

# BUSINESS GAME MODELING FOR THE NEGOTIATION BETWEEN GENERAL CONTRACTOR AND SUBCONTRACTORS

Yusuke Komatsu  
Tokyo Institute of Technology  
komatsu08@cs.dis.titech.ac.jp

## ABSTRACT

*The interior finish work of apartment building does not progress on schedule in Japan through the apartment construction. One of the causes of the delay is in the negotiation between general contractor and subcontractors. We propose a way to model this problem as a kind of the business game, in order to examine the relation between the characteristics of the negotiation process and the delay in the execution of the works. By applying this technique, it is possible to find an effective strategy and a proper value in the periods of the negotiation and bargaining. The main innovation of this study is modeling the business relation between general contractor and subcontractors and the structure of the competition between subcontractors*

## INTRODUCTION

Recently, high-rise buildings, which are building of 60 meters or more in height according to the building code, have increased in Japan. However, the major contractor companies in Japan cannot do the interior finish work of apartment building on schedule, and a great delay has happened. We consider that one of the causes of the delay is in the negotiation between general contractor and subcontractors.

In the construction industry of Japan, construction is executed by the general contractor's assigning tasks to subcontractors and specialist contractors [1]. It is general that each stake-holder gives priority to its own self-interest in the negotiation. For instance, to construct it enough for the budget and the period, subcontractor considers room at the stage when the general contractor ordered subcontractor construction. However, the general contractor has the case to apply again for the negotiation from the viewpoint of management and the self-interest for conditions of performance from subcontractor. As a result, the problem that the negotiation with subcontractor cannot be approved and the company in charge becomes absent, has happened to the general contractor after the general contractor starts constructing in construction. The delay at this negotiation stage has the possibility that no discovery of the controlled point easily and the person concerned is not mutually conscious. Moreover, after the contract is concluded, subcontractors might correspond to the work delays in Japan. When the delivery date approaches, subcontractors is done to increase the number of men after it agrees to influence the

profit, and to escape the delivery date delay. Therefore, we think that there is a necessity for discussing the relativity of the contract and the term of works delay.

We propose the way to model this problem as a kind of the business game, and examine the relation between the characteristics of this game and the delay in the tasks. A real negotiation will be reproduced using the technique of gaming simulation. This technique allows us to reproduce human strategies, which are difficult to reproduce by other means. In particular, it allows us to develop a prototype and conduct a proof experiment. It also allows the players to experiment assuming different roles. We can find an effective strategy and a proper value in the period of negotiation. Therefore, this method allows the relationship between the construction delay and the negotiation process to be examined.

In this paper, we propose a way to model the negotiation between general contractor and subcontractors. Chapter 2 explains the characteristics of the interior finisher thing and the business game, and discusses the relevance of the proposed approach. In Chapter 3, the negotiation between general contractors and subcontractors is modeled. Chapter 4 presents the main conclusions and proposes future works.

## METHODOLOGY OF THIS RESEARCH

### Characteristic of interior finish work in Japan

Despite the great interest in shortening the term of works in the interior finish work of apartment buildings, there is still room for efficiency improvements. In building construction, because works are executed by roles of subcontractors and specialist contractors, the process is intricate and the entire construction process is difficult to standardize.

There are some previous researches concerning improvement delay of works in the construction site. Ueda proposed to use the TOC (Theory of Constraints) for cost minimization in the planning process of building operations [2]. Contrary to the conventional notion of constraints as "requirements to be satisfied", TOC considers constraints as "requirements that may change according to increases or decreases of costs", which made it possible to create an optimal process plan including a range that was not originally considered. Moreover, it made possible to search for a suboptimal solution while efficiently changing the three kinds of parameters of TOC by using *LocalSearch* methods. Kamata proposes a way to improve the planning

process from the viewpoint of labor cost by using GA (Genetic Algorithms) considering labor leveling [3]. Their optimization method, which considers constraints on equipment and individual work, was shown to be effective in real projects. In related research, Shide showed that there exist differences in workers and foreman's roles and information transmission according to the terms of the contract [1]. As a result, it is shown that the decision making in the site is related to the difference of the employment system. Excluding Japan, V.Gonzalez examines the productivity of repetitive work using simulation [4]. They designed proper work-in-process buffer in both time and cost by setting the difference of the work progress. Also, there are many previous studies concerning the] term of works delay from the shop floor, but there are few studies regarding the negotiation general contractor and subcontractors. In Japan, the subcontractor side undertakes the trouble concerning the term of works delay at the stage when the general contractor and subcontractors concluded the contract. Therefore, we consider necessary to discuss the relation between such negotiation and delays in the work. However, we also consider important to incorporate real people's decision making. Then, we propose to use gaming simulation as a tool that can simulate the process while taking person's decisions directly.

