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Hybrid analytic and simulation models for assembly line design and production planning

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Abstract

Hybrid analytic and simulation models are used in solving complex problems in a variety of domains, but are less commonly used in production system design. This paper reviews hybrid approaches and their applications, proposes a new hybrid modeling class, and illustrates a cost function for selecting analytic or simulation modeling approaches via a problem solving process. To illustrate the new class, a case study is presented, in which a hybrid analytic and simulation modeling approach is used in designing a multi-stage, multi-buffer electronic device assembly line. Development of a robust integrated modeling support environment is proposed as a future direction.

Keywords: Assembly line design; Hybrid analytic and simulation model

1. Introduction

A hybrid simulation and analytic model is a mathematical model that combines identifiable simulation and analytic models [10,12]. An analytic model is a set of equations that characterizes a system or a problem entity; and a simulation model is a dynamic or an operating model of a system or problem entity that *mimics* the operating behavior of the system or problem entity. The analytic model tends to provide *exact* and *static* information, while the simulation model provides *approximate* and *dynamic* information about the system of interest or problem entity.

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A simulation modeling approach often requires more effort to obtain solutions than an analytic one if analytic procedures are available. However, it is more costly to model real system behavior over time using analytic models than simulation models. As computer technology and simulation software has advanced, the cost of computer time has become much cheaper, and simulation software has become more widely available. Use of simulation models to model complex systems has become more feasible and popular. The choice between simulation or analytic models now depends primarily on the nature of the application, required accuracy, and availability of solution procedures. Making more use of one or the other during the various stages of problem solving can result in tremendous cost savings. Banks et al. [5] note the advantages and disadvantages of using analytic and/or simulation models as follows:

- Simulation models are often easier to apply than analytic models.
- Analytic models often require many simplifying assumptions.
- Analytic models provide a limited number of system performance measures.
- Simulation models can be costly to construct and validate.
- An analytic model may serve as a simple, initial model.
- A simulation model can give early insight and estimates of behavior for more complex systems.

Combining analytic and simulation modeling approaches can result in cost savings in solving complex problems [26]. Over the years, hybrid simulation and analytic models have been applied to product and structure design [16,19], process design [9], power plant performance prediction [21], and the semiconductor industry [22]. The number of hybrid simulation/analytic model application domains has also expanded rapidly with the development of the information technology industry; typical applications include computer network performance [25], processor interconnection design [11], and distributed memory architecture performance evaluation [24].

In the area of computer performance modeling, significant effort has also been devoted to developing integrated modeling support tools (IMST) for performance engineering. Performance engineering describes the entire process of using performance techniques within software and hardware design and implementation [13,28]. It includes modeling, measurement and use of results. Beilner and Stewing [6] presented the needs, overall concepts and techniques for a prototype of an integrated tool called HIT. An example is included to illustrate tool functions. Pooley [23] describes the need, architecture, support environment, and modeling aspects for an IMST system that is a later version of HIT. This IMST architecture consists of several layers – such as modeling study, Experimenter, model construction, model analysis, and reporting – each with different tools to facilitate the tasks for that layer. The tools in the model construction layer facilitate analytic and simulation model development. The user may choose appropriate tools for different stages of problem solving. To enhance the use of performance models and make such models more accessible to non-expert users, the IMST Experimenter layer enables users to automatically create and run experiments within a performance-modeling context. The Experimenter of-