SIMUL8-PLANNER
SIMULATION-BASED PLANNING AND SCHEDULING

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ABSTRACT

This paper provides an introduction to the technique of simulation-based production planning and scheduling, a fast growing and popular area in the simulation industry. SIMUL8 and Visual8 Corporations have collaborated to develop a new software application called SIMUL8-Planner that assists in the development of this type of system. The following document outlines some of the requirements, advantages, and features within this exciting new product.

1 INTRODUCTION

1.1 Visual8 Corporation

Visual8 Corporation is the primary application development, support, and training provider for SIMUL8 in North America. The company has been active over the past ten years in the development and implementation of simulation-based production planning and scheduling solutions to its clients. Through this experience Visual8 Corporation and SIMUL8 Corporation have joined forces to develop SIMUL8-Planner, a simulation-based development tool designed to convert SIMUL8 simulation models into production planning and scheduling systems.

1.2 SIMUL8 Software

SIMUL8 was first launched in North America in 1995 and is now considered the preferred simulation tool of thousands of engineers in enterprises such as Ford, McDonald's, Fidelity, and Hewlett Packard (as well as many smaller organizations). SIMUL8 has provided an easy-to-use, discrete-event simulation package that is used for supporting numerous critical decisions every year. As an object-oriented modeling tool, SIMUL8 incorporates programming language and model visualization capabilities that enables it to create accurate, flexible, and robust simulations more rapidly.

SIMUL8 can be used to provide enterprise solutions using its SQL, COM, and XML connectivity capabilities. It became evident that this power could be harnessed to bridge the gap between ERP systems and the shop floor in order to provide simulation-based production planning and scheduling solutions, Elder (1992). The first release of SIMUL8-Planner was available in early 2002.

2 SIMULATION-BASED PLANNING AND SCHEDULING

2.1 Bridging the ERP Gap

Many organizations have implemented ERP systems to satisfy finance and production management requirements at the upper echelons, but these systems have a limited capability to meet the needs of the shop floor. ERP systems cannot help when an organization needs to react quickly with alternative planning and scheduling decisions when changes arise.

Many of the ERP systems on the market today lack the level of detail required to respond to unforeseen situations within the plant such as a machine failure, production line stoppage, lack of material, or resource shortages, Filling the Plant Gap (2000). Consequently, manual production plans are created that result in inefficient "work-arounds" that create deviations from the ERP plan. A simulation approach accurately models operations to create new and feasible production plans that are consistent and current with the ERP system.

2.2 How the Simulation Approach Works

SIMUL8-Planner links directly to an organization's ERP system, accessing current information on sales orders, production processes, bill of materials, and inventory data, to help make timely scheduling decisions that work on the

shop floor. Capturing all of the system's operational rules, finite capacity constraints, and management objectives, a pre-simulation production plan is generated. The plan is based on the scheduling rules and decisions that are encompassed by internal scheduling heuristics. A simulation-based production scheduling system executes the plan through the various plant processes, as seen in the simulation model below, to quickly generate an efficient and feasible production schedule.
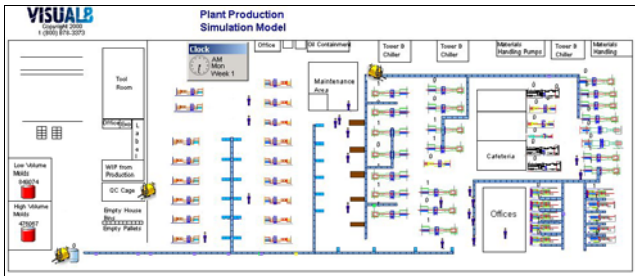

Figure 1: Plant Simulation Model

2.3 Advantages over Static Methods

A dynamic simulation-based approach to production planning and scheduling has distinct advantages over commonly-used static approaches. The most vital of these is the direct and dynamic link to the shop floor. Simulation has the ability to accurately model detailed system operating rules and evaluate them visually over time, Bell and O'Keefe (1987). This capability is invaluable in ensuring that a plan or schedule is viable on the shop floor level.