### **Business Game**

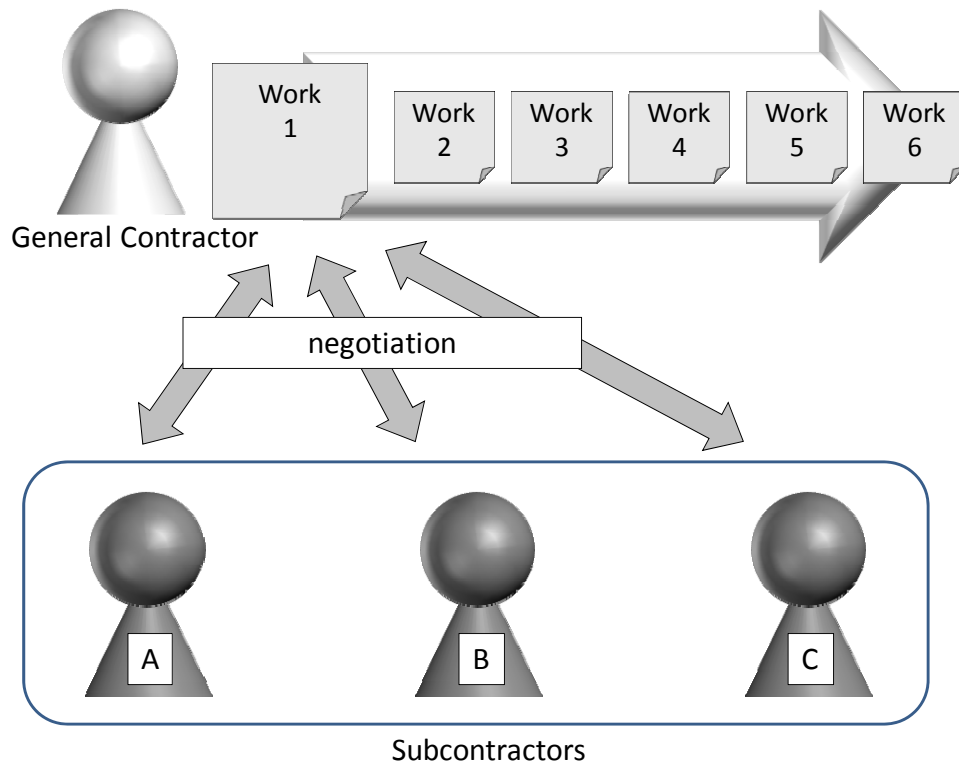
This paper considers the problem in the negotiation between general contractor and subcontractors as a kind of business game. In business gaming, the "Beer game", which is used to illustrate SCM (Supply chain management), is very famous. The beer game is a role playing simulation of the production and circulation system in an industry; the game imitates the production and circulation of beer [5]. The player in the game are divided into sectors such as "Retail store", "Wholesale", and "Factory", and make decisions regarding orders having as an objective the minimization of total cost. One of the findings of this model is that the oscillations in the input are amplified by the decision making of the players. Also, the players pay little attention to the feedback they get from their own decisions, and underestimate the time lag between their decisions and their consequences. In this game, players learn that it is important to consider the consequences of current decision making in future decision making. Gaming simulation allows the ideas of the player to be expressed qualitatively and allows a player to experience several roles in the game. This is very difficult to accomplish using simple simulation. The negotiation between general contractor and subcontractors resembles the above-mentioned beer game, and also suffers the undervaluation of the consequences because of immediate profit pursuit. Therefore, it is necessary to reexamine the negotiation strategies and to discuss the delay structure through a gaming simulation that resembles the real

problem as much as possible. However, the some differences exist in this case. One difference is the existence of competitive bidding. When subcontractors are selected, the general contractor chooses the best business partners and so it should contain to examine the structure of competitive tendering. Especially, the process of negotiation, price disclosure, and reexamination is required. Another difference is the existence of the main customer. The building constructor generally has continuous association with the customer. Such differences are important for the description of the negotiation process between contractor and subcontractors in Japan using gaming simulation. This makes possible the recognition of problems related to the strategies in the negotiation and delays in the process.

