Master's Science in Engineering

Managing Tenant Movement scenarios based on Tenant Satisfaction during Occupied Renovation Activities

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Abstract

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The demands for renovation works in Korean construction market are expected to increase due to the advantages it brings. The two main classification of renovation methodologies are non-occupied condition and the occupied condition. The occupied condition allows the tenants to occupy the building during the construction, while non-occupied condition defines the complete vacancy of the building.

The advantage of occupied condition, which the research focuses on, includes rental income collected during the renovation, retaining the tenant, and retaining the customer in the leasing market. The disadvantage of the occupied conditioned renovation includes durational disadvantages compared to the vacant building and considerations of the tenant within the building during the activity.

During the occupied renovation, the time-cost tradeoff between finishing renovation quickly and obtaining rental income from partially occupied building necessitates an optimal solution. To optimize the solution, previous researches have focused on the optimization of the time-cost trade off using various analysis. During the analysis, case studies have shown that tenant satisfaction caused delays due to the movement of building user within the building. Since it is inevitable to create space for the workers without removing the tenants, managing tenant satisfactions requires detailed management skills.

The tenant dissatisfaction that the renovation causes can result in schedule delay, cost overrun, and loss of building users productivity, which also creates Trade-off between tenant satisfaction, cost, and schedule. The research addresses occupant satisfaction as a main factor that hinders the occupied renovation and takes the satisfaction in to simulation input while scheduling the project. The research provides the building owner the tenant movement scenarios during the renovations works that considers occupant satisfaction as the most important factor.

Keyword : Occupied renovation, scheduling, ABM, Tenant movement, Tenant satisfaction

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Chapter 1. Introduction

1.1. Research Background

The renovation works compared to the constructing the new building has cost flexibility, environmental, and durational advantages, increasing usage of the renovation in various building types internationally and especially in Korea.

Nation - Korea	2015	2020	2025
Percentage of Renovation / Construction Market	15~20%	25~30%	Above 30%

Source: 리모델링 총설 (개정판), 2014

Figure 1-1. Future usage of renovation works in Korea

As most of the construction project does, the main decision making factor in renovation project is the profitability. Due to the constraints that the existing building gives to the construction works, securing the profitability remains as issue that is more vulnerable in remodeling business (Ji, 2011). In addition, the environmental, social, and political constraints that make the profitability complex affect the profitability of the project. However, focusing on renovation methodology can be a solution to the problem.

The renovation methodology can be classified in two main processes, which are renovation in occupied condition and vacant renovation. There are large economic differences between occupied condition and vacant condition. The occupied condition allows additional profit during the renovation period with the rental income collected according to the tenants. However, the vacant renovation does allow the renovation period to be flexible, but discarding the rental income during the period. With the two methodologies, different alternatives can be created considering the work sequence.

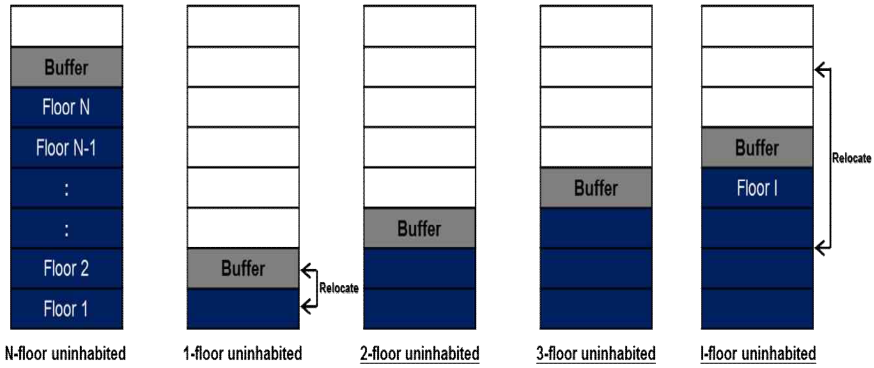


Figure 1-2. Comparison of the various renovation methodologies

(Adopted from Paek et al., 2013)

From the suggested alternatives the 1-floor uninhabited condition and 2-floor uninhabited condition is compared. From figure 1-2 the result shows that N=2 takes less renovation period to complete the works, but has less space for rental income before the renovation completes. Also, N=2 graph collects more rental income after the renovations works. In the other hand N=1 graph shows that more rental income is collectable before the renovation work ends, but takes as twice as longer alongside N=2. The buffer space also accounts with the profitability. The buffer space in N=2 costs less than N=1 creating more rental income whether it is after the renovation or before the renovation. The examples shown in figure 1-2 states that the profitability is related with renovation methodology in various ways.

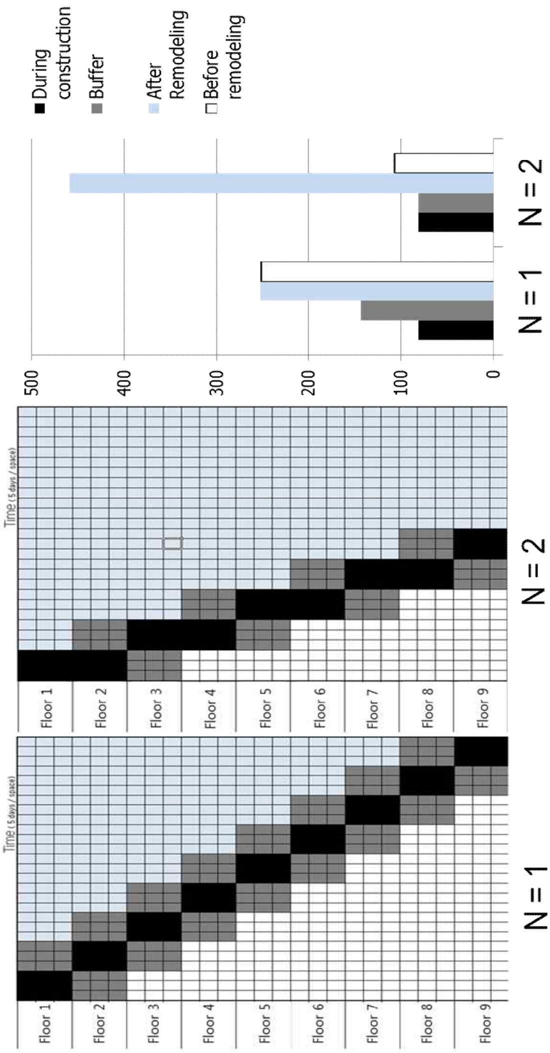


Figure 1-3. Comparison of the methodology alternatives N=1 & N=2

From figure 1-2 the result suggested that factors are related with each other in considering the profitability of various projects. According to the selection of renovation methodology, the renovation period can increase or decrease. With the renovation period changes, the construction cost can increase or decrease. For example, a reconsideration of the profitability is necessary if there is an additional material or work force necessary to complete the renovation period quicker. Also, affects on the rental income, which can increase, or decrease with the selected renovation methodology, construction cost, and time. While considering the renovation profitability, the time, cost, rental income variables must be taken in to account (Douglas 2006).