Solutions can be fully customized according to the current planning and scheduling rules. Simulated operating rules are designed to be flexible, easy to change, and dialog-driven using object-oriented build tools. This allows the system to evolve within the organization without the need to contract large programming projects when new operational rules are implemented.

Sudden changes in employee availability, machine breakdown, extra orders, order expediting requirements, etc. can be reacted to quickly using simulation to generate a new and efficient schedule within minutes. In contrast, it is difficult for large ERP systems to respond to detailed operational changes in a timely and tactical manner.

The simulation approach also provides a means of assessing the effectiveness of schedules by evaluating the simulation results such as machine and resource utilization, overtime requirements, and other standard analysis results. Multiple "what-if" analyses, run off-line, can be performed to ensure that the plans created are practical, up-to-date, and coordinated with current managerial and environmental requirements, Schrage (2000), we have to constantly test our assumptions to move forward and innovate. Conversely, it is difficult to assess the feasibility of schedules generated by static methods other than by actually executing it in real time

on the shop floor. This limits the opportunity to anticipate inefficient or unfeasible plans in advance.

3   SIMUL8-PLANNER

SIMUL8-Planner provides the facilities that are necessary to turn a process simulation into a production planning and scheduling system. Given that the simulation has been developed to capture all the relevant process rules, the model can be used to evaluate the production plan. SIMUL8-Planner has the ability to link to ERP systems to download current product orders, bill of materials, and current inventory levels. This information, with the facilities available in the application, can then be used to generate a detailed production schedule. The three main components of SIMUL8-Planner consist of the following:

- Time management facilities help define machine and resource availability across the plant. This helps to determine the available time slots for the assignment of jobs to specific machines.
- Indexed tables provide the ability to quickly search and manipulate large data sets within the simulation. This includes production orders, time-based inventory files, and importantly scheduled tasks on individual machines.
- Interactive Gantt charts display the production schedule in a user-friendly customizable manner. End-users can interact with the Gantt chart to drill down for detailed order information or drag and drop jobs for rescheduling purposes.

The following section provides a more detailed explanation of these features.

4   SIMUL8-PLANNER FEATURES

4.1   Time Management

SIMUL8-Planner Calendars can be used to define the starting day of the production planning period as well as individual schedules on the shop floor. Schedules can be used to switch off production on weekends, lunches, and breaks much like the shift patterns available within SIMUL8 Standard. However, they can also be used for scheduled downtime and maintenance using a date-time format, making this a much more powerful method of scheduling for use within a production planning environment.

4.1.1   Start Time and Schedules

Because a production plan may not necessarily commence on Monday morning at 9am or some other default time, a start date and time can be specified using a simple calendar input screen. SIMUL8-Planner then provides the ability to specify schedules for any SIMUL8 object, from the entire plant to work centers and resources. These schedules are

defined using date and time allocations for the start and finish times of unavailable blocks.

The example below shows that the entire plant shuts down on Christmas Day. The Plant schedule option is checked and the unavailable time slot applies to midnight on Christmas Morning for 24 hours, through to midnight on Boxing Day morning.
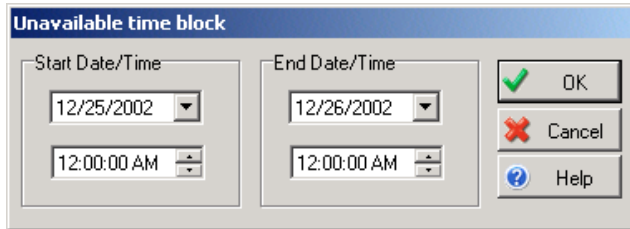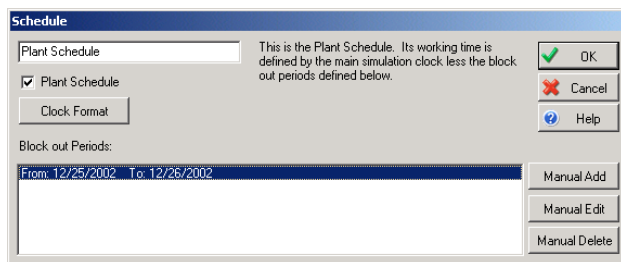

Figure 2: Start Time and Finish Time

Figure 3: Plant Schedule

The difference between a plant schedule and an individual schedule is the ability to specify the objects to which the schedules apply. SIMUL8-Planner provides a list of all available objects within the simulation model allowing the ability to select which objects will be affected by the scheduled downtime.

