Research on Construction Company's Strategy Transformation Based on BIM

Rua-Huan Tsaih
Yao-Tang Hsu

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Rua-Huan Tsaih, Department of Management Information Systems, Taiwan Chengchi University, Taiwan, China, tsaih@mis.nccu.edu.tw
Yao-Tang Hsu*, Department of Management Information Systems, Taiwan Chengchi University, Taiwan, China, yc.yc0088@hibox.hinet.net

ABSTRACT
This paper explores the strategic planning for a case company based on BIM transformation. This paper first analyzes the organizational structure and BIM strategy of the current case company, uses IDEF0 to build an existing business process model, and uses Time-Driven Activity-Based Costing (TDABC) to analyze the working time and manpower required under the existing business process; Using the Theory of Constraints (TOC) thinking process model to identify the fundamental factors of problems and bottlenecks in existing business processes, explore how to remove bottlenecks and re-engineer business processes through importing BIM; then propose future IDEF0 business process models; then use TDABC to analyze the working time and manpower required to import BIM business in the future. Through the future mode of operation and the time and manpower that can be streamlined, from the perspective of BIM's impact on the business activities of the case company, and refer to the BIM platform deployment, operation type and how to use BIM to provide services for BIM successful companies to propose a case company BIM platform setting strategy, optimal BIM platform structure, operation type and function items and operation function adjustment suggestions of the case company.

Keywords: Enterprise transformation, business process, BIM, organizational change, TDABC, TOC.

*Corresponding author

THE BACKGROUND DESCRIPTION
Taiwan's construction industry is facing a different business world than before. The construction industry is one of the pillar industries of Taiwan's economy and plays an important role in economic and social development. As the government's policy to cool real estate speculation and labor regulations tightened, the competition in the construction market has become more intense. This has put a severe test on construction companies. The traditional construction industry's operation methods, management concepts, management models and business models have been difficult to adapt to the new economic environment and new ways of competition. An enterprise can continue to successfully survive and develop in a new business environment only through its own changes, or it will face a situation of being eliminated.

From the development direction of BIM in the international construction industry, it is not difficult to see that BIM management of construction enterprises is to break through the various information barriers existing in construction enterprises. It is necessary to fundamentally change the way in which companies collect, process, and use information, which leads to tremendous changes in organizational forms, and promotes business processes reengineering and even restructuring of organizational structures, and turns the original hierarchical structure into a “dynamic network” structure of precise, agile and innovative flat. Therefore, it is possible to maximize the production and operation mode of the company's operational efficacy.

THE RESEARCH OBJECTIVES
According to the above research background, Taiwan's construction industry faces many conflicts and difficulties such as stricter labor regulations, government's policy to cool real estate speculation, rising factor costs, overcapacity, intensified market competition, and slow pace of transformation and upgrading. From the perspective of external competition, a far-reaching BIM new technology revolution is taking place, and a new round of profound changes in the global construction industry is accelerating. At the same time, developed countries have implemented the "BIM" strategy and developed high-end construction industry in order to occupy a favorable position in the international economic competition. Facing the changes in the domestic and international industrial development environment and the competitive environment, it is particularly necessary and urgent to learn from the BIM strategy and promote the transformation and upgrading of the case company's construction industry. The case company's transformation through BIM strategy mainly hopes to achieve the following aspects:

1) Intelligent and digital as the direction of the case company development
2) Re-construct the business process of the case company based on the perspectives of system, association, integration, collaboration and integration
3) Equip the case company with BIM technology
4) Development the case company construction project life cycle management
5) Develop the case company’s BIM platform construction
LITERATURE DISCUSSION

Building Information Model (BIM)

BIM (Building Information Model) technology is a digital tool for engineering design, construction and management processes. The US National BIM Standard (NBIMS) has three definitions of BIM: 1) BIM is a digital representation of a facility (construction project) entity and functional characteristics; 2) BIM is a shared knowledge resource and is the shared information about the facility. It’s a process that provides a reliable basis for all decisions in the facility's life cycle from concept to dismantling; 3) at different stages of the project, different stakeholders insert, extract, update and modify information in BIM to support and collaborative work that reflects their respective responsibilities. (NIBS, 2006)

The US bSa (building SMART alliance) proposed 25 different applications of BIM (Building SMART Alliance, 2010) in its "BIM Project Execution Planning Guide", as shown in “Figure 1: 25 different applications of BIM". As can be seen from Figure 1, the application of BIM runs through the entire life cycle of the construction project.