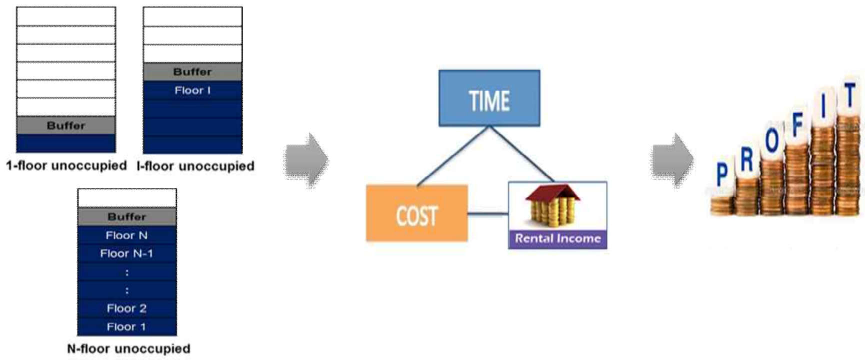


Figure 1-4.Time, Cost, and Rental income considering the renovation profitability.

Apart from the profitability issues of the renovation works, there are variables that conducts the renovation methodologies. For example, if the building has risks attracting the tenant due to the competitors or other building leaseholders the owner can decide to renovate the building using the occupied condition. Also, if the rental income of a specific tenant is profitable enough to renovate using the occupied condition the owner can make the decision. In case of H-company, Seoul, South Korea, the H-company owned the building and used about half of the building for the company's workers and half for the rental income. The H-company failed to provide such a large capacity of work area while renovating the building, and decided to renovate the building in occupied condition in order to keep the workers working. There are many case studies and data other than the profitability that renovation in occupied condition is necessary which leads to a new discussion.

Even though the scheduling technique considering maximum profitability is necessary, the research suggests that more consideration should be focused on the occupant satisfaction. The occupied renovation requires tenants within the building to function as before the renovation, and collect the rental income at the same time. However, the current scheduling techniques lacks the tenant satisfaction considerations and did not focus as much on occupant satisfaction. The following data suggest that renovation methodology must consider occupant satisfaction as a main variable due to the average number of reworks and unforeseen sight conditions. In figure 1-5, Reconstruction which can be considered as renovation, is compared with the new construction. The research data shows that reconstruction has significantly higher numbers of unforeseen sight condition compared to the new construction and has higher average number of rework and complaints. Even though the chart did not address it’s reasons, McKim states the reasons to be found from the tenants using the buildings.

Quality criteria (1)	Reconstruction (2)	New construction (3)
Average cost of rework (percentage of total cost)	1.6%	0.27%
Average number of rework requests	7.4	1.3
Average number of users' complaints	7.8	1.0

Factor (1)	Reconstruction		New Construction	
	Cost (%) (2)	Schedule (%) (3)	Cost (%) (4)	Schedule (%) (5)
Unforeseen site conditions	52.8	50.4	21	27.5
Scope change by owner	16	13.8	52	47.1
Design change	13	14.7	23.6	16.7
Procurement problem	3.8	11.6	—	4.4
Design coordination	10.8	8.2	3.4	3.3
Regulatory requirement	3.6	1.3	—	7.0

Source: McKim, 2000

Figure 1-6.Unforeseen site condition number or reworks

1.2. Research Objective and Scope

The research suggests tenant-management model considering the user satisfaction. The research only scopes to analyze the selected buildings in which rental income is collectable. The model does not consider complete vacant renovation method and only analyzes the renovation activity that is conductible under the occupied condition. The research inputs the satisfaction in to the simulation model as well as the activity components aims to improve the satisfaction of the tenants during the renovation activities.

1.3. Research Procedure

The order of this research is as follows:

1) The research conducts a study on previous researches and analyzes the studies for improvement. For the first step the research conducts a research on existing literature, such as user satisfaction within the building, Agent based simulation method, existing scheduling technique, and case studies regarding the user satisfaction within the occupied renovation condition.

2) Using an Agent-Based Modeling (ABM), a model was developed to schedule the activities and improve the user satisfaction of specified situation. In order to do the step, a study on JAVA programming technique was necessary as well as the tools from Anylogic software.

3) Simulate the results using the model and analyze the results.

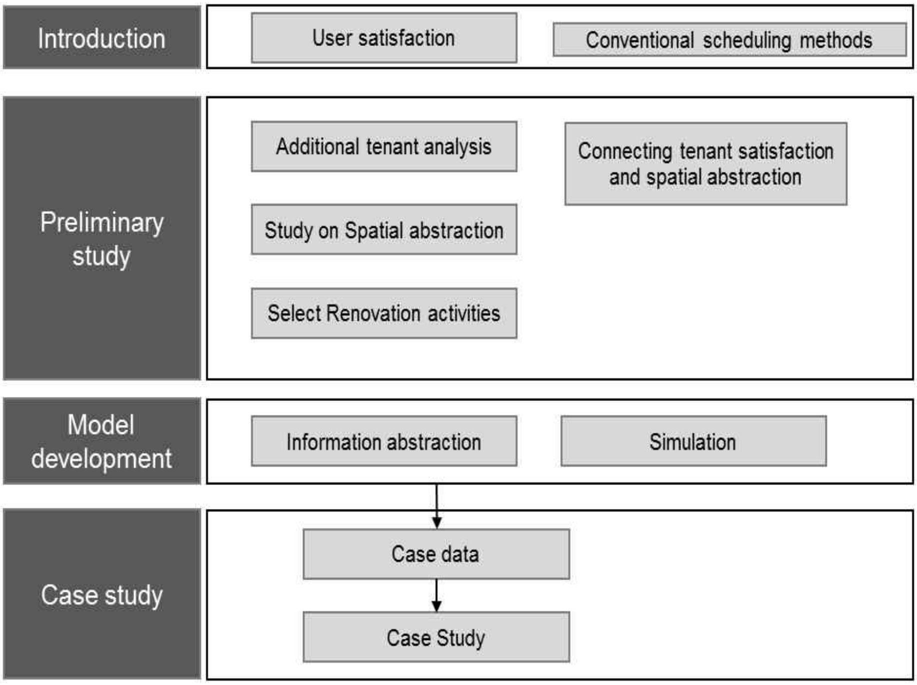


Figure 1-7. Research Process

Chapter 2. Preliminary Study

In this chapter, contents of previous studies are described in detail. The preliminary studies include the case studies of the occupied renovation, and the user satisfaction research. Also the ABM methodology and the simulation approach is described.

2.1. User Satisfaction in renovation of occupied condition

The user satisfaction includes any variable that affects the tenant within the building. As a result, according to the usage, the definition scopes widely between a small factors as aesthetics and the most important factors such as safety.