In the following example the individual schedule applies to Work Center 1 and Work Center 2. Now it is possible to apply off-periods to these particular areas by simply using the manual add, edit, and delete functions.
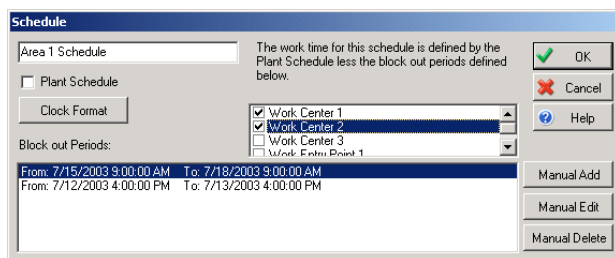

Figure 4: Individual Schedule

4.1.2 Calendaring Facilities and Job Assignment

Once calendar schedules have been created it is possible to interrogate these schedules from SIMUL8's internal programming language, Visual Logic as seen below, to identify available time slots for which jobs can be processed by

an area, resource, or machine. These schedules are then translated to time unit counts from zero and it is possible to move between schedules and simulation time to assign orders and jobs. Other routines exist to allow the user to specify dates as simulation or schedule time so that due dates can be compared. This would be used in the pre-planning section of the system where the plan is created to be executed through the simulation – see section 5.
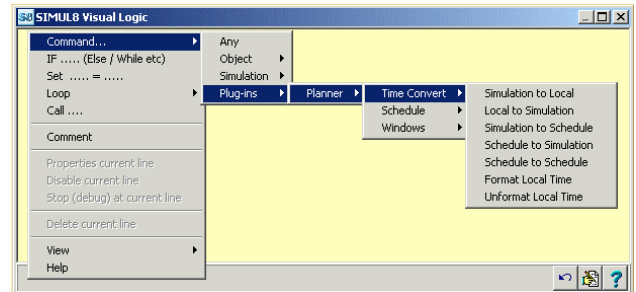

Figure 5: Time Management Visual Logic

4.2 Indexed Tables and Search Routines

4.2.1 An Introduction to Indexed Tables

An Indexed table provides the user with a fast and efficient method for sorting and searching through large amounts of information within SIMUL8's Information Store spreadsheets. By holding the information contained within the table in SIMUL8's internal memory, fast manipulation of the data is possible without complicated Loop within Loop statements to find and sort data. This is essential when scanning large order and inventory databases to assign orders to inventory and machine/ resource time.

Indexed tables are presented within SIMUL8's internal information store, which operates much like an Excel spreadsheet.

4.2.2 Scanning and Sorting Indexed Data

Several routines are provided for manipulating data within an Index table. So long as the values are provided in numerical format, they can be sorted and searched. Applications of this capability may include the following:

- Search for a specific order,
- Find orders with the order information,
- Add or delete orders, and
- Identify sorting criteria such as due dates.

Most of the functions, see Figure 6, are similar to the types of queries that are used by ERP systems to search through internal databases. SIMUL8's Visual Logic allows these queries to be made using a dialog-driven, user-friendly interface. Because of this, the user is not required to have expert knowledge of syntax or programming in order to manipulate the data.
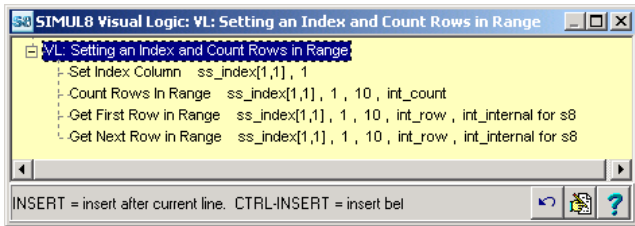
Figure 6: Sorting Data Visual Logic

4.3 Interactive Gantt Chart Routines

The Gantt chart feature within SIMUL8-Planner is the most visible to the end-user. Figure 7 shows two examples of this feature. It has a number of interactive features including drag and drop capabilities, formatting, pop-up text, customizable right-click menus, custom buttons for the tool bar, and multiple bar heights. All features are customizable by the developer to meet the end-user requirements.