Enterprise Transformation

In response to changes in the times, companies are gradually transforming through new digital technologies to drive changes in business models. According to Gartner (2014), 75% of the world's enterprises will be transformed into digital enterprises in three years or so. The digital transformation will be a complete change of the organizational structure of the enterprise, but also test the company's determination and resources. Many companies understand the importance of digital transformation for corporate innovation, but more than half of them have no corresponding strategies or stagnation.

Digital transformation will be the top priority for companies in the next three years. Most companies understand that digital transformation must cater to future technology trends, but most companies lack specific strategies and plans (Microsoft, 2017). If you want to get rid of the past and make a smooth transition, companies must actively face two major problems and challenges: Conflicts within the organization, resources and applications.

IBM (2011) proposed that enterprises have three ways to achieve transformation at the implementation level. The first transformation is to first establish a digitalized operating model, and then reshape the customer value proposition; the second transformation is the opposite of the first transformation, first to enhance the customer value proposition and then pay attention to the digital Operation. The third transformation is that companies need to break the framework and create new capabilities to achieve transformation.

The “silver bullet” theory of transformation ((Lynne, 1997) emphasizes the need to adopt a single method or process tool to change the performance and behavior of the company, including IT, process reengineering, total quality control, human resource management reform and new strategic solutions, etc. (Each single scheme is analogized to a bullet). Hammer and Champy (2006) proposed the concept of BPR. Subsequently, many scholars conducted in-depth research on the organizational transformation based on BPR. Henderson and Venkatraman (1994) as the representative scholars began to study the organizational transformation of IT enablement, and studied the organizational transformation path from the perspective of enterprise information system planning and enterprise strategy planning matching.
MIT Sloan Management Review published in 2015, Strategy, Not Technology, Drives Digital Transformation pointed out that the enterprise digital transformation perspective, in addition to IT technology level, also includes the required talent, thinking and digital transformation culture (Culture of Digital Business Transformation), and the key to its success or failure is not technology, but focus on a clear digital strategy.

**Business Process Reengineering**

In 1990, Michael Hammer proposed the concept of Business Process Reengineering (BPR). Process reengineering is a fundamental thinking and thorough rebuilding of the company's business processes. Its purpose is to achieve significant improvements in cost, quality, service and speed. It enables enterprises to adapt to the modern business environment characterized by customers, competition and change to the maximum extent. BPR emphasizes business process as the center and advocates fundamentally redesigning organizational structure and business processes. It is a cross-functional innovation for all business processes.

The theory of BPR breaks through the concept of traditional theory of division of labor. It emphasizes the replacement of the traditional “functionally oriented” organizational form with “process-oriented”, which provides a brand-new idea for business management. Since the current enterprise is based on the theory of division of labor, the business process is divided and concealed by the organization. People are very familiar with departments, administrative or technical offices, and teams, but turn a blind eye to business processes. In fact, the process of the enterprise is the lifeline of the enterprise and determines the operational efficiency of the enterprise. Compared with the functional management concept based on the theory of division of labor, the theory of BPR has the following three salient features: The first is to emphasize the needs of customers. Since customers are no longer passive recipients of production products, but active determinants, companies must consider meeting the individual needs of customers. It can be said that the customer's demand is the most fundamental driving force for the company to carry out process reengineering. The second is to focus on overall optimization. The traditional organizational structure is divided according to functions. Each functional department performs its own functions and focuses on the optimization of its own departments. However, due to the lack of cooperation and coordination between departments, it is difficult to achieve the overall optimization of the enterprise. The theory of process reengineering is to re-establish the operating mechanism and organizational structure of the enterprise to achieve overall optimization. The third is to pursue a significant increase in enterprise efficacy. The process reengineering theory is not to pursue the gradual improvement of enterprise efficacy, but to improve customer satisfaction as the main direction, through the redesign of the process to achieve great improvement in enterprise efficacy.