The following data is a case study presented by Yee, 2009, where the data proved that tenant satisfaction, construction cost, and time are closely related. From the different satisfaction variables, the research selected number of movement as the main customer satisfaction variable. The case study presented five different sequences that number of tenant movement varied between 9 to 24. With the different movement count resulting construction time and cost savings were resulted. The purpose of this case study was to prove that the satisfaction is directly related to cost and time.

Sequencing Option	Construction Time	Time Savings	Cost Savings
Concept Design Schedule	60 months		
Sequence One	55 months	5 months	$440,000 - $600,000
Sequence Two	56 months	4 months	$880,000 - $1,200,000
Sequence Three	52 months	8 months	$1,760,000 - $2,400,000
Sequence Four	45 months	15 months	$3,300,000 - $4,500,000
Sequence Five	36 months	24 months	$5,280,000 - $7,200,000

Sequencing Option	Number of tenants that must move twice
Sequence One	16
Sequence Two	21
Sequence Three	21
Sequence Four	24
Sequence Five	9

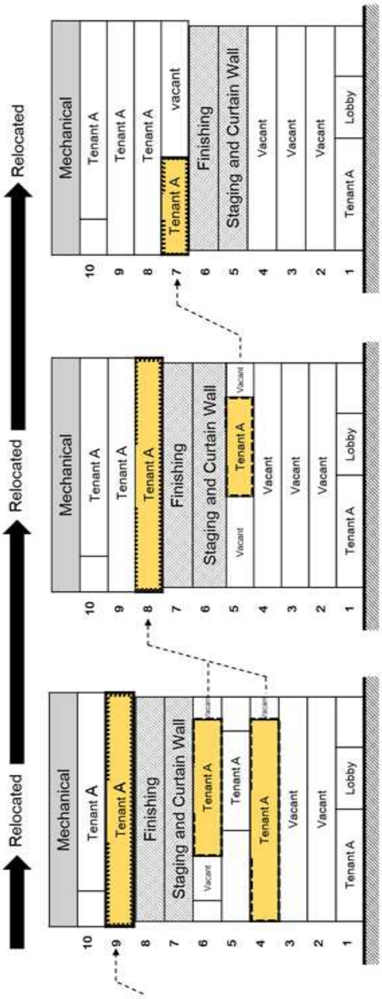


Figure 2-1. Case study of the renovation of occupied buildings considering satisfaction, cost, time (Yee, 2009)

In case of OCAD University, Toronto, Canada, during the occupied renovation works the tenant dissatisfaction caused complaints, which required additional works. In addition, Indoor Air Quality, IAQ constantly opened a committee to improve noise, odor, and dust within the building during the renovation works. In Seoul, South Korea, where the rental income is very high that occupied renovation is profitable, the suggested picture in figure 2-2 shows a case study of occupied renovation. The tenant could not be vocal with the dissatisfaction during the construction phase because the same company occupied and owned the building, which were the employer of the tenants.

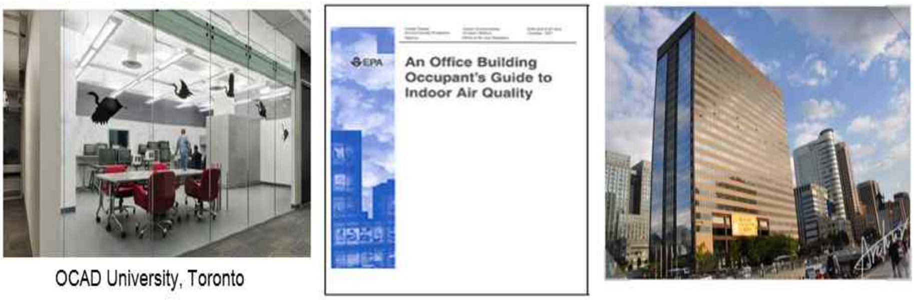


Figure 2-2. Case study of the renovation of occupied buildings

2.2. Occupied Renovation scheduling

Table 2-1. Occupied renovation profitability analysis related research

Objective type	summary	Author
Profitability	Classifies the building objects in order to analyze profitability of occupied renovation	Yang et al. (2012)
	Developing profit model to Analyzing project feasibility in occupied renovation	Ahn (2004)
	Combining Profitability prediction and cost prediction model and analyzing factors affecting the occupied condition	Kim et al. (2013)
	Analyzed the profitability of rental office buildings before and after the renovation using the Hedonic model	You (2006)
	Analyzed and surveyed construction project participants for performance comparison of renovation projects	McKim (2000)
Occupant satisfaction	Using the AHP method and surveying, drew constraints that affects occupied renovation	Shim (2006)

Yang(1999) Classified the building objects in order to analyze profitability of occupied renovation. The classified then analyzed building included rental office buildings and apartments, which were distributed according to the tenants' usage. You(2006) analyzed the profitability of rental office buildings before and after the renovation using the Hedonic model. While Kim(2013) Combined Profitability prediction and cost prediction model and analyzing factors affecting the occupied condition. McKim(2000) Analyzed and surveyed construction project participants for performance comparison of renovation projects and new construction buildings. The performance comparison included cost overrun and unexpected situations, which directly affected the profitability of the building.

2.3. Identifying Occupant Interaction (IOI) Method

The most advanced simulation method or the occupied renovation ontology is the IOI methodology. IOI method focuses on the interactions of worker and tenants during the work process. It classifies the worker and tenant to sharable, non-sharable, and semi sharable space profiles. A non-sharable profile defines that the tenant is not willing exist on the same space. A semi-sharable profile defines that the tenant is unwilling to share space when the occupant is active, but is sharable when the occupant is idle. A sharable profile defines that an occupant is allowing other occupants to share space whether the occupant is active or idle.

The defined occupant space profile draws the interaction types, which are Tenant-Tenant, Major Tenant-Crew, Minor Tenant-Crew, Crew-Crew, and no interaction. Interaction is this case is either having occupant, worker or tenant within the same space. Whether the Tenant's profile was sharable, semi-sharable, or non-sharable, tenant existence in same space is non-considerable in IOI. Therefore, the IOI method does not consider Tenant-Tenant to be in same space and rather moves the trailing tenant to an open space. The Crew-Crew interaction occurs when construction crews are in the same space. The IOI schedules the crew-crew interaction within the space if both of the crew does not have non-sharable profile. The major Tenant-Crew interaction occurs when either the crew or tenant has non-sharable profile. In this case the

Tenant or the crew is moved to a new space creating additional time. The minor Tenant-Crew interaction occurs when both the tenant and crew are willing to share the space. Then the crew and the tenant can be in the same position deducting time and cost.

