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Development and Application of Active Allocation Model for Construction Workspaces in BIM Environment

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Abstract. Construction activities required specific workspaces with different shape to facilitate safe execution of these activities. Activities may share workspaces which can involve: loading of materials, waiting for equipment availability, and rebar fabrication and formwork. As the workspaces in any construction site are linked to a number of activities which can be executed at the same time causing congestions, it causes H&S issues and delays in delivering projects. Since the 'Shared Space' can be also located anywhere in construction sites, it might be difficult to identify amount and shape of workspace that used by each activity. To consider these issues, in this study, an 'Active Allocation Model' is developed to integrate methods of allocating workspace to activity and vice versa. The objective of such integration is to build an efficient workspace planning in 4D CAD environment based on BIM (Building Information Modeling). Moreover, the 'Active Allocation Model for Workspaces' is configured by WBS (Work Breakdown Structure)-based 4D CAD link process. Therefore, the proposed model can assist the construction planners in efficiently verifying workspace utilization status for each activity and vice versa. A reasonable workspace distribution planning through the visual identification and analysis of workspace operation status is achieved.

Keywords: BIM, 4D CAD, Workspace, Active Allocation Model, Virtual Reality, Workspace Planning

1. Introduction

Workspace information is organically linked with the project management information in construction industry. This is also considered as a critical resource factor, which is essential to complete the successful project [3][4]. Recently, the workspace information has been reflecting for site operation as the project management information with the growing interests in H&S (Health and Safety) issues. However, an establishment of work and safety management planning considering the workspaces is not being made in practice. Moreover, execution planning of activities has been established by constituting roughly the workspace model according to the resource input planning. An existing workspace allocation method [5] utilized the workspace allocation information by assigning the resources into an activity. Besides, in order to secure constructability of works, it is not easy to identify objectively on what sorts of activities are linked with workspaces and what kinds of the workspaces are shared with activities.

To address this, an "Active Workspace allocation Model" that can construct bi-directional allocation strategies as a new allocation method, which includes method for allocating workspaces into activities and vice versa, is developed according to space utilization level of each activity, task features and sharing features of the workspaces.

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The aim of this study is to develop the "Active Allocation Model for Workspaces" based on a virtual environment so that the project managers can identify dynamically congestion status and safety level of activities under BIM-based 4D CAD environment in order to establish an efficient workspace allocation planning by considering the workspace information as a critical resource factor to secure the constructability of the construction project.

2. Configuration of Workspace Information Model

2.1. Definition of Workspace and Allocation Type

The workspace is divided into two types of workspaces that include an object space and shared space according to the available execution pattern of resources and work characteristics (Fig. 1).

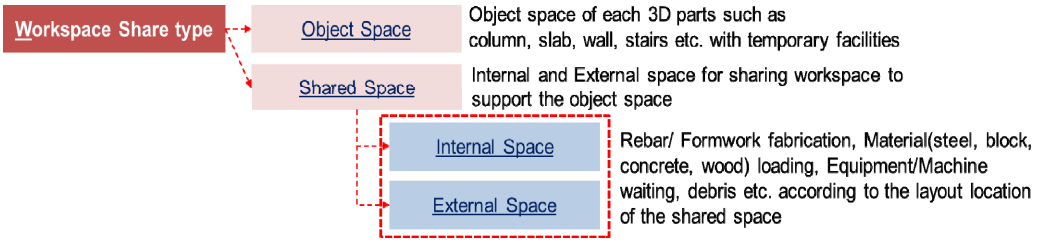

Fig. 1: Classification of Workspace Shape Type.

The object space is the workspace, which has an individual activity such as foundation, pier, abutment, column, elevator and slab. The shared space is the workspace, which is shared by the majority of activities that are linked with the workspace types for fabrication of rebar and formwork, loading space stacks the delivered materials, waiting space of equipment and wasting space of debris generated from the site (Figure 1).

The shared space is divided into internal and external space depending on the relationships of the size of delivered resources, layout locations and activities. Both the internal and external spaces are similar, but the utilization type is separated depending on the layout location of each shared space type.

2.2. Concept of Workspace Allocation

Fig. 2 represents linking and sharing model of activities for each representative workspace type [5].

