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TUTORIAL
SCHEDULING MANUFACTURING SYSTEMS WITH FACTOR

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ABSTRACT

This tutorial covers the basic concepts used in scheduling a production facility with the FACTOR product. Topics covered include: basic modeling constructs and their use; user written model components; advanced modeling constructs; integration with existing production systems and data; options for tailoring reports and the user interfaces; and daily use of the model for scheduling. The object of the tutorial is to provide an introduction to modeling methodology used by FACTOR and to the concept of schedule simulation as implemented by FACTOR.

1. THE ROLE OF SIMULATION IN SCHEDULING

In the past simulation has been used extensively for purposes of production system design and analysis with great success. Many simulation professionals recognized the possibility of using simulation to develop and analyze production schedules for these systems, but there were many obstacles in the use of existing simulation languages for this purpose.

The use of simulation for scheduling requires that actual orders and specific activity durations (move, setup, processing, etc.) be used rather than simply aproximating an average mix through the use of probability distributions. The scheduling simulation must be started with the model in the same state as the actual production system, not at all the same thing as clearing statistics after steady-state has been reached. The output from a scheduling simulation must be far more detailed than summary statistics, and must be in a form usable either by a human operator or an automated controller. Large portions of the model must be extracted from existing production databases on a daily basis and the access to the model must be on a level which is easily comprehended by a production supervisor with no simulation experience. Finally if the simulation is to be of any use for detailed short term scheduling on the shop floor, the turn-around time for the evaluation of scheduling alternatives and the access to performance displays must be immediate.

2. THE FACTOR PRODUCTION SCHEDULER

FACTOR is a comprehensive approach to detailed short term scheduling which incorporates simulation technology for the evaluation of scheduling alternatives. It is specifically designed to meet the needs of the scheduling environment, but at the same time provides the flexibility to model a given production system to any required level of detail.

As with most simulation languages, a FACTOR simulation model is built by combining basic modeling components in a way which duplicates the actions of the real production system. However, there is no "language" involved in modeling with FACTOR. Model components are stored in a fast access database prior to the simulation of the production system. Components may be entered into the database directly from existing production software through the use of a standard or customized import utility, or manually via a standard or customized screen oriented editor. Input integrity checking is provided, as is detailed on-line help.

FACTOR output for simulated alternatives is also stored in the database. This output may be formatted into standard or tailored reports using a report generator utility and printed or viewed on the terminal using a full screen review function. It may also be exported to production control software through the use of an export utility. Graphical display of critical schedule performance measures is provided, as is a simple animation capability.

The FACTOR simulator is coded entirely in the C programming language and uses advanced techniques to provide rapid turn-around of the schedule simulation. It is portable to a wide variety of hardware, from micro-computers to mainframes, with model size and complexity being the major criteria for hardware selection.

3. MODELING COMPONENTS

FACTOR provides a rich set of standard modeling components for use in building models of production systems. Some of these standard modeling components are:

- Order Objectives and Status
- Production Calendar
- Shift Schedules
- Resources
- Resource Maintenance
- Parts
- Materials (Raw and Subassemblies)
- Process Plans

Resources are categorized by a user definable type and are used to model machines, material handlers, operators, fixtures, etc. Resources which may perform similar tasks but differ in terms of setup, processing time, shift, or other details may be placed in one or more resource groups. Each group may have individualized logic for choosing among the available members of the group. A resource group may then be treated as a simple resource for operations without having to specify the selection logic on each operation.

Process plans provide the details of how and in what order operations are to be performed on a part. A process plan consists of a sequence of jobsteps with provisions for standard and alternative routing at any point. Each jobstep may have multiple resource or resource group requirements, and has a duration that may be fixed, per piece, part based or calculated in a user defined manner. Some of the standard jobsteps provided by FACTOR are:

- Move
- Setup
- Operation
- Assemble
- Produce
- Inspect
- Palletize/Unpalletize
- Add to Material
- Remove from Material

Optional modeling components are available for situations involving conveyors, AGV's, automated or manual storage and retrieval systems and for scheduling tooling delivery and rework.

In addition to the wide variety of modeling components provided with FACTOR, the modeler may create specialized modeling components or decision logic of his own design. FACTOR provides many installable entry points for user code. User defined components may include: jobsteps, resource sequencing (dispatch) rules, jobstep duration calculations and alternative routing decision rules.

4. EXTENDED INTEGRATION CAPABILITIES

One of the major factors in the success of any scheduling software is the integration of this software with existing production data systems. A scheduling simulation is dependent upon accurate status of the production system and production objectives. The ease and speed with which this information can be extracted from existing databases is as important to the success of the scheduler as the development of the model itself.

