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PRODUCTION SCHEDULING SYSTEMS USING PROVISA

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ABSTRACT

This tutorial describes the application of AT&T Istel's simulation-based finite capacity scheduling system, PROVISA. The strategies that differentiate a finite capacity scheduling system from a general purpose simulation system are described. A brief description of PROVISA and how it fits into the manufacturing environment is presented. In addition, the steps required for building, implementing and verifying a PROVISA system are given.

1 BACKGROUND

The term scheduling is commonly used for two distinctly different tasks. Master Scheduling is the process by which assemblies and components get assigned due dates. Detail scheduling is the process where individual operations get assigned a date to be performed. In this paper the term scheduling will refer to detail scheduling.

1.1 TRADITIONAL SCHEDULING

Without computer based scheduling most plants will plan production one of two ways, either they will generate schedules by hand, or will not schedule and run by means of "Hot-Lists". When the detail schedule is created by hand it is usually done on a magnetic board or drawn on paper. For all but the most simple sites, the time required to do this is prohibitively large unless short cuts are taken.

These schedules usually take the form of a Gantt chart so a scheduler can quickly analyze the volume of information involved. The use of a Gantt chart also highlights the time dependent nature of the scheduling process. Most manufacturing consists of several consecutive operations that are defined for a part. These operations must be performed sequentially using one or more manufacturing resources. The availability of the resources also restricts the timing by forcing some allocation logic, usually one operation at a time.

In addition to analyzing the finished product of a scheduler's effort (the Gantt chart), it is interesting to observe the schedule as it is being created. An experienced observer will see that the scheduler performs some form of a manual simulation. Due to incomplete data, the results of the manual simulation are inexact. This in turn, degrades any schedule that is derived from the results.

These observations give insight into a systematic approach to automatic schedule generation. The first is the application of visually interactive simulation technology to perform scheduling. By combining the data handling and simulation capabilities of the computer, with a graphical planning board to display the resultant schedule, a superior scheduling solution can be produced.

2 SIMULATION BASED SCHEDULING

PROVISA (**PRO**duction **V**isual **I**nteractive **S**cheduling **A**id) is a finite capacity scheduling system geared for manufacturing facilities. While the mechanisms behind PROVISA are based upon AT&T ISTEL's simulation technology there are several features that differentiate a simulation based scheduling system from a general purpose simulator.

A general purpose simulator is usually a model centric tool. The purpose of the system is to analyze how the model performs. It is normally used by modifying how the model works. To initialize the model a warm-up period based on statistical generalizations may be used. The system uses a stochastic simulation engine to generate the variability in the output that is useful for analysis (with a confidence level after a number of runs). These simulation models usually have a finite life, when the analysis is complete the model is rarely used again.

A simulation based scheduling system is data centric. A scheduler must produce specific items that will fulfill some demand. To initialize the model the actual status from the plant floor must be used. A scheduling system must produce a "good" solution in a minimum time in order to be effective. This leads a simulation based scheduling system to use a deterministic model instead of a stochastic one. In addition, the benefits of a statistical based output do not fit into the scheduling environment. As an example, breakdowns generally occur in a random fashion. Since the exact time that a breakdown will occur is impossible to predict, it is impossible to schedule. In this case, it is better to generate a schedule based upon the best data available, and reschedule when and if the breakdown occurs. Lastly, a scheduling model has a much longer life than a simulation model. A scheduling model is expected to survive for many years of daily use with little or no modification.

While both types of systems encourage "What-if" experimentation, a scheduling system is working with tangible things while a simulation package models things that "could be". These differences between the two highlight the mode in which they are applied. When used for scheduling the simulation is tactical, however when it is used for simulation it is strategic.

3 ELEMENTS FOR SCHEDULING

For a scheduling system to be a useful tool it must be able to do the same functions as the manual scheduler. Specifically, it must generate the expected start and completion dates for the operations that are to be performed and it must able to analyze this data to determine its acceptability. To perform these functions the scheduling system needs to provide several capabilities:

- Incorporate the logic of how a site produces its goods.
- Handle any manufacturing mechanisms that the site uses, for example, JIT, Kanban, Theory of Constraints.
- Provide flexibility when unexpected conditions arise.
- Help the scheduler analyze the resultant schedule to determine the desirability of the schedule.
- Create an output of the schedule that is useful in the operational environment.

To accomplish this, PROVISA is organized as shown in Figure 1. The data is manipulated through the simulation engine. The resultant data is analyzed through generated reports, and the Comparison and Planning Board modules. If the first schedule is not satisfactory then PROVISA offers several options that allow refinement through iteration.

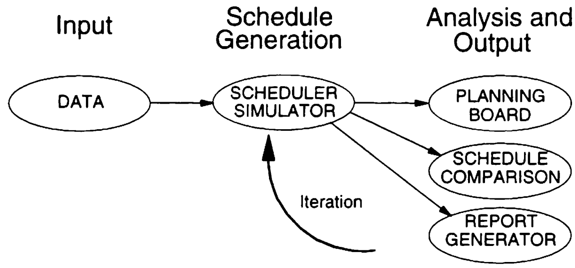

Figure 1: Scheduling Process

3.1 DETAILED DATA MODEL

As discussed above, the scheduling process is dependent upon data. In addition to shop floor status a scheduling system will require what is to be produced (Orders and Parts), how to produce it (Routes) and the resources to be scheduled (Work Units). A data hierarchy showing this relationship is presented as Figure 2. This diagram shows the relationships: An Order is for a Part, and A Routing ties Parts to Work Units.

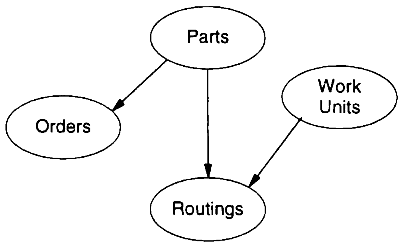

Figure 2: Base Scheduling Data (No status)

While these four data types are sufficient to "schedule", in most cases there are many other factors that need to be considered. PROVISA provides for inclusion of the following optional data when modeling a facility:

- