Proceedings of the 2013 Winter Simulation Conference
R. Pasupathy, S.-H. Kim, A. Tolk, R. Hill, and M. E. Kuhl, eds

SIMULATION VERSUS CONSTRAINT-BASED GRAPHICAL MODELING OF CONSTRUCTION PROCESSES

Ian Flood and Valeh Nowrouzian

Rinker School, College of Design, Construction and Planning
University of Florida
Gainesville, FL 32611, USA

ABSTRACT

The paper introduces a new constraint-based graphical approach to modeling construction processes, Foresight, designed to combine the versatility of discrete-event simulation, the ease-of-use of the Critical Path Method, and the visual insight of linear scheduling. The usability of Foresight is compared with Stroboscope (a construction-specific simulation system) in a case study of the classic earthmoving problem. The Foresight model is shown, first, to be visually more insightful than its Stroboscope equivalent, and second, to require a fraction of the number of modeling terms and modeling concepts in its definition.

1 INTRODUCTION

Simulation is the most versatile tool currently available for the planning and control of construction projects. Despite this and the fact that there are simulation systems designed specifically for modeling construction processes (such as Stroboscope (Martinez 1996)) simulation is rarely adopted by construction planners. This is due to the high degree of expertise required in its use (Flood 2010). The Critical Path Method (CPM) has become the standard analytical tool for construction planning and control since it is easy to use and applicable to a relatively broad range of construction processes. CPM is, however, a compromise solution; it is not very effective at modeling repetitive tasks, and it is time-centric treating all other limiting factors (such as resource demand and space buffers) as secondary constraints. A third approach to modeling construction processes that has gained popularity in recent years is linear scheduling (LS) (Flood 2010). The popularity of LS is due largely to the strong visual (graphical) insight it provides into the relative progress of individual tasks. However, LS can only be used to model construction work that is repetitive, and even then it is limited by the types of constraint it can consider .

This paper introduces a new graphical constraint-based method of modeling construction processes, Foresight, that has the goal of combining the modeling versatility of simulation, the simplicity-in-use of CPM, and the visual insight of LP. The performance of Foresight is compared with Stroboscope (a popular discrete-event construction simulation system) in a case study of the classic earthmoving problem.

Foresight is a constraint-based graphical approach to modeling processes described in detail by Flood (2010). Foresight models comprise a hierarchically structured set of nested boxes termed *work units*, each representing a discrete unit of work, such as *excavate trench* or *erect steel frame*. The *work units* exist in an *n*-dimensional attribute space, example attributes being time, money, distance, work to be completed, and productive resources (anything that is key to defining and measuring progress). The section of attribute space occupied by a *work unit* is defined by constraints between the *work units*. A *work unit* at any level (including its constraints) can be repeated within a model as often as required.

2 FORESIGHT VS. STROBOSCOPE: EARTHMOVING SYSTEM CASE STUDY

Figure 1 shows a Stroboscope model of an earthmoving system (Martinez 1996) in which an excavator is used to load a fleet of dump-trucks that haul excavated material to a spoil heap and then return. Figure 2 shows the Foresight equivalent of the system for the first 47.5 minutes of work: part (a) shows the hierarchical organization of the work units; and part (b) shows the work units with their constraints and repetitions applied. Note that a Stroboscope model must be fully defined before performance can be predicted by simulation runs, and that the predicted performance of the system has no visual relationship with the logic of the model. Foresight, in contrast, provides an on-the-fly prediction of performance as both *work units* and constraints are added. The Foresight model also provides a direct visual understanding of how the predicted performance depends on the constraints, thereby suggesting ways of optimizing the system.

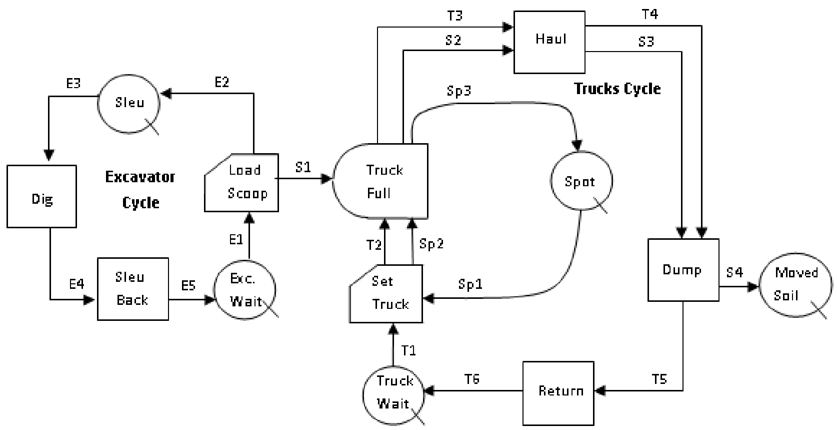

Figure 1: Stroboscope model of the earthmoving system

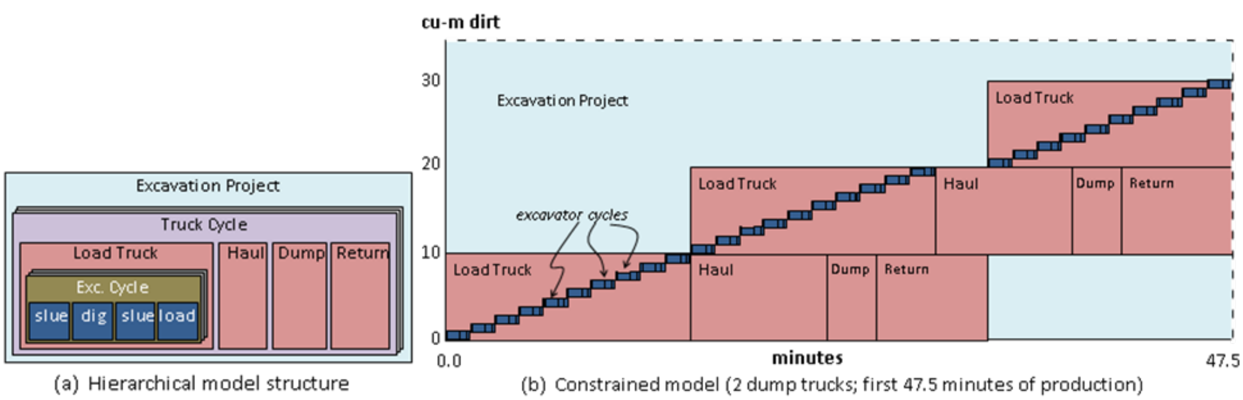

Figure 2: Foresight model of the earthmoving system

Although both models represent the earthmoving process to the same degree of detail, the Stroboscope model is considerably more complicated to develop and use. If the earthmoving system comprises two dump-trucks then Stroboscope requires 88 terms to define the model and employs 27 different modeling concepts. For the same scenario, Foresight requires just 26 terms and employs 5 different modeling concepts. Earlier work has found similar advantages for a range of construction processes, and demonstrated that the two approaches are comparable in terms of their modeling versatility (Flood 2010).

REFERENCES

Flood, I., 2010. "Foresight: A Structured Graphical Approach to Constraint Based Project Planning", *Proc. 2nd Int. Conference on Advances in System Simulation*, Simul 2010, Nice, France, IEEE, 6 pp.

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