

VIRTUAL CONSTRUCTION FOR AUTOMATED SCHEDULE GENERATION

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Abstract

Ongoing research in automated schedule generation does not allow for interactive user input sessions to translate design information required for sequencing project activities. Rather, current research has focused on capturing, among other things, design knowledge through interpreting 2D drawings and/or 3D CAD models to develop intelligent schedule generation tools. Further, many of these tools do not address the importance of schedule development during the design phase. In this paper the authors introduce “virtual construction” sessions for re-assembling of 3D CAD models in a virtual environment. This will allow for capturing and recording user input for automatic generation of project schedules.

Keywords: planning, scheduling, virtual construction, 3D CAD, 4D planning, constructability, design, construction

1 Introduction

Schedule generation is an important part of the construction planning process. Scheduling is generally carried out several times during the life of a construction project from preliminary schedules at the project feasibility phase to detailed short interval schedules during field construction. Most planning efforts in construction use the schedule and the design documents as the primary planning tools supported by estimating packages and other aids.

The work carried out at the Center for Integrated Facility Engineering at Stanford has demonstrated the benefits of using 4D (time and space) models in



visually demonstrating the progress of the field construction stage of the project (see for example McKinney Liston et al, 1998). The Stanford researchers have identified that the current 4D CAD tools are useful to communicate the overall sequence of construction, but generally do not provide enough information for construction planners. In our opinion this problem arises from the way that the schedule, the time part of the 4D model, is developed. The schedule is a sequencing document that defines when construction activities will occur and may also provide information on when resources, materials and previously completed work will be utilized. There is no information, in the schedule, on the method that the designer, estimator or construction planner envisaged would be used to perform the work. In fact it is not unusual for the designer to give little consideration to the construction method in coming up with an overall schedule for the project. Such issues are left for determination later in the process. This results in the schedule being built with little consideration of construction and production issues. This problem has long been recognized by those involved in field construction. Recent work by [Fisher and Aalami (1997)] utilized integration mechanisms called “computer-interpretable models” for the representation of construction methods and automated generation of schedules. Work by Tommelein (see e.g. Tommelein and Chua, 1998) using discrete event simulation gives an excellent explanation of how inadequate schedules arise and the problems they cause for specialty contractor performance. Time-space conflicts are another example of inadequate scheduling causing loss of production (see e.g. Riley and Sanvido, 1995; Thabet and Beliveau, 1993).

This paper will explore schedule generation in the construction industry with an emphasis on how and when schedules are produced. Using virtual construction an alternative approach to schedule generation will then be proposed linking together several existing technologies. The approach if adequately developed has the potential to change the way schedules are used by the industry, by allowing construction process design to be undertaken in earlier phases of the construction project. This will allow for designing, evaluating and testing the construction method and the schedule before field execution.

2 Current schedule generation processes

In current practice, construction schedules (baseline schedules) are usually generated during the pre-mobilization phase, Figure 1. During this stage, and based on an understanding of the design documents, including design drawings (2D) and/or CAD models (3D) of the facility, the scheduler determines a list of activities required to construct the project. Using common knowledge of construction methods and based on available resources, the scheduler creates sequential relationships among the activities and calculates activity and project duration to generate the schedule. Once construction starts, the person responsible for maintaining the schedule performs schedule updating and develops short interval schedules. In many cases, tasks involving schedule maintenance and/or detailed Short-Interval schedules generation are performed by project personnel other than the original scheduler. Schedule generation is mainly dependent on the scheduler’s interpretation of the contract

documents including 2D drawings and/or 3D CAD and manually translating such interpretation into a list of activities. These activities are manually linked together through knowledge of construction methods and crew availability. This process of translating the visual understanding of the project documents into a schedule is time consuming and may lead to schedule errors.