FACTOR provides a complete set of standard transfer formats for use in importing and exporting model components and simulation output. While this is adequate for many situations, FACTOR also provides an information transfer module for customization of the data exchange process. This module allows the modeler to modify the standard transfer formats or create entirely new formats for his application. This module includes the ability to tailor the standard report formats or create entirely new report formats for use with the report generator. Also included is a library of functions for accessing the FACTOR database directly. This library may be used to develop custom data interfaces or for such sophisticated tasks as creating a process plan from a new part by using group technology information and a template process plan stored in the FACTOR database.

Often the ultimate user of the scheduling simulation is a person with little or no simulation knowledge. It is critical to the use of the scheduling package that information be presented to this user in terminology with which he is familiar. He must have easy access to all of the functions required for evaluating and implementing the schedule without being burdened with modeling details or data fields over which he has no control.

FACTOR has two standard interfaces, a modeler's interface for the user who builds and maintains the simulation model and a scheduler's interface for the user concerned with day to day use of the model for scheduling. The modeler's interface is designed to provide quick access to the full spectrum of features provided by FACTOR, while the scheduler's interface is designed to guide the user through the tasks normally required in scheduling. In some instances it is desirable to tailor the scheduler's interface to fit even more closely into an application environment. FACTOR provides a user interface tailoring option for this purpose.

The interface tailoring option provides the modeler with the ability to modify either or both of the standard interfaces or to create a totally new modeler's or scheduler's interface. He has complete control over the organization of screens, screen content, help messages, input checking and the commands which will be executed for a selected option. It is possible to integrate functions provided outside FACTOR, such as the initiation of a network data transfer, into the interface, thus providing a single consistent interface to the entire application.

5. SCHEDULING WITH FACTOR

In practice FACTOR is used both on the basis of a regular scheduling interval and to handle unexpected events as they occur. At the start of a scheduling interval (a shift, a day a week, etc.) current status information is loaded into the FACTOR database. The scheduler executes the schedule simulation and reviews summary reports and graphics to evaluate the performance of the schedule. These reports allow him to detect potential scheduling problems and to take action to correct these problems. These new alternatives are then simulated and compared to determine the effectiveness of these solutions. Once an acceptable schedule has been developed, schedules for all components of interest (machines, material handlers, materials, tooling, etc.) may be generated for distribution to operators or transferred to automated cell controllers.

Often one or more unforeseen events will occur during the scheduling period. These could include a machine failure, the arrival of a rush order or a missed delivery date by a supplier. These events could be signaled by a human operator or by an automated controller. When the event occurs, the scheduler enters this information into the FACTOR database and evaluates the impact on his schedule through the use of the simulation. Alternative strategies to address any problems created by the event may be formulated, and their effectiveness determined prior to implementation.

The function of FACTOR in the scheduling environment is thus both as a tool to generate feasible and achievable schedules and as a decision support system for rapid "what if?" analysis of scheduling alternatives. The scheduler is provided with the capability to completely and accurately determine the outcome of a scheduling decision and any possible side affects before actually committing to that decision. This capability is a virtual necessity when scheduling the highly complex production systems in use today.

6. THE FACTOR TUTORIAL

The tutorial at the Winter Simulation Conference will provide details about modeling and scheduling with FACTOR. The presentation will include slides of FACTOR screens, details about modeling components and example output reports. The modeling process will be discussed in detail as will the implementation and integration of the model, and the use of the model for scheduling.

7. ADDITIONAL READING

Grant, Floyd H. 1987 co-editor. Scheduling and Loading Techniques. Production and Inventory Control Handbook. Second Edition Green, James H. editor American Production & Inventory Control Society.

Grant, Floyd H. Production Scheduling Using Simulation Technology. Advanced Manufacturing Systems Conference. IFC (Conferenced) Ltd. June, 1986 pp. 129-138.

FACTOR Implementation Guide FACTROL, Inc., West Lafayette, IN 47906 August, 1987.

FACTOR: User Code FACTROL, Inc., West Lafayette, IN 47906 August, 1987.

FACTOR: User Interface Tailoring FACTROL, Inc., West Lafayette, IN 47906 August, 1987.

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MacFarland, Douglas, G. and Grant, F. Hank, "Shop Floor Scheduling and Control using Simulation Technology". Shop Control '87 Cincinnati, Ohio.

BIOGRAPHY

DOUGLAS G. MACFARLAND is the Manager of Research and Development for FACTROL, Inc. Prior to joining FACTROL, Mr. MacFarland worked on the development of several decision suport systems for Pritsker & Associates. He has a strong background in the implementation of operations research techniques to the solution of business and industrial problems. Mr. MacFarland has a B.S. and M.S. in Industrial Engineering and Operations Research from Virginia Polytechnic Institute and State University.
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