## **MODEL**

### **Outline of the model**

Here, the whole image of the model is explained. This model assumes the negotiation game between one general contractor and three subcontractors(A,B,C). There are six construction tasks in total, and the general contractor decides which subcontractor takes charge of each work. So there are 6 negotiation rounds between general contractor and subcontractors. The general contractor decides the success or failure of the contract based on the budget and the delivery date that subcontractor presents. The re-negotiation starts when the general contractor does not contract to any subcontractor, and subcontractors present a budget and a proposal of delivery date again. In this case, it is necessary to indicate the price presented by all of the subcontractors in the last negotiation. General contractor and subcontractors have also a parameter indicating financial capacity. This parameter decreases at the negotiation and recovers for the contracted subcontractor when the contract is concluded. The player with the role of subcontractor aims to maximize its financial capacity by the end of the game. In other words, the winner of the game is the subcontractor with the best financial capacity after the 6 negotiation rounds. The works are executed in order according to the work number. Though the works actually progress in parallel, this model was simplified to pay attention to the problems of negotiation. In the real world each subcontractor is often a specialized construction company, and the subcontractor that participates in work 1 and work 2 is a different company. But the same subcontractors participate in the negotiation all the six times, in order to discuss the strategy there. There is no limitation in the negotiation frequency and the negotiation is repeated until the general contractor approves to the amount of money that subcontractor presents. However, because the funding ability decreases at each negotiation, it is better for both the general contractor and the subcontractors the contract to be approved at an early stage. Fig1. illustrates the outline of the model.



**Fig 1. Outline of the model**

**Table 1. Example of the role differences according to the work**

Work	1	2	3	4	5	6
main client	A	B	C	A	B	C
other player	B,C	A,C	B,C	B,C	A,C	B,C

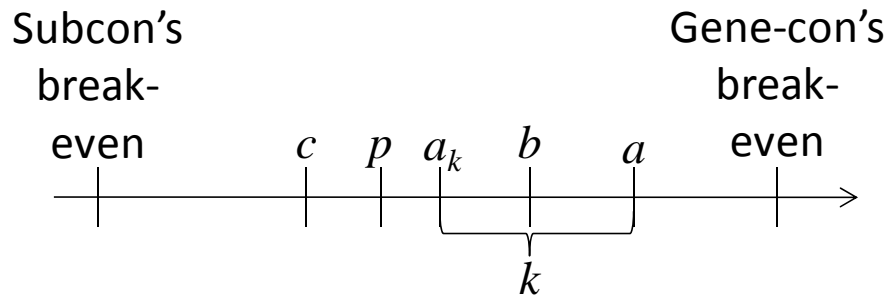
### General contractor

General contractor refers to building constructors that undertake various engineering works and manage the entire construction. General contractors in Japan are complexes of various specialist contractors. The focus here is in the building constructors who are called super general contractor in Japan, and hold the design section, the engineering section, and the research and development section, while assuming construction work to be a kernel of business.

The general contractor is a subject in this model that orders work  $W$ . The general contractor possess capital  $FG$ , a whole delivery date  $TD$ , the management cost  $k$  and the standard amount of money in each work  $p_w$ . If the negotiation is first or second time for a work, the decrease in financial capacity is low, but from the third re-negotiation it will be set higher.

Now, I will explain the management cost  $k$ . In the real negotiation, there are contractors which have low

management cost  $k$  for the general contractor compared to other companies, because of their current relationship with the general contractor. It means that it does not incur in management costs more than the cost asked to other general contractors for work in previous works after the contract was concluded. Therefore, in the negotiation scene, when assuming that main client is company A, and the offered budget is  $a$ , it can be thought as a  $a-k$  contract by the general contractor. This is called the actual amount of money of the negotiation. After considering this actual amount of money of the negotiation, the general contractor does the decision-making. This main client changes alternately through the six works. For example, subcontractor A become main client in the negotiation of work 1 and subcontractor B become main client in the negotiation of work 2 and so on. Table 1 is shown as an example. Moreover, when the negotiation ends, the general contractor presents the budget proposed by each of the subcontractors in the last negotiation. This is done in reality, and can



**Fig2. Decision making of the general contractor**

generate competition between subcontractors.

### Subcontractor

Subcontractor is a trader only who constructs a specific kind of work, and is also called special contractor. Therefore, they have wide technology concerning construction. In Japan, it refers to the building constructor who undertakes a part of the engineering works and the construction work as a subcontract of the general contractor. For instance, there are electric equipment construction, air conditioning equipment construction company, hygiene equipment construction company, digestive equipment construction company, etc.

In this model, subcontractor is a subject that undertakes work. Each subcontractor maintains a financial capacity  $F_i$  and a delivery date  $D_w$ . Note that  $I \in A, B, C$ . Each Subcontractor aims to maximize capital  $F_i$  when the negotiation for the sixth work ended. Each subcontractor present a budget of  $i$  based on the standard amount of money  $p$  that the general contractor presents in each negotiation. Here,  $a, b, c$  are that the budget that subcontractor player A, B, C present, and also  $i \in a, b, c$ . Moreover, subcontractors do not know who the main client is. Finally, consultation between subcontractors is assumed to be prohibited in this game, to avoid collusion.

### Flow of the model

Here, the flow of the negotiation gaming between general contractor and subcontractors is explained. In this case, Number of works NW is set as six and are expressed from Work 1 to Work 6.