After the theory of process reengineering was put forward, many companies in Europe and the United States invested heavily in reengineering the business processes of enterprises. Although the culmination of process reengineering has become a thing of the past, the redesign of processes and continuous improvement of processes are an eternal topic. Especially under the drive of the mobile internet, the company's processes must be designed and improved.

**Process Measurement Technology: ABC and TDABC**

In 1952, the American accounting scholar Professor Kohler studied the method of allocation of indirect costs, and put forward the concepts of operation, operation account, and operation accounting. This marks the birth of Activity-Based Costing. Activity-Based Costing (ABC) considers that production activities consist of a series of operations. The operation consumes resources, which in turn generates costs. Collect resource costs spent on the job or activity cost center through resource drivers. Then, through the activity drivers, the operation cost is collected into the target product. The production process is the operation chain, and the various main indirect costs that constitute the product cost are allocated by different resource drivers, activity drivers and workloads. More accurately reflect cost information. Operation is the activities provided by the company for the production of products. It is the intermediary of cost calculation and control, and also the presentation of business processes. ABC can comprehensively aim the entire enterprise operation process, effectively display the accounting management functions, and expand the scope of management. Robin Cooper and Robert Kaplan (1993) defined activity-based cost management as a series of actions using adequate activity-based cost information and articulated operational-based cost management from both operational and strategic aspects.

In the implementation, ABC has many insurmountable problems. For example, the implementation of ABC cost management system requires expensive funds, the information interview and investigation process is long, the cost of data storage, processing and reporting is high, and the maintenance and upgrade of the system is difficult. The calculation process is too complicated, and the above-mentioned shortcomings of the traditional Activity-Based Costing make the Activity-Based Costing low in adoption rate.

Kaplan, R. S. and Anderson, S. R. (2007) have improved ABC for this phenomenon and proposed a new concept of Time-Driven Activity-Based Costing. The investigation data and system update problems encountered in the implementation of the Activity-Based Costing in recent years have been explained in detail, and the reasons for these problems have been explained. At the same time, in response to these problems, an improved method - Time-Driven Activity-Based Costing is proposed. TDABC's invention does not need to obtain a large amount of data through survey interviews. It only needs two sets of parameters to calculate the product cost. That is, the time capacity that the resource can provide and the time of the work.
consumed by each product. At the same time, because of the existence of time equations in TDABC, in the emergence of new products and operations, we no longer need to re-edit the entire model and assignments, only need to observe a new set of data and do a simple update. Then you can get accurate calculation results.

Process Problem Diagnosis and Improvement – TOC
The Theory of Constraints (TOC) was founded by Eliyahu M. Goldratt (1999). The meaning of TOC is to solve complex management problems in reality through the use of a set of simple logic deductions. On the surface, the more complicated and difficult the problem, the simpler the solution is. For enterprises, the main content of TOC is divided into two parts, one is where the enterprise should improve, and the other is how to better accomplish these improvements. TOC helps companies identify bottlenecks that constrain their development and take effective measures to improve the company's shortcomings to break through these bottlenecks and eliminate obstacles in the process of accomplishing corporate goals. As a system, the input and output of enterprises are divided according to stages or links. TOC believes that if there is a problem in the output of one link or several links in this system, this problem will also affect the next one or the next few outputs, which ultimately affects the capacity of the entire system and reduces production efficiency. This view is similar to the barrel effect, that is, the most critical factor affecting system output is the least productive link in the entire system. According to TOC, a series of tools have been developed to help companies more clearly understand their own measures and behaviors, and to know more clearly what factors in the business will have a favorable or adverse impact on the company's achievement of the goal. TOC points out the bottlenecks and constraints in the operation process for the company.