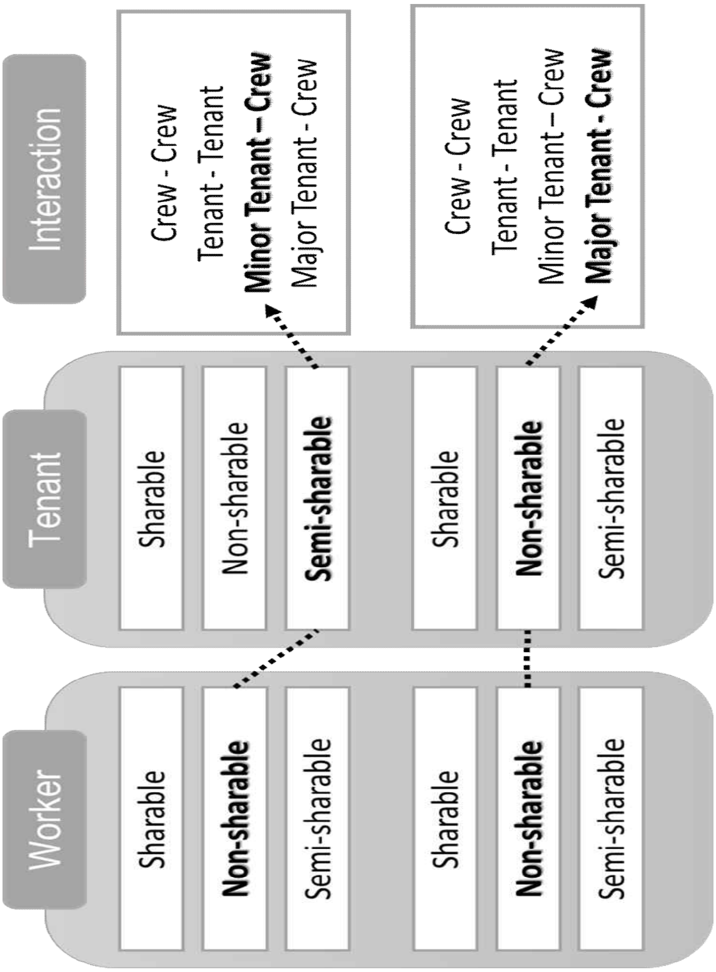


Figure 2-3. IOI profile and interactions

From figure 2-4, shows an example of how IOI plans the tenant occupied condition with the interaction. The red dotted line highlights the interaction that occurred during the construction. The First red dotted line is a major interaction between a Tenant and crew. This means that one of the occupant, whether the tenant or crew has a spatial profile that is non-sharable. Since the spatial profile is non-sharable the installation of pipe in space 2 is pushed back at the last and planned after other schedule is complete.

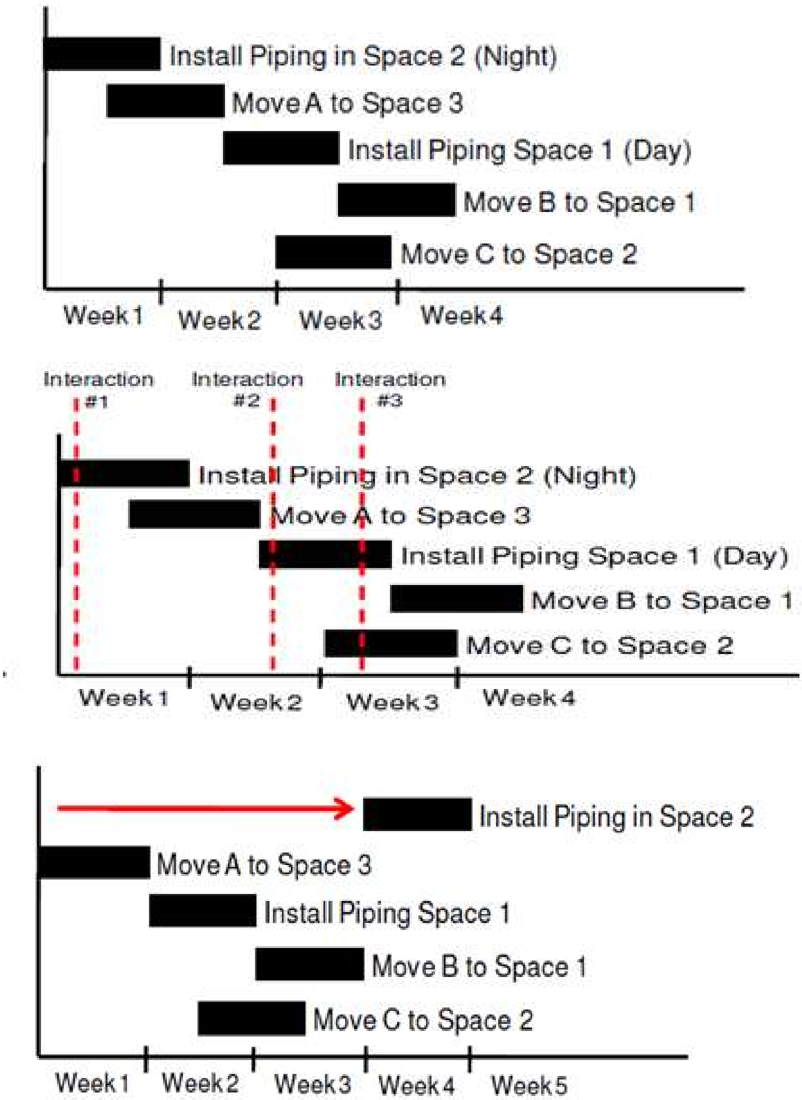


Figure 2-4. The planning process

From the spatial profile and the interaction, following tenant movement is resulted. The vacant area triggers the renovation activity after the construction is over the tenant moves in to the finished space. While moving in to the finished space, the IOI checks the interaction of the tenant and crew in order to solve the conflict. The result is shown with the chart with the space unit and occupants within the space.

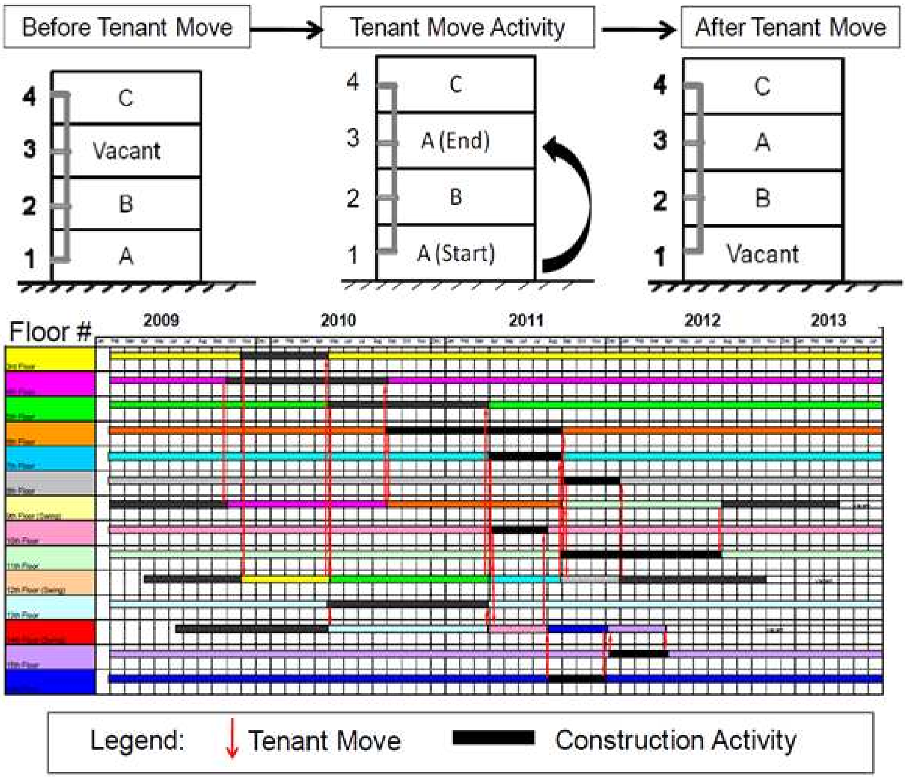


Figure 2-5 The result of IOI method (Yee. 2010)

From the modeling, the IOI does not consider the tenant satisfaction and rather share the worker and tenant's space. As the model will be explained, the model developed focuses on the representation of tenants, which is done in form of satisfaction.

2.4. Agent based Modeling(ABM)

The Agent based models can be considered models of complex systems and the ABM approach considers the simple and complex situations of each entity. In other words, agent-based model can be simplified representation of a given reality, either already existing or just planned. The ABM is used in variety of areas including SCM, human perception, and entity interaction researches. While modeling the simulation must comply the satisfaction of tenants within the building, the following interaction logics maps the interactions between the agents while using the agent base simulation.

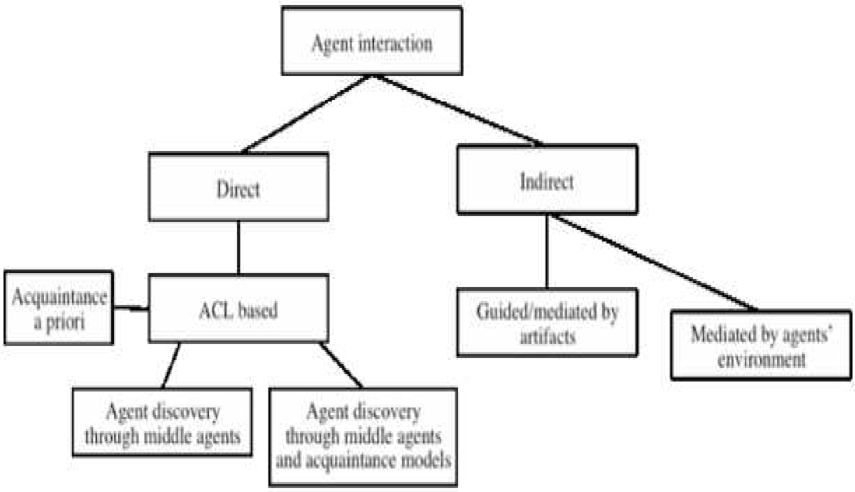


Figure 2-6. Interactions of ABM (Bandini, 2009)

Using the Agent based modeling, the simulation outputs varies including schedule, interaction types, tenant position or state, and various environmental aspects. The tool is advanced enough to select the dynamic output and inputs and visualizing the simulation schemes as well.

Figure 2-7. Example output of ABM (Anylogic sample image)

2.5. Summary

The literature review focuses on the occupied condition of renovation works and how it was analyzed using the profitability. In addition, the IOI method, which did focus on the interactions, had less focus on the satisfaction of the tenants. As the satisfaction is related to Cost, Duration, and profitability, the literature review states more analysis is necessary. Therefore using the ABM, the scheduling must consider the tenant satisfaction while scheduling the tenant's schedule during the renovated construction.

Chapter 3. Model Development

The Model development chapter is composed of four chapters, which are modeling the tenant satisfaction, tenant agent, and activity agent. Each chapter explains the input factor, output factor, and the model schemes independent of the case variables that includes are different building, environment, and tenant attributes.

The agent based modeling requires the real world attributes in the abstracted form since the simulation cannot represent the real world as it is. First, the satisfaction was defined with tenant movement and moving distances. In addition, the tenant movement causes changes in the construction activities and periods, which affects the cost directly. Therefore, controlling the moving distances and limiting the total number of movement does increase the tenant satisfaction.

The input factors of the environment contain the starting building configurations, the number of tenants, and the number of activities. The building characteristic does change throughout the simulation, but the previous methods failed to apply the dynamic building use in to the model. The number of tenants may or may not change throughout the model with the activities required, but the dynamics was not applied in the model. The activity requirement includes number of buffer areas and units as the activities require different material or equipment.

Addressing the difference between the IOI method and the suggested model must be critical in order for readers to understand the difference. IOI model focuses on the construction itself. The sequence of the activities focuses on managing the delays and producing the best result for activities itself, and in other words produces the most efficient schedule for the planner. The core logic of the IOI method lies on semi-sharable and semi-sharable profile. It defines that the both worker and the tenant can be in the same building, while the construction proceeds. In the model, that research suggests the tenant and the worker cannot be in the same space, in order to maximize tenant satisfaction. In addition, the input value of the model heavily lies on the tenant satisfaction. The two suggested variables defines the tenant satisfaction and the model keeps the dissatisfaction in the records.