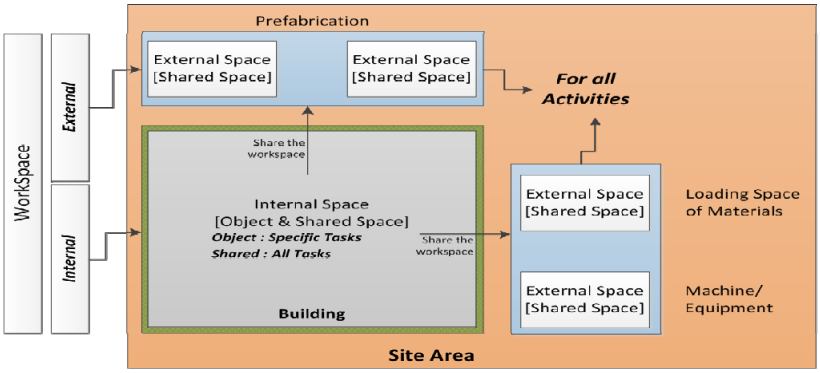

Fig. 2: Configuration of Workspace Allocation Type by Workspace Type.

This allocation concept is defined as the shared space for supporting an activity of column element. The shared space supports the object space like columns of the building. During constructing the column, the shared space is utilized for activity. Moreover, occupation status of the workspaces depends on the input quantity of resources, and level of its shape is shown with fluctuating linearly.

3. Development of "Active Allocation Model for Workspaces"

When workspace generation is completed, the occupancy status of the created workspace is visually identified. In addition, mutual linking process between workspaces and activities are essential in order to find

out the required workspace for activity and shared spaces by the workspaces. This is to identify what the workspaces are being used for each activity. In contrary, allocation model of activity to workspace is also to verify about what the tasks are being shared for each workspace. Therefore, the allocation method by space-time tradeoff is as follows (Fig. 3).

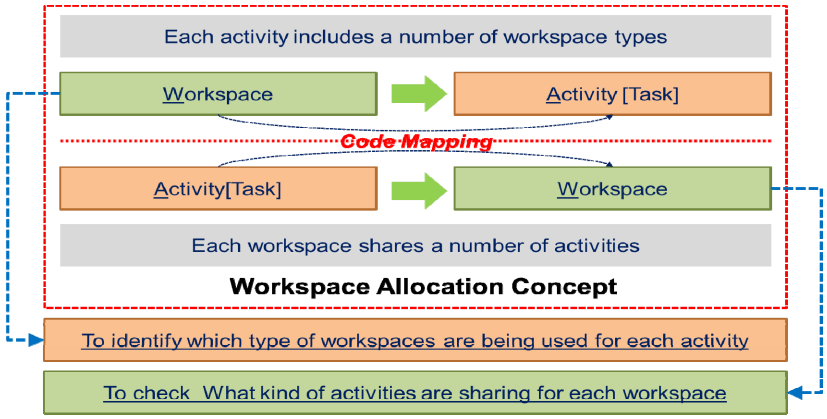

Fig. 3: Bi-directional Allocation Concept of Workspaces and Activities.

3.1. Method for Allocating Workspace to Activity

3.1.1. Features of Workspace Allocation to Activity

The method for allocating workspaces to activities is generally applied by making a single model for an activity. Such allocation method is applied for the object space, which has an individual element model for a single activity. Process of this allocation model is conducted by WBS code, and the process is also easily operated by the 4D model from workspace generation stage. The allocation model can be applied for activities of elements such as column, window, door, stairway, wall, slab, floor and elevator. If a single activity requires multiple workspaces (1:N), the multiple workspaces such as safety and moving space for corresponding activity are assigned into a single activity.

3.1.2. Link Model of Workspaces for Activities

The majority of workspace types need to be defined depending on execution features of each activity. In order to assign a single or multiple workspace type into each activity, attributes of WBS code that individual activity requires also need to be considered. This method uses the type of either 1:1 or N: 1. Therefore, the mutual allocation process is conducted by mapping codes of many workspaces with them of a single activity.