TOC provides several thought-technical tools for the improved process, helping to see the root of the problem and what the problem really needs to be solved at the time of the decision. TOC's technical tools include: Tools for describing causal relationships: Current Reality Tree, Future Reality Tree, negative effect branch diagram and transformation tree; tools for describing inevitability: Evaporating Cloud and the Prerequisite Tree.

CASE ANALYSIS

Case Company Profile
The case company was established in 1982 and is committed to residential construction. It has “construction 1”, “construction 2” and “leasing” departments. The construction division 1 has a number of construction companies, and it is stable to promote 3 to 5 cases every year. The total amount of the case is about NT$4-6 billion. In addition to self-construction, it is also built with landlords in many places. With the joint efforts of more than 200 corporate colleagues, they have been adhering to the enterprise spirit of "sincere and practical" and have been doing sustainable service for 30 years. The three major business bodies - the construction business division 1, the construction business division 2, and the leasing business division are flourishing. Distributed in Xinzhuang, Taishan, Banqiao, Tucheng, Shulin, Taoyuan and other places, it has become a strong chain enterprise in the north of Dahanxi in New Taipei City. They are deeply immersed in the land, and they are constantly innovating in technology, seeking new changes, and striving for excellence. This is to provide high-quality related corporate services to the citizens, and hopes to promote the "quality of living space and the business vitality of real estate".

In the operation of the company, it is inevitable to bear the risks. The various business bodies of the case company have encountered the test of the overall market and the environment. For example, when the construction department 1 develops land in the Greater Taipei area, it has already faced high land prices, and the urban area is increasingly difficult to obtain. The dilemma, coupled with the government's suppression of the housing market, is very obvious. The construction risks have increased a lot. Facing the fact that building materials, raw materials and wages have risen, the cost of construction has increased substantially, and the quality of construction has not been discounted. So construction profits have become less and less. Therefore, in the face of such adversity, the case company's founder and the cadres of the various departments have brainstormed, boldly innovated, and sought different solutions to open up another feasible way and continue to achieve success.

After a one-year strategic meeting discussion, the case company will move toward BIM to meet the new challenges brought about by the changes of the times. In particular, the case company's main business of construction has been operating for many years in the housing market where the bull market has ended. For sustainable operation BIM's business strategy must be adopted to meet the needs of the development of domestic smart buildings, green buildings, high-rise buildings and individualized buildings.

Description of the Case Company BIM Plan

Case company management problems
Case company management status: At present, the company's existing business adopts internal growth strategy. Safety, quality and service are the purpose of the case company's growth along the way, from the early low-rise bungalows to the high-rise buildings that are now on the 20th floor and above. The design is from the early brick structure, reinforced concrete structure to the steel reinforced concrete structure used in today's high-rise buildings. The construction technology and construction quality are constantly innovating and improving. Only by continuously improving and enhancing the market competitiveness can enterprises thrive. If they are not willing to launch new products to meet the needs of the public, they will soon be eliminated by the environment.
In the past, the case company established financial management, public works systems, personnel management, budget management and other systems. However, the lack of a unified information management platform, information feedback and analysis is not timely enough, information resources are not fully shared, cannot meet the needs of enterprise management information communication and sharing, resulting in information islands in various departments within the company. As the scale of business operations continues to expand, the need for information sharing and system integration is increasing.

The case company plans to use four years. With BIM as the core, the integrated BIM platform is used as the framework to solve the collaborative work of the organizational structure of the enterprise. Coordinate the management of various resources in the construction process (including labor, materials, equipment, time, funds, etc.) and the comprehensive planning, control, optimization and decision analysis of objectives (including schedule, quality, cost, safety, etc.) during the construction process, providing advanced and effective methods as the goal. Establish an integrated information resource management system of project life cycle management based on BIM to optimize the allocation of enterprise resources and enhance the core competitiveness of enterprises.

**Important steps for the case company to import BIM**

Below, we introduce BIM's BIM strategy establishment, business process reengineering, information integration, structure establishment and introduction of case-based reasoning case library from case company. These five aspects illustrate the transformation of case company.