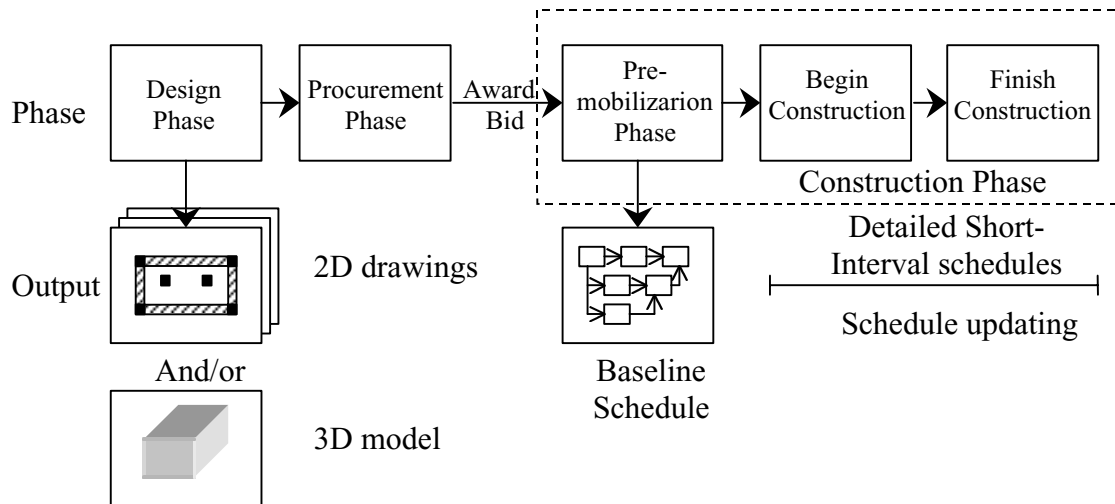


Fig. 1: Schedule generation during pre-construction phase

Several major disadvantages exist in the current practice of schedule generation. Schedule generation is only thought of during the pre-construction phase as well as the construction phase with no serious consideration to its generation during the design phase. Developing a detailed understanding of how the project may be built through the development of a schedule during the design phase will allow for a more constructable design.

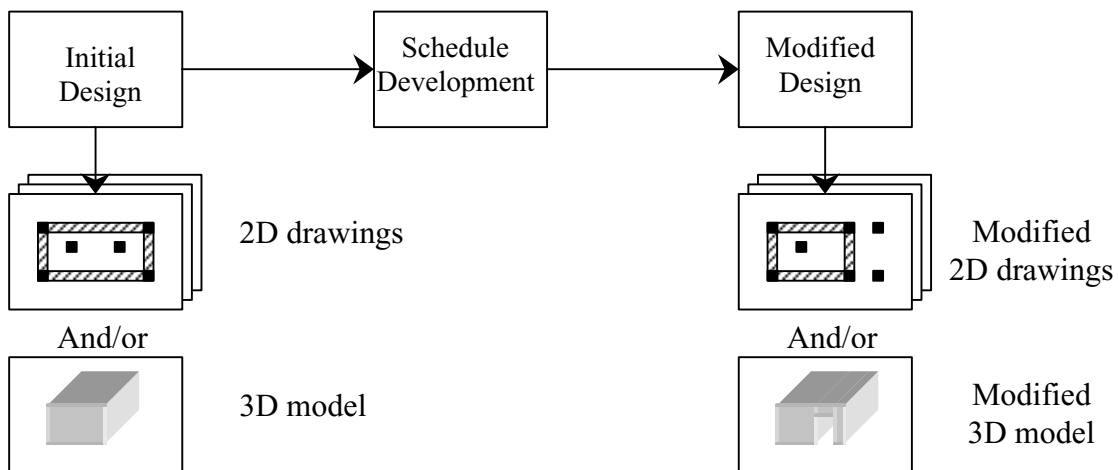


Fig. 2: Schedule generation during design phase

3 Activity generation and sequencing using virtual construction

The proposed scheduling process involves utilizing virtual construction for automatic generation of project activities and their sequential relationships. As depicted in Figure 3, using a preliminary 3D CAD model of the facility, the user can manually construct the project by re-assembling the 3D graphical elements in the virtual construction window in the perceived order of construction. The user can click and drag a graphical element, or a group of elements, from the 3D CAD model window and places it into the virtual window.

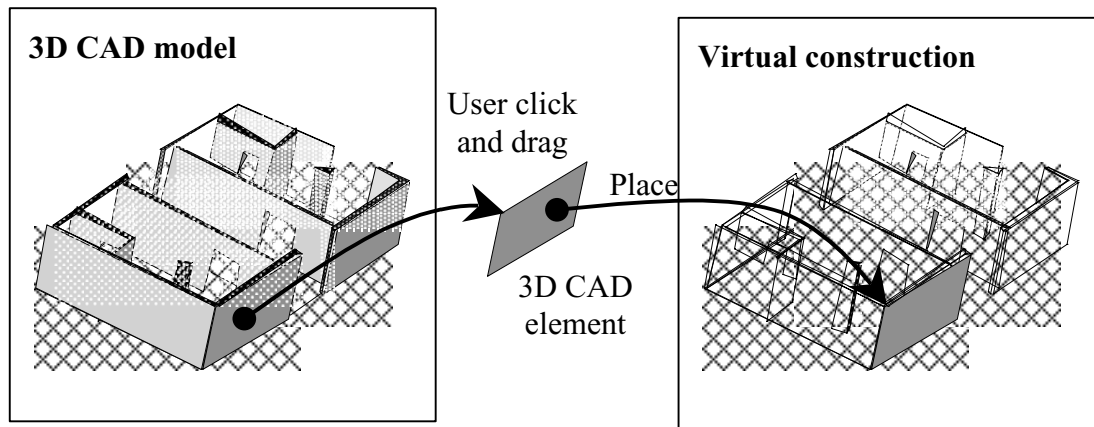


Fig. 3: The virtual construction generation process

To generate activities of the project, the user will select one or more graphical elements. Each graphical element or group of elements will represent an activity in the project activity list. The sequence of dragging the selected graphical elements will allow for creating the relationship among the activities. The relationship between the activities requires further specification. It will be possible for the user to specify concurrency, lags, and other relationships between activities in the virtual construction process.

