future direction of business process innovation for small-medium scale projects, this paper demonstrated the methodology of business process change.

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