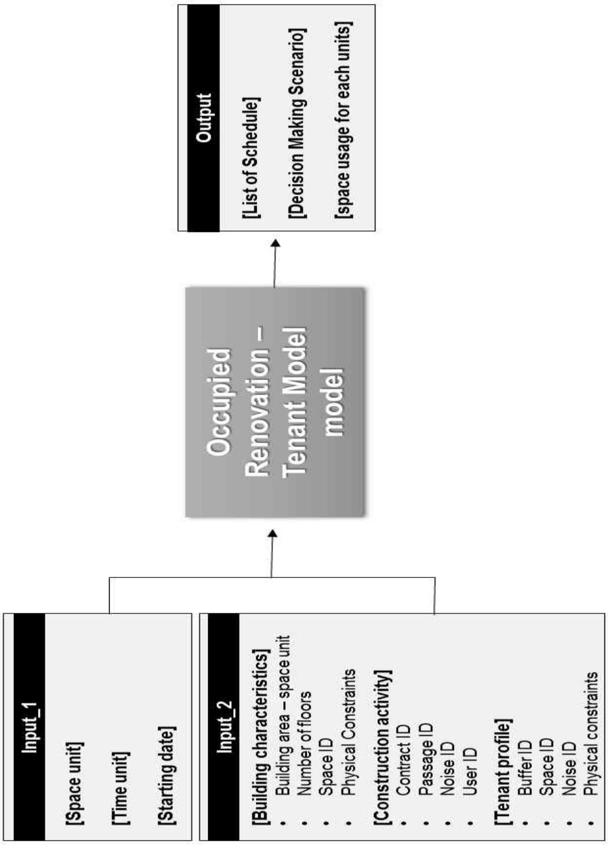


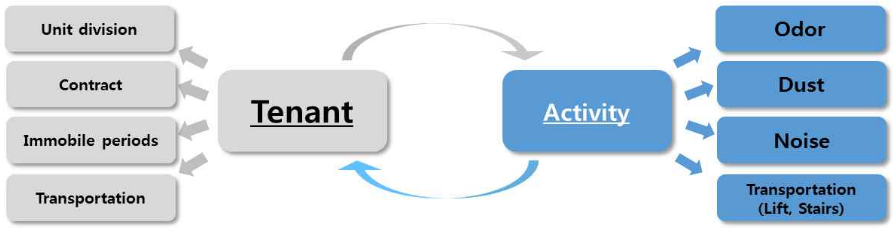
Figure 3-1. Model process.

3.1. Modeling the Tenant Satisfaction

The tenant satisfaction during the construction is defined in variety of ways according to its usage in researches. The satisfaction of the building use during the construction period scopes from small things as aesthetics to the most crucial factors such as safety. The dissatisfaction includes noise, odor, and dust , and as the figure 3-2 shows, there are ongoing research in Indoor Air Quality committee in order to satisfy the tenant’s building usage. As a result, in case of OCAD University, Toronto, Canada the article proves that failed management of occupant’s odor, dust, and noise caused delays and additional cost to the project.

Figure 3-2. Ongoing researches regarding the tenant satisfaction

Figure 3-3. Tenant satisfaction from the case study. (Ho. 2009)



Tenant name	Tenant Sensitivity Requirements			
	Noise	Odor	Dust	Transportation
Tenant A	1	2	3	Lift–nonsharable , stairs-sharable(3)

Figure 3-4. Tenant activity abstraction for the model

In previous studies by Ho, 2009, the tenant showed the suggested dissatisfaction variables showed in figure 3-3. Therefore, in this research the modeling focuses on the schedule of tenant as a main factor, as well as minimized number of movements. Also the distance of the tenant movement must be considers as well. To create a balance between movements, cost, and satisfaction each tenant will provide the planner the minimized number of movement it can sustain during the construction. Considering the minimized movement the simulation considers open unit of the building that is closest when necessary. For example moving from the 3rd floor to the 11th floor is more dissatisfying than movement from 3rd floor to the 4th floor. Therefore within the simulation the tenant moves to the 4th floor if the 4th floor is available. The simulator weighs movement within a closer distance compared with the larger distance within the building. If the movements of the shorter distance are inevitable, the simulator executes the action as an alternative plan.

3.2. Modeling the Tenants

As the modeling of Tenant satisfaction is abstracted as Number of movement, dynamic building units, and the moving distances, a modeling of these satisfactions can be interpreted in many ways. The most commonly used chart in agent based modeling is called a state chart. The state shows the current variable of the agent, and Idle and Active state represents the agent's state in the research. The initial area is a parameter, which does not change throughout the simulation states; however, current area is a variable, which changes throughout the state. Each tenant agents has a state of Idle and Active classified as a variable, and only moves when the state is Idle.

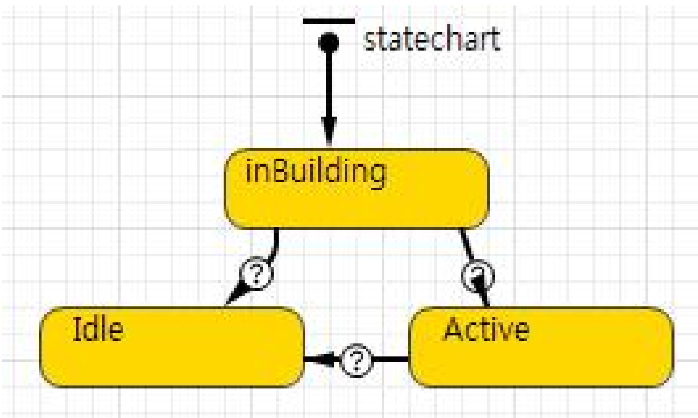


Figure 3-5. Tenant state chart

Week	Tenant 1	Tenant 2	Tenant 3	Tenant 4	Tenant 5	Tenant 6	Tenant 7
1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1
15	1	1	1	1	1	2	2
16	1	1	1	1	1	2	2
17	1	1	1	1	1	2	2
18	1	1	1	1	1	2	2
19	1	1	1	1	1	2	2
20	1	1	1	1	1	2	2
21	1	1	1	1	1	2	2
22	1	1	1	1	1	2	2
23	1	1	1	1	1	2	2

Figure 3-6. Tenant schedule chart (1=tenant active or will be moving, 2= tenant Idle)

The time unit in 'weeks' are used as a controlling tower to implement the tenant schedule. In other words, the model is in unit of weeks and the tenant agent decides to move or not in unit of weeks. The number 1 means that the tenant will be able to move or 'active' while the number 2 defines that the tenant will not be able to move at the time. If the tenant is active, the simulator goes through the different checking scenarios to navigate the tenant to a next space unit for the specified time. The navigation or variables that dictate the navigation are included in the following 2 sub chapters, it will include the Activity agent and the environment setup that has been done in the main domain.

3.3. Modeling the environment

In most of the projects, the building has defined number of floors and defined number of units per floor. A building unit was a space where one tenant agent occupies the space according to the defined number of week. The building unit can be changed dynamically where one agent can occupy two spaces at the same time leaving some building space open or closed according to the situation. With the dynamic building configuration, the scheduler can maximize the building space efficiency resulting better satisfaction for the tenants. From figure 3-6 a controller named pedAreaDescriptor is assigned to all the space units in order to control the space units. pedAreaDescriptor functions to block, free, and controls the agents in space, and is a main part of the space checking function that runs multiple times as the simulation proceeds. Space checking function checks the space if the tenant must leave the space due to the construction activity, which outputs whether the space is occupied by the tenant or not.