- ① One general contractor player and 3 subcontractor players (A,B,C) participate in the game. In this case, they have capital ( $F_A, F_B, F_C$ ) respectively.
- ② In work  $n$ , subcontractors A, B, and C proposes a budget  $i$  and a delivery date  $DW$ , based on the standard amount of money  $p$  and the delivery date of the work presented by the general contractor.
- ③ General contractor compares  $p, a, b, c$  and then assume the management cost  $k$ . For example, if the subcontractor A is main client, the amount of money of A for the general contractor is  $a_k = a - k$  because the management cost is not caused in A compared with the other companies. Figure 2 illustrate this idea. The right

edge is the break-even point of the general contractor, and the difference between it and  $p$  is the expected profit of the general contractor. On the other hand, the left end is a break-even point of the subcontractors, and the difference between it and  $i$  is the profit of the subcontractors.

- ④ The general contractor decides whether to contract or not. If it decides to contract, it decides which subcontractor to contract.
  - i. When the general contractor contracts, it shifts to the next work. If the current work is the last work, the game is over.
  - ii. When the general contractor does not contract, it shows all the budget proposals it received to the subcontractor players.
- ⑤ Both, general contractor and subcontractors, decrease their financial capacity. If the negotiation is happening for the first or second time for the current work, the financial capacity decreases only by a small amount. However, if it is happening for a third or more times, the financial capacity is decreased by a higher amount for the general contractor.
- ⑥ Returns to.

## CONCLUSION AND FUTURE WORK

This paper focused on the negotiation between general contractor and subcontractors as one of the causes of the delay in the interior finish work of apartment buildings. In Japan, once the contract is established, the subcontractor must take responsibility in the cases when a delay occurs. This research proposed the actual application of a negotiation game model to this problem by using the gaming simulation. This method enables to reproduce the gamesmanship of the negotiation and the relationship between the companies. Moreover, it allows discussing a proper negotiation period and the negotiation procedure. Using gaming simulation it is also possible to exchanges roles, which makes possible to experiencing other party's standpoint.

Future work focuses on developing a prototype and conducting proof experiments. We are currently under development by using the SOARS language, which is a social simulation language for prototype development [6][7].

This tool allows performing simulations, animations and gaming simulations, and is easy to use. Currently, the values of the parameters have not been decided, but we'll set up the proper parameters by taking the opinion of the persons on the field and the results of the simulations. Especially, because a proper value at a negotiation period can be used in future negotiations, it is necessary to calculate it through the trial experiment. To examine the characteristics and causes of delay in the negotiations through useful experimental strategies is effective in future negotiation situations. The experiments will focus mainly in the following. 1) How are delivery date and proposed budget influenced by the subcontractors recognizing the main client? We consider that this has an important influence in the level of the competition. 2) The influence of the general contractor presenting a standard amount of money in the first stage and subcontractors knowing such standard amount of money: it is useful for the reproduction of characteristics of real companies. 3) It is necessary to think about the existence of conditional bidding in actual negotiations. In this case, conditional bid means that general contractor choose a subcontractor and extend the negotiation with that company. We think there is room for argument about this situation because this is an actual bidding method. 4) It is also important to evaluate the established theory on contracts. In Japan, it is said that prolonging the negotiation is an effective way of decreasing depreciation, but it is also thought that it is necessary to check experimentally whether the established theory is true or not. Considering the above experiments, we can examine real negotiation strategies and their degree of influence on the delays.

simulations of social interactions and gaming. Introduction as a social microscope., Proceedings of the 38th Annual Conference of the International Simulation and Gaming Association,p-36(2007)  
SOARS Project: <http://www.soars.jp>

## REFERENCE

- Shide.K., Yuasa.Y., Someya.S., Kanisawa.H., Ishida.S., A Research on Interior Finish Work of Apartment Building Part Two: Investigation of Process-Information Transmission Process in Interior Finish Work, AIJ J.Technol. Des.,Vol15, pp557-562 , 2009
- Ueda.K., Furusaka.S., Fujisawa.K., Muroya.T., Kaneta.T., Construction Planning of Repetitive Work with Theory of Construction, J.Archit. Plann. Environ. Eng., AIJ, No.557, 281-288, 2007
- Kamada.M.,Furusaka.S.,Kaneda.T.,Katsuyama.N., Construction Planning of Repetitive Work Using Genetic Algorithms and Application to Real Project, J.Archit. Plann. Environ. Eng., AIJ, No.522, 255-262, Aug., 1999
- V. Gonzalez: Multiobjective design of Work-In-Process buffer for scheduling repetitive building projects, Automation in Construction (2009)
- Ichikawa.M., Koyama.Y., Deguchi.H., Human and Agent Playing the Beer Game, Developments in Business Simulation and Experiential Learning, Vol. 35, pp231-237, 2008
- Ichikawa,M.,Tanuma,H,Koyama,Y.Deguchi,H.:SOARS for