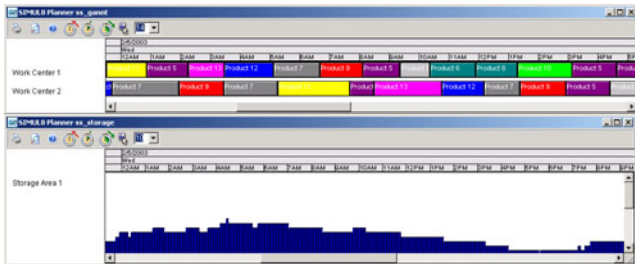With this feature, the developer can display large amounts of information in a user-friendly format.

Figure 7: Gantt Chart Display

4.3.1 The Gantt Chart Data Sheet

The Gantt chart is driven by a special data sheet that provides information on job start and end times as the simulation portion of the system is executed. Figure 8 shows an example of a Data Sheet and its corresponding Gantt chart. Other job information can be included in the data sheet such as text on the job, bar color of the job, bar pop-up text on mouse-over, and many other uses.
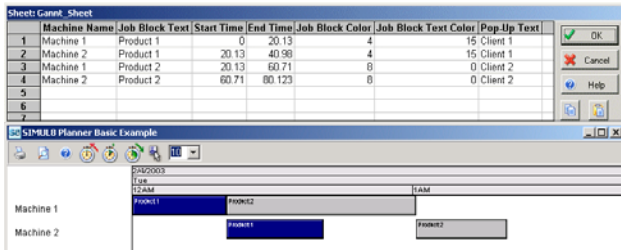

Figure 8: Gantt Chart Data Sheet

4.3.2 Gantt Chart Right-Click Menus

For drilldown options, SIMUL8-Planner provides right-click menus, see Figure 9, on the Gantt charts that return the job row that is being interrogated. Index tables can then be used to identify the order and provide other information such as the customer and order due date.
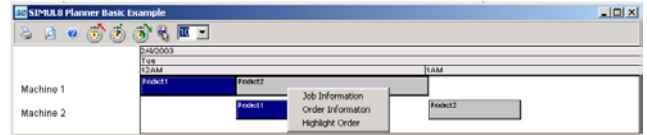

Figure 9: Gantt Chart Right-Click Menu

4.3.3 Customizable Buttons

Customizable buttons can be placed on the Gantt chart so that the end-user can drill down to other areas of the plant, display overall reports, or access rescheduling options. Since these are customizable, many features and options required by the end-user can be provided. A typical use of this would be to display performance reports specific to the client organization.

4.3.4 Rescheduling Jobs on the Gantt Charts

SIMUL8-Planner permits the user to pick and move jobs on the Gantt chart. It is possible to limit these movements based on time or other user-restrictions as demonstrated in the diagram below. This can be customized by the developer through the Visual Logic commands that provide information on the job start time and machine assignment. The developer then has the ability to restrict job assignment. This would include user-defined management rules for rescheduling orders.

Changes to the Gantt chart can then be evaluated by re-running the simulation to assess their impact on the defined performance measures.

The developer can also specify different user access levels to prevent manipulation of the plan by unauthorized users.
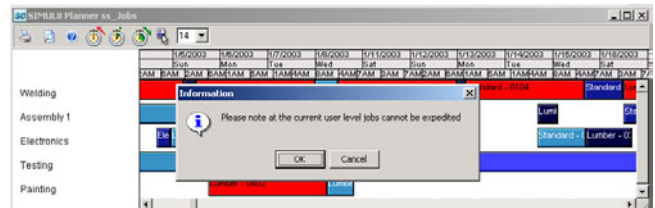

Figure 10: Gantt Chart Expediting Warning

5 APPLICATION OF SIMUL8-PLANNER

There are many different ways that SIMUL8-Planner can be applied. A typical approach is to use a pre-simulation

planning routine followed by simulation-based schedule generation. The following sections provide a brief summary of this method.

