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Stroboscope

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STROBOSCOPE

THE NEED

Planning and control of construction can take place at the project and/or the operation level. At the project level a facility is broken down into activities, each of which maps to a physical project component (e.g., second floor columns) or to a major time-consuming process (e.g., order and delivery of kitchen cabinets). The planner uses techniques such as the Critical Path Method (CPM) to estimate the time frame during which activities can take place and the times at which important project milestones can be reached.

At the operation level, planning and control are concerned with the technological methods, number and type of resources, and logical strategies required to accomplish an activity or a group of related activities (e.g., erect second floor columns). The effort focuses on work at the field level. The interactions between equipment, labor, materials and space are considered explicitly in the performance of tasks (e.g., lower hook, attach and lift column). The same tasks may be repeated many times, using non-deterministic durations described by probability distributions. Since projects must ultimately be constructed, success in projects is entirely dependent on the success of construction at the Operations Level. Proper operations planning is therefore a necessity.

Traditionally, the actual planning and design of construction operations is carried out in the planner's "head" or using other ad-hoc methods. Experienced construction managers and foremen typically acquire such planning skills over decades and many times by learning the hard way. The traditional operations planning effort relies heavily on the intuition, imagination, and judgment of the planner.

Experienced construction planners have elaborate thoughts about how they will carry out operations and mentally evaluate alternatives that can be quite complex. There is a limit, however to the number of issues that can be simultaneously and correctly considered in thought. Moreover, there is evidence that knowledge and experience are not always enough to accurately plan construction operations. Construction operations range from the very simple to the very complex. Complex processes are difficult to analyze and optimize using standard mathematical methods. Planning construction operations is therefore a very challenging task that can be substantially improved by using techniques such as Discrete Event Simulation.

THE TECHNOLOGY

STROBOSCOPE is an acronym for STate and Resource Based Simulation of COnstructionProcEsses. It is a general-purpose simulation programming language that has been designed for the simulation of very complex construction processes that involve many different types of resources. STROBOSCOPE models are based on a network of interconnected modeling elements and on a series of programming statements that give the elements unique behavior and control the simulation.

At the conceptual level, the elements used in a STROBOSCOPE model are a superset of those in CYCLONE. For example, STROBOSCOPE allows for the explicit identification of bound activities with the elimination of the corresponding superfluous queues. In addition, STROBOSCOPE introduces five new nodes and four special types of links of conceptual significance. STROBOSCOPE models, however, do not rely on functional CYCLONE elements (e.g., Generate, Consolidate, Counter) and are not subject to any of the simplifying assumptions found in functional CYCLONE models (for example, resources of the same type can be distinguished from one another and each can have individual properties).

The character of STROBOSCOPE arises from its ability to dynamically access the state of the simulation and the properties of the resources involved in an operation. The state of the simulation refers to such things as the number of trucks waiting to be loaded; the current simulation time; the number of times an activity has occurred; and the last time a particular activity started. Access to the properties of resources means that operations can be sensitive to properties – such as size, weight, and cost – on an individual (the size of the specific loader used in an operation) or an aggregate basis (the sum of the weights of a set of steel shapes waiting to be erected).

STROBOSCOPE modeling elements have attributes – defined through programming statements – that define how they behave throughout a simulation. Attributes represent such things as the duration or priority of an activity, the discipline of a queue, and the amount of resource that flows from one element to another. Most attributes can be specified with expressions and have default values that provide the expected behavior.

Expressions are composed of constants; system maintained variables that access the state of the simulation and the properties of resources; user-defined variables; logical, arithmetic, and conditional operators; and scientific, statistical, and mathematical functions.

The attributes of STROBOSCOPE modeling elements allow simulation models to consider uncertainty in any aspect (not just time), such as the quantities of resources produced or consumed (example, the volume of rock resulting from a dynamic blast). Attributes also allow models to dynamically select the routing of resources and the sequence of operations; to allocate resources to activities based on complex selection schemes; to combine resources and dynamically assign properties to the resulting compound resource; and to activate operations subject to complex startup conditions not directly related to resource availability (example, do not blast rock until all crews of all trades have left the vicinity, the wiring has been inspected, and there are less than 10 minutes left in the current shift).

BENEFITS

STROBOSCOPE was designed as a simulation programming language that provides seamless and dynamic access to the state of the simulation and the properties of resources. It is capable of modeling the highly complex and dynamic processes encountered in construction with unprecedented ease.

The STROBOSCOPE simulation system offers a number of benefits including:

- A framework that provides dynamic and comprehensive access to the state of the simulation through pre-defined, system-maintained variables.
- A framework that provides dynamic access to the properties of resources at the individual and set level through pre-defined, system-maintained variables.
- An add-on Interface Specification that allows STROBOSCOPE to be extended seamlessly using high-level compiled languages and without the need to statically link with the STROBOSCOPE engine.
- A Three-Phase Activity Scanning executive that prevents zero-duration activities from introducing undesirable side effects in the simulation logic.
- An Integrated Development Environment that allows simulation models to be edited, run, and debugged easily.

A Graphical User Interface that can be used to create simulation networks using drag and drop drawing. The GUI can run models directly and can also generate the STROBOSCOPE source code for simulation models.

STATUS

The STROBOSCOPE system is very robust, can handle extremely large and complex situations, and is available for immediate industrial use. It has been used to model numerous construction field operations in addition to construction business processes. STROBOSCOPE has been used to teach advanced simulation in several of the leading construction programs in the United States in addition to several other countries. It has also been used by researchers to create higher-level systems and to solve complex problems.

BARRIERS

STROBOSCOPE requires dedication for mastery and effective use. The EZStrobe user interface is very easy to use and can be learned quickly, but modeling systems where the properties of individual (but similar) resources are important (e.g., trucks of different sizes) becomes cumbersome.

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REVIEWERS

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