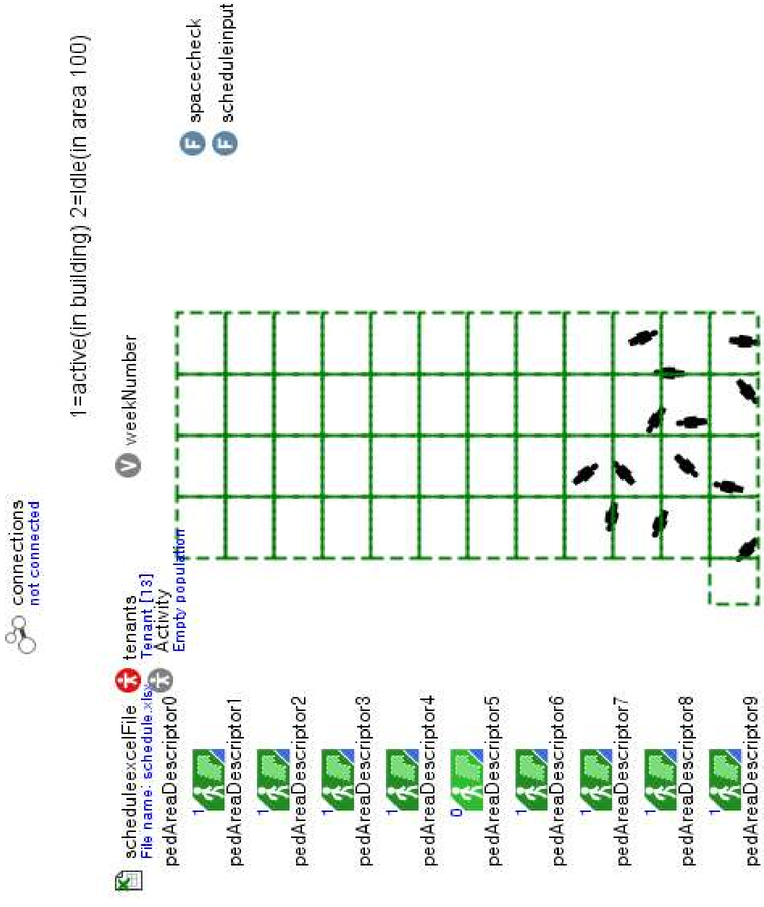
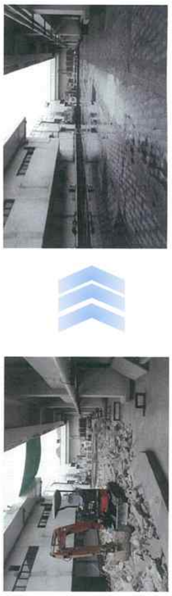


Figure 3-7. Tenant in space # 1 to space #14

3.4. Output Derivation Process

The activity agent triggers the agent, which goes in to the space during the construction activity. The activity event is in the highest hierarchical position while mapping the activity movement. While the Activity agent gets its attributes, the simulation model starts by inputting the tenant agents in parameter called initial space. The tenants in initial space checks if the schedule has a preferences and if the renovation start point is from the bottom. If the activity start point is from the ground, in which most of the cases are, the activity agent goes to the ground floor, and designated buffer floors as well. As the tenant agent searches the places to move first, the tenant agent checks the time unit and sees if the agent was willing to move in certain season. If the agent is free to move the simulator checks for the closest space the closest space in this case is checked using the pedAreaDescriber, and tries to send the agent to the closest Area. The iteration continues until all the renovation activities are complete.



Activity name	Activity Attributes		
	Buffer	Most efficient space usage	Starting point
Interior Demolition	1-1	2 units	Ground start

Figure 3-8. Activity agent abstraction

3.6. Summary

The chapter explained the model deriving process and how the derived satisfaction factors were simulated using various agents. The entities or the agents are used in the simulation were abstracted using the previous researches, which allows the research to simulate the abstracted information. With the simulator, the model can output the schedule for the individual spaces, and how the space is used over time. Each of the tenant, in this case an agent must move whenever the space must be occupied to the working crew, and most of the cases minimized tenant movement scenarios can help the workers manage the working plans as well as the productivity. The user satisfaction was defined as any variables that affected the productivity of the building tenants, which was meant to be analyzed during the simulation.

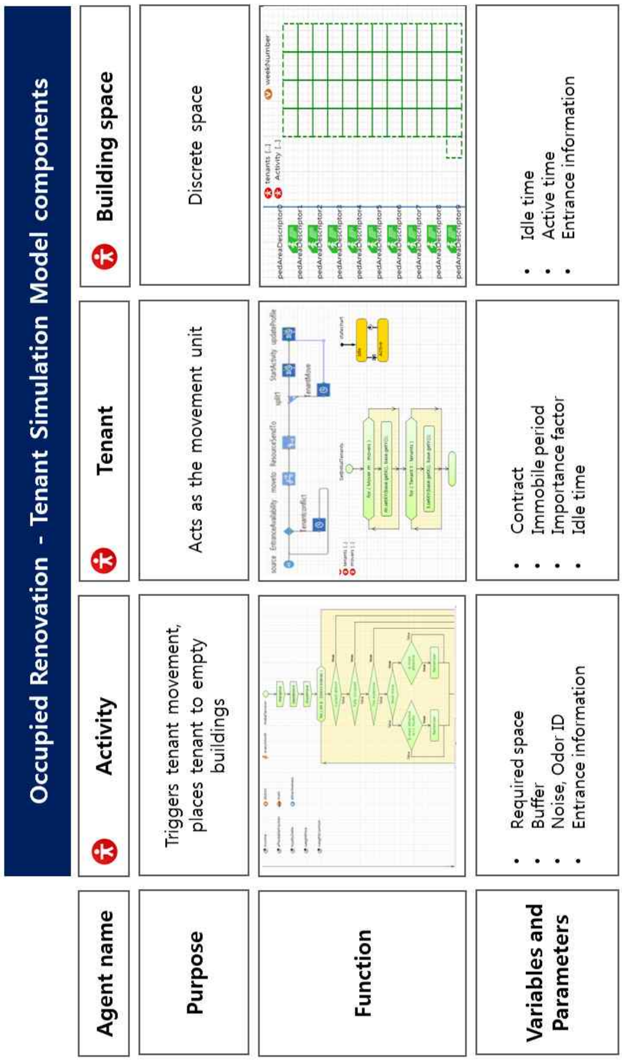


Figure 3-9. Summary of the occupation model

Chapter 4. Model validation and Result analysis

The chapter 4 describes the model validation and the results regarding the model. The result of the model shows where the tenant should be within the number of units with the given input of the tenant schedule. The simulation itself and runs to minimize the moving distance of the tenants, and satisfies the tenant satisfaction within the renovation period. The model process defines the definition of movement with both Activity and Tenant agent. While the both agents searches for the space to go on, the controller records the agent type within the space with the given week number, recording the movement of the agents. The controller draws the results of each spaces, and individual agent unit schedule. The model is can be validated in different ways; however, there were limitations collecting data of such a specific cases. First, the renovation of occupied condition was not frequent enough especially in Korea due to following reason, the history of the occupied renovation was too short, and dissatisfaction of the tenants. Second, even with few the collected data, the data was not suitable for the model to check if the tenant satisfaction was satisfied. The data from the collected cases contained the sequential and the special use of the building in a rough time scale. In other words the collected data was not detailed enough to check where the tenant stayed within the building with the given time unit. To resolve the limitations from the validation, the research contains the verification of the model. The verification is conducted by comparing each tenant and the result of the model. Therefore comparison of the two virtual scenarios were attempted to see if there was any resulting changes.