5.1 Pre-Simulation Planning

Traditional ERP systems plan work across a production facility using an aggregate, or timed-view of machine and resource capacity.

Customer orders or product demands are offset against available finished goods inventory to produce time-phased production requirements. These requirements are generated from the bill of materials, process sheets, and work-in-process inventory data.

Where production capacities are exceeded, work orders are assigned to earlier periods. This master planning approach does not ensure that orders will be completed on time when executed on the shop floor.

SIMUL8-Planner uses a similar planning approach, prior to running a simulation. The simulation considers the physical capacity constraints within the system along with the softer management rules or preferences with regards to order priorities and production targets.

5.2 The Planning Heuristic

There a several different heuristics that can be applied during the planning portion of SIMUL8-Planner. However, the typical method of scheduling jobs or production using the software is to first create a plan using intelligent heuristics based on user defined objectives and dispatching rules. Creation of the plan is centered around identification of the critical process or bottleneck based on overall capacity Schmenner (1984), total planned usage, user-defined weightings for changeovers, due date conformance, and other decision rules that will impact upon the dispatch of jobs. A backward plan explosion through the bill-of-materials is then used to allocate jobs within the plan. This process can be iteratively continued until all machines have been backward planned.

5.3 Simulation Schedule Generation

A key advantage of SIMUL8-Planner lies in its ability to quickly execute a production plan generating a feasible and efficient schedule, Flanagan and Walsh (2003). A production plan, on its own as described above, lacks the level of detail to ensure that it is both feasible and efficient. Executing a plan through a simulation of the plant processes results in a production schedule that includes job start and finish times by machine. It also provides service levels and manufacturing key performance indicators (KPIs).

The production schedule is presented through interactive Gantt charts as described earlier with the facility for the end-user to manually change or re-sequence allocated work at the machine level.

After inspection of the resultant schedule and plant KPIs, the user may elect to adjust the scheduling rules that control the simulation's execution of the plan. This may include order due-date conformance, the minimization of change-overs, the level of work-in-process build-up, etc. These rules can be weighted to produce an overall scheduling preference that is applied within the simulation of the plan.

5.4 Adaptive Planning and Scheduling

Plants and systems operate on a dynamic basis where changes are a natural and every day occurrence. A machine can go down, an urgent order is requested, or manpower availability can vary. The scheduling tool has to be adaptive to these changes in order to be useful, being capable of reacting to changing circumstances in a fast and efficient manner.

A key advantage of a simulation-based-scheduling approach is its ability to re-schedule quickly given a wide variety of unplanned conditions, Drake, Smith and Peters, (2002). This could be controlled through manual intervention by the scheduler or through an automatic schedule update.

Today it is now possible to link scheduling systems with manufacturing intelligence systems (MIS) for real-time data updates on the state of the plant. Machine or programmable logic controllers (PLCs) collect and feed detailed operational information to the MIS for monitoring purposes. Uploading plant information into the scheduling system it is possible to identify deviations from the plan. Then with the current states of work-in-progress, machines, and resources to re-schedule the plan, a valid re-aligned schedule is ensured. This Adaptive Planning and Scheduling approach (APS) keeps shop-floor systems in synchronization with dynamic production processes, Umble and Mokshagundam (1996). Also, eliminating manual intervention, the scheduling system can automatically provide, real-time feedback on scheduling solutions.

6 CONCLUSION

SIMUL8-Planner offers a valuable tool kit to the developer of simulation-based planning and scheduling solutions. Experience has proven that this approach is both practical and effective. These solutions can be easily integrated within existing ERP or legacy systems. The result is a purpose-fit scheduling system that addresses the immediate needs of the shop floor while remaining consistent with long-term production plans.

Simulation-based planning and scheduling, bridge the gap between tactical and strategic management information systems resulting in a more coordinated production planning and execution.

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