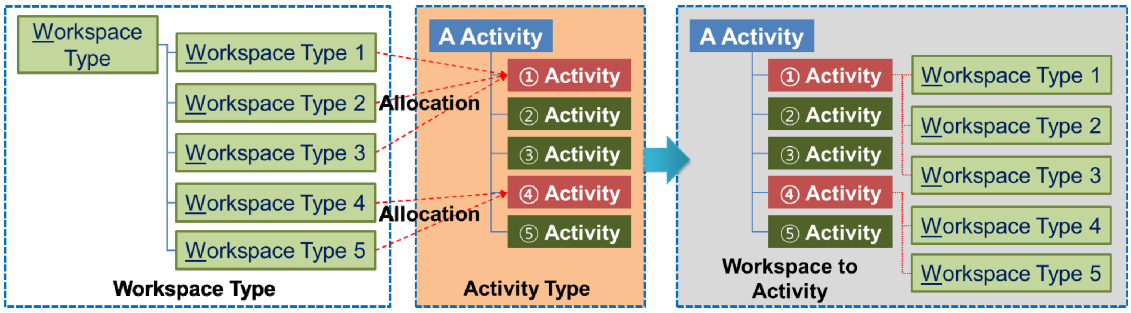

Fig. 4: Allocation Method of Workspaces to Activities.

In Fig. 4, the allocation process of workspace, which is required for each activity, is performed for five types of the workspaces. When the Workspace 1, 2, and 3 are assigned into the Activity 1, a linking method using WBS code is utilized. The allocation process is performed by adding the workspace properties to WBS code for each activity or by doing Drag & Drop of the workspace codes to activities. Therefore, Activity 1 has Workspace 1, 2 and 3, and Activity 4 has also Workspace 4 and 5. These activities should include the

workspace type like installation space created by object base. The rest of workspaces are utilized to support tasks for each activity.

3.2. Method for Allocating Activity to Workspace

3.2.1. Feature of Activity Allocation to Workspace

The method for allocating activities to workspaces is applied by utilizing 3D model inputted in an initial stage that creates 4D model. This method is applied for only when one or more activities are shared for a single workspace. At this moment, linking process for multiple activities to a single workspace is conducted by mapping WBS codes [1] for activities with workspace WBS codes. Since a single workspace have duration of multiple activities, utilization level of workspace and occupation of resource are identified until given activities are completed. This includes the shared workspaces such as loading space of materials, fabrication space of rebar and formwork, material (resources) delivery space and equipment space.

3.2.2. Link Model between Workspace and Activity

The shared space such as loading, fabrication and waiting of resources means a space type that many activities require at the same time.

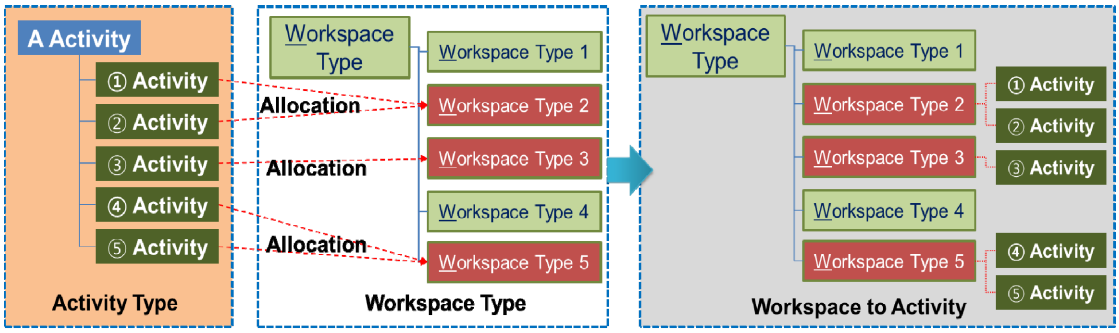

Fig. 5: Allocation Method of Activities to Workspaces.

Allocation process of workspaces for a single shared space is performed by selecting the WBS codes for the majority of activities (Fig. 5). This type follows both N:1 and N:M allocation type. The workspace allocation process can be executed by mapping the multiple WBS codes with properties codes of the workspace WBS. Activity A has 5 detailed activities (Activity 1 to Activity 5). Let's suppose that these activities have five types of workspaces for given activities. The Workspace 2 shares Activity 1 and Activity 2 and 3 share Workspace 3. Finally, the workspace allocation process to activity is completed by sharing the Workspace 5 for the Activity 4 and 5. Therefore, Workspace 2 supports Activity 1 and 2. In addition, Workspace 3 supports Activity 3, and Workspace 5 was also linked to support Activity 4 and 5. Therefore, execution of activity for each workspace and sharing status of workspaces are visually reviewed in order to rehearse workspace congestion level depending on those allocation relationships.