1. **Establish a BIM strategy**
   Since this is the case company's first contact with BIM for the project, there is no experience in itself. In preparation for the BIM implementation, the case company has opened several BIM strategy meetings, inviting senior executives, external BIM consultants and experts to discuss BIM together. The implementation strategy of the future will establish an integrated dynamic BIM development strategy and name this project an integrated dynamic BIM information platform. The objectives of the integrated dynamic BIM development strategy are as follows: establish a BIM-centric collaborative platform to provide full-life cycle construction management to strengthen communication with project personnel, and directly connect with enterprise database, case library and component library to facilitate data management and facilitate project personnel can make full use of the company's database, case library and component library to improve project management efficiency and standards, improve the overall quality of the project, and form core competitiveness.

2. **Reengineering based on business processes of an integrated dynamic BIM information platform**
   The case company recruited several BIM process integration meetings, and successively interviewed the construction project department, the cooperation companies (owner, design, construction and supplier), the information department, and several representative construction project personnel. Understand the business and system requirements. And jointly discuss with the construction project department, the cooperation companies, the information room to discuss the existing and future operational processes of the integrated dynamic BIM information platform, the support of the current system and the inadequacies. Based on the integrated dynamic BIM development strategy established in the preceding paragraph, they will jointly develop the optimal operating procedures, functions and requirements in the future.

The case company project team first learned from the interviews about the current business processes of the construction project department, the cooperation companies, the information room, and the construction project-related units. Use IDEFO to build existing business process models and use time-driven activity-based costing (TDABC) to analyze the time and labor required for existing business processes. Then use TDABC to analyze the working time and manpower required in the future business model, through the future work mode and the time and manpower that can be reduced. Then establish a service blueprint and adjust the organizational structure and service functions of the case company according to the service blueprint. The results obtained will be used in the next steps. The relationship between the models established in this step is shown in “Figure 2: business process analysis step diagram”.

The service blueprint is a special and more practical system flow chart that stands in the user's position, describes the services required by users in each phase of each life cycle, and presents them in the form of a flowchart. The service blueprint is rooted in the user experience, enabling the service process to be displayed dynamically. Services are dynamic, experiential, and are usually generated immediately by users, personnel technology, and some static tangible material. The service blueprint has five components: User behavior, visible human behavior, invisible back-office personnel behavior, support behavior during service delivery, and tangible display during service, as shown in “Figure 3: business process analysis step diagram”.

The service blueprint not only shows the entire service provision process of the dynamic construction project planning, execution, monitoring and user services, the front-end back-end and support work, but also shows the dynamic construction project planning, execution, monitoring and user service and user service contact process. Through the analysis of the service process, key points and overall service process, it can provide reference for the dynamic construction project planning, execution, monitoring and user services to improve the service experience.
(3) Establish a data model that integrates BIM and the company's legacy systems
The case company established a unified data model of the integrated dynamic BIM information platform, and analyzed the data models of the current related systems one by one, including the content of the data, the relationship between the data, the data format and coding rules, and the unified data model was improved and revised. Establish coding rules for a unified data model. Analyze the core data and coding in the source system, and establish a mapping relationship with the information and coding of the unified data model. And analyze the interface, data interfacing content, interfacing way and timing between the future integrated dynamic BIM information platform and related data exchange systems.

For the unified data model of the case company's integrated dynamic BIM information platform, it is first necessary to understand the correlation and data model of each related system, and to analyze the current situation of individual systems.
Due to the large number of systems to be analyzed and the different architectures and types, the main steps are to use software applications for reverse engineering: Including the user interface, functions, processes, system architecture, data structure, and mutual relationship of the current system. In order to avoid deviation from the design core during analysis, the analysis of the application software should be based on the system development file, and then analyze various processes according to the user operation mode, and finally return to the integration of the data stream, and clarify the exchange interface between systems.

The integrated data model is based on the BIM data model. By analyzing the data content involved in the BIM construction project decision-making process, various BIM construction project materials are integrated and stored in a unified format. According to the theme, through the professional model, the original data in different source databases are captured and aggregated to form a multi-dimensional perspective, which provides an integrated, unified and comprehensive data environment for decision-making analysis for case company construction project dynamic management.