As depicted in Figure 4, modules defining knowledge about resources, space and construction methods will help guide the user in constructing the schedule during the virtual construction session. The virtual construction system will utilize a Petri Net based tool (Wakefield and Sears 1997) to record information developed during the virtual session. Information recorded will include construction methods selected, resource utilization, and space decisions made. This will allow for carrying further checks on resources, space and construction methods following the virtual session.

By performing scheduling generation during the design stage, the developed system will enable designers and constructors to consider and tackle construction issues earlier in the project life, hence, improving design and enhancing productivity in the field. Constructors will also be able to undertake rehearsals of the construction process allowing them to analyze and compare different construction methods. This should improve on-site performance and result in better utilization of resources.

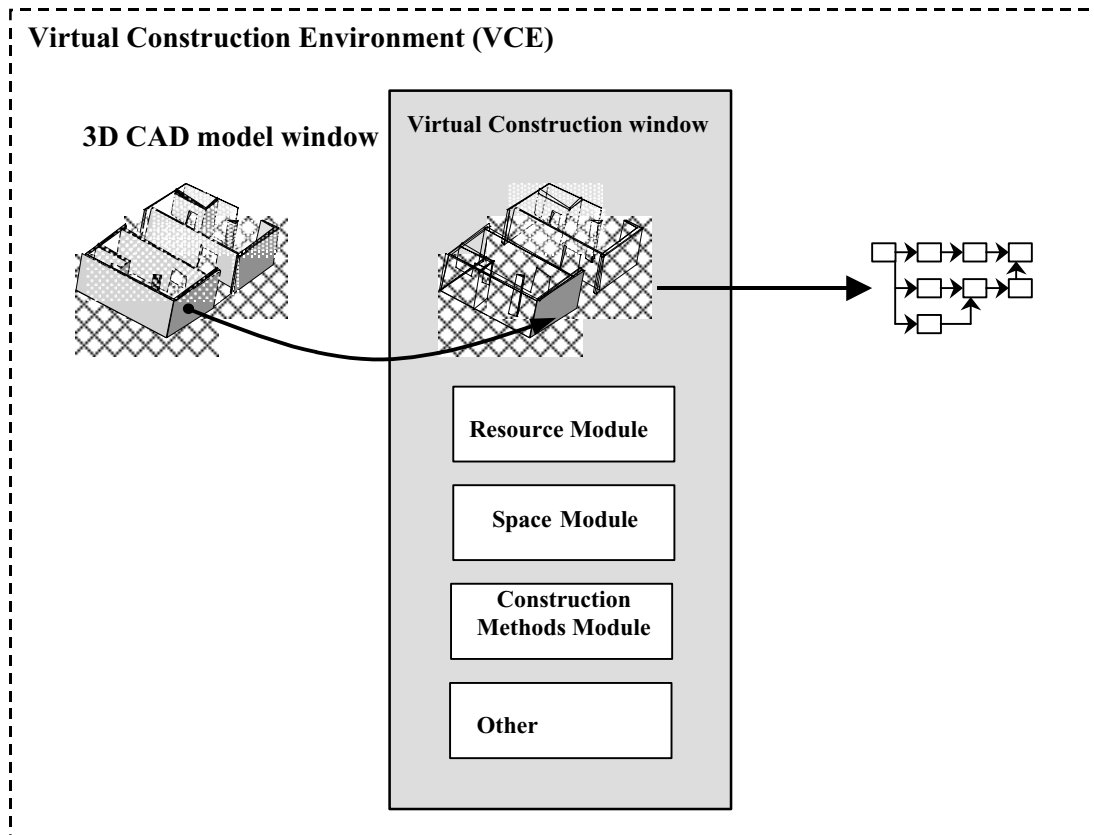


Fig. 4: The proposed VCE model

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The research ideas proposed in this paper are part of a larger research effort being developed at Virginia Tech to investigate and reconsider the planning process during preconstruction (design/procurement phases). The objective of the research work is to provide a mechanism to assist the project team in depicting construction barriers and problems that can arise during the construction phase. A Virtual Construction Environment (VCE) model is (currently at an initial stage) is being implemented to test and support the research objectives.

4 Conclusion

During the construction of a project, the constructor faces many problems that severely limit the construction performance. The depiction of these problems during early phases would tremendously reduce the cost and the duration of the project.

A Virtual Construction Environment (VCE) approach is proposed to help the project team in developing a better understanding of the project prior to actual construction.

1. Using a 3D-CAD model and a knowledge base of construction means and methods, the project team can construct the project virtually. Designers during the design phase, as well as constructors during the procurement phase, will be able to test various construction methods to virtually build the project. This will allow for predicting constructability problems that could arise during the real execution of the project.
2. Using virtual construction sessions will allow for capturing and recording user input about selected construction means and methods for automatic generation of project schedules.

5 References

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