4.1. Comparing the results and heuristic scenario

Two of the virtual scenarios were compared using the model, which resulted in two different schedules. The first scheduling scenario had 14 tenant agents, and each tenant had schedules in number of weeks. The input value also included that the tenant number 1 was willing to move after week number 20. In scenario number 1, four of the building units existed in one floor. The division allowed tenant number 1 to operated two units in a given time in order to work without any disruption. While the second scheduling scenario contained twice as many tenants with the more number of activities. With the same given number of construction time per unit, the dynamic changes of the tenant in the scenario with twice more tenants had less satisfaction ratings. The satisfaction ratings were dropped with more number of tenants within the building, due to the less allowable space. The number of movement units that each agent skipped defines the satisfaction ratings. For example, if tenant numbers 1 was in space unit 14, but were not able to move to space unit 18 because of the construction works that was going on, it searched the next unit. If the model succeeds to find the next space the tenant move while recording the number of space units. As well as if the agents schedule is in track, if the movement distance is increased the model keeps the record and applies it to the satisfaction. the actual case data remains as a limitation in order to compare it and show the improvement that could have been made. However, the virtual scenarios did show the change in user satisfaction as well as the schedule. The virtual scenarios did output the space unit schedule as well as the tenant's schedule; however, is left as the biggest limitations of this research.

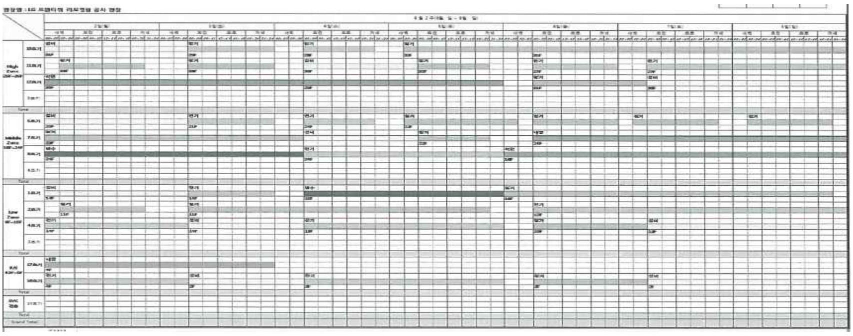


Figure 4-1. Output scenarios

Scenario #	# of Tenants	Number of Activities	Building units per floor	Week #
1	14	26	4	50
2	28	29	3	50

Figure 4-1. variables of scenarios

4.2. Summary

In this chapter using the virtual cases two different scenarios were compared using unnatural variables. Despite the lack of real case data, the case model was with virtual variables to see if the case ran. In addition, the satisfaction values were hand check to verify if the model algorithms were satisfied. The satisfaction input value of each tenant's numbers, which were the quantified numbers from scale of 0 to 1, did match with the results. The resulting data does not allow the planner to have a scenario that can be applied to a real situation; however, can be used as a sensibility study that satisfies the tenant satisfaction. Further research must be needed on this issue with a detailed data that can help the model to be validated.

Chapter 5. Conclusion

The chapter presents the conclusion of the Tenant scheduling model considering the user satisfaction. The schedule the tenant suggests to the planner and the minimized number of movement or the moving distances defines the satisfaction of the tenants within the construction period. While managing the tenants in space, the tenant schedule is the most hierarchical value and considered in advance of different variables. The schedule itself represents the tenant satisfaction as well as the less movement distances. The model shows that inputting the abstracted satisfaction and running the values through the renovation sequences did meet the consequences of the renovation activities as well as the tenant satisfaction. The activities itself did contain spatial values such as the most efficient activity units and the required buffer floors. The activity sequence preferred to be started from the empty space, if not the sequence started by moving the tenant from the current space. The simulator also includes the dynamic building unit changes, which will increase the user satisfaction and the planning.

5.1. Result and Discussion

Using the virtual scenario the result was presented with unrealistic variables. However, the module seems practical enough since the tenant schedule scenarios and the minimized moving distance allows the tenants to move within the building without the sequential interference. The moving distance is minimized within the building, but with the interference with the sequential factors, the moving distance is ignored since it is less important value to be considered compared with the sequential values. Therefore, the result shows a form of sensibility study with the number of tenants and tenant satisfaction that was defined in the literature review. The actual data is necessary in order to have an applicable output in the future researches.

5.2. Contribution and limitation

The limitations of method can be discussed in various ways. Those who are familiar with the Anylogic software tool must conduct the model due to the modeling difficulty. Despite the quick changes, according to the each cases, the simulation software must be conducted by those who can change things. In addition, the tenant satisfaction abstraction needs with stronger data or case studies in order for this research to be firm and more understandable. In addition, the limitation can include the fact that environmental or different variables that affect the scheduling were not incorporated in to the model. The case data that can be applied to this research must be in-date, and firm enough in order for this research to have stronger conclusion.

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Abstract in Korean (국문 초록)

재실자 만족도를 기반으로 한 재실 리모델링시 재실자 이동 시나리오 도출 연구

박 찬 용

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건축학과 건축공학전공

건물을 유지하고 개선시키는 리모델링은 주택을 포함하는 전체 건설시장에서 2025년에는 30% 이상에 이르는 비중을 차지할 것으로 전망되고 있다. 이러한 리모델링 공사를 수행하는 방법은 크게 공실 리모델링과 재실 리모델링으로 분류하고 있고 재실 리모델링의 경우 공사 중에도 임대료를 보장한다는 장점, 임대 시장에서의 신규 임대인 유치시의 장점 등의 이유로 대형 오피스 건물 및 임대료가 높은 빌딩에서 주로 사용되고 있다. 하지만 재실 리모델링은 재실자의 사용공간과 공사를 진행하는 공간을 재실자 사용 만족도를 고려하여 공사 순서 및 건물 내 재실자 이동순서를

선정하여야 함을 알 수 있다.

따라서 본 연구에서는 시뮬레이션을 통하여 재실자 만족도, 건물 환경 및 건물 내 구역 배열, 공사 순서 등을 반영한 건물 내 재실자 이동순서를 도출 하였으며 가상의 시나리오를 통한 결과를 도출하였다. 향후 본 연구가 재실 리모델링 프로젝트에 사용될 경우 프로젝트 초기 과정에서 재실자의 만족도를 조사하고 스케줄링에 반영함으로써 공사 시 재실자 불만족으로 인한 프로젝트 지연 등을 사전에 방지 할 수 있다.

주요어 : 재실자 만족도, 재실자 관리,

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