(4) Plan, analyze and design the system architecture, functions and data flow of the future integrated dynamic BIM information platform.

The system architecture of the integrated dynamic BIM information platform is shown in “Figure 4: System architecture of the integrated dynamic BIM information platform”.

![System architecture of the integrated dynamic BIM information platform](image)

Source: Case Company.

The platform data layer includes data from BIM, existing systems and a database of construction project cases. The logic layer includes statistical analysis, calculation and data exploration of data. The presentation layer contains system features. Among them, the design subsystem includes functions such as pipeline collision detection, building efficiency analysis, and cost estimation; the construction subsystem includes functions such as site management, resource management, schedule management, construction process simulation, and construction safety monitoring; the operation management subsystem includes facilities management, user management, space management, disaster prevention and other functions.

(5) Constructing a project component case library based on case-based reasoning

The case company also proposed the idea of the project component case library, stored the case classification of the construction project, and established a web-based construction project case database. Let the project company's construction project related personnel add various construction project cases to the database through the network, and continuously enrich the construction project case library to realize resource sharing. In the future, you can directly query the case or add cases through the network, learn from and draw lessons from the experience of construction projects in the past, and expand the case library.

To effectively and quickly extract solutions from past construction project components, case companies intend to use CBR methods that are self-learning, self-adjusting, and capable of applying tacit knowledge hidden in the case. The CBR method overcomes some shortcomings of the traditional expert system based on Rule-based Reasoning (RBR), such as difficulty in acquiring knowledge, system cannot self-learn, cannot solve new problems, etc. New problems and new components that frequently appear in construction projects can better apply existing component processing experience.
CBR is a relatively mature theory developed from the field of Artificial Intelligence (AI) (Michael, 2013). There are corresponding rules and standards for the structured representation of the case, database storage, case retrieval and matching, case adjustment, case correction and verification.

The design of the case library system mainly includes six aspects. The first five aspects are the operation procedures of the case library, namely: Case representation and organization, case retrieval, case reuse, case correction, case preservation and case library maintenance as shown in Figure 5. The sixth item is the system functional architecture design.

(a) Representation of the case.
(b) Retrieve the case most similar to the current problem from the case library.
(c) Find a historical case where the solution is best suited to solve current problems from similar cases.
(d) For the current problem, make appropriate corrections to the recommended solution to form the final recommended solution.
(e) After the current problem is solved, it is determined whether it is preserved in the case library based on the decision on the similarity threshold.
(f) Case library system architecture and functional planning.

![Figure 5: the main operational contents of the case library system.](source: Case Company.)

CONCLUSION

After years of development, our country's construction companies are facing the harsh facts of low profits and fierce market competition. Due to the potential of BIM in terms of cost savings, improving efficiency, and enhancing competitiveness, etc., construction industry players are increasingly feeling that the widespread use of BIM has indeed brought many changes to the industry. In recent years, research on new IT adoption and enterprise transformation, etc. has always been an important issue in the field of management, and it has also received extensive attention from scholars. In order to accelerate the development of BIM, researchers have done a lot of research on the problems arising in the process of enterprise BIM adoption and transformation, and accumulated many results.

Based on this background and foundation, this research is based on the relevant theories and research literature on BIM and enterprise transformation. The introduction of BIM implementation transformation for case company, analyze from the five aspects of strategy, business process reengineering, information system integration, platform architecture and case library of case-based reasoning. The technologies that have contributed to the transformation of the case company include BIM in the field of architecture and CBR in the field of artificial intelligence. The methods used are BPR (Business Process Reengineering), TDABC (Time-Driven Activity Based Costing), TOC TP (Theory of Constraint, Thinking Process), DW (Data Warehouse), service blueprint, etc. The comprehensive application of these theories and methods helps the case enterprise transform.

We hope that the analysis of this paper can bring some reference to the construction industry engaged in transformation, and can provide some small help for the transformation of domestic construction enterprises.
REFERENCES