4. Example and Application of Workspace Allocation Model

Fig. 6 shows a case configured by allocation model between workspaces and activities.

The workspaces linked with rebar fabrication work have loading and fabrication space of rebar and waiting space of equipment. An external workspace for the rebar fabrication is assigned as a supporting work in order to construct column members. In case of formwork installation, since this activity is executed around column element model, installation space for formwork is created and assigned using the WBS around the column object. The allocation method presents allocation system of N:1 type to assign activities share the external workspace. Installation and object workspace out of five types of workspaces are applied as a space type for allocating given workspaces to activities. However, fabrication, waiting and loading space is utilized as the shared space that supports activities for an external space.

Through these processes, execution and sharing status of activities for individual workspace is visually identified based on VR environment [2].

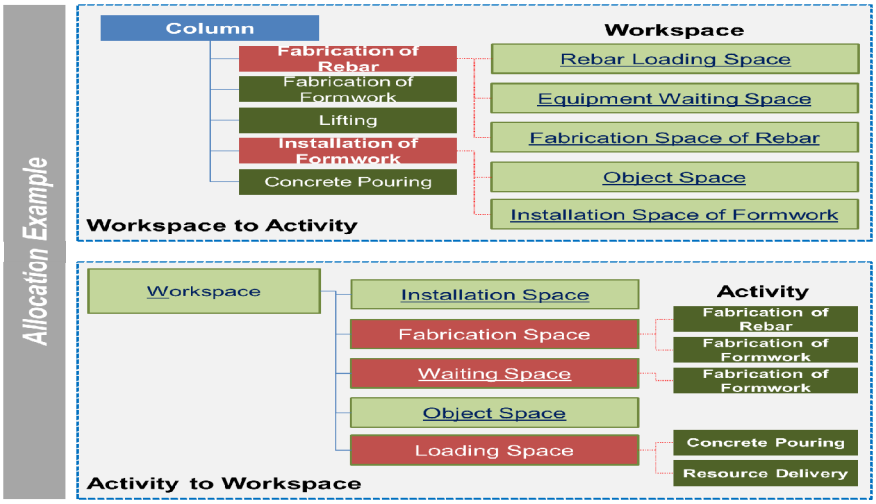

Fig. 6: Example of Active Workspace Allocation.

5. Construction

The results of this study are as follow. First, workspace types were classified with object space and shared space as a framework for allocating workspaces. Second, mutual linking system is established by a space-time tradeoff in order to assign the workspaces to activities and vice versa. This can review the sharing system what workspaces are linked for activities and what activities are utilized for workspaces. Third, utilization level and occupation status of workspaces were identified by constructing mutual linking system between workspaces and activities based on BIM environment. Finally, the suggested methodology of the active workspace allocation model was verified by a case model how workspaces and activities are utilized for a structure. The active allocation model can be utilized as an identification model to visually analyze workspace congestion considering resource. This allocation model will be integrated into the system framework by facilitating an automated allocation system for construction workspaces. Therefore, it is expected that the proposed allocation model will be widely applied to develop conflict verification simulation, congestion identification and risk evaluation for workspaces by BIM-4D CAD environment.

6. Acknowledgements

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7. References

[1] L.S. Kang and B.C. Paulson. Adaptability of Information Classification Systems for Civil Works. *Journal of Construction Engineering and Management*, 1997, 123(4): 419-426.

[2] L.S. Kang, H.S. Moon, N. Dawood and M. S. Kang. Development of Methodology and Virtual System for Optimized Simulation of Road Design Data. *Automation in Construction*, 2010, 19(8): 1000-1015.

[3] H.S. Moon. Development of an Interference Verification System for Planning Efficient Construction Workspace by Multi-dimensional CAD, Ph.D. Dissertation. *Dept. of Civil Engineering*, Gyeongsang National University, Korea.

[4] H.S. Moon, L.S. Kang, and N. Dawood. Development of a Workspace Conflict Verification Model for Temporary Facilities based on a VR Simulation. *The International Conference on Computing in Civil and Building Engineering-2010*. University of Nottingham. UK. 2010.

[5] Sy-Jye Guo. Identification and Resolution of Work Space Conflicts in Building Construction. *Journal of Construction Engineering and Management*, 2002, 128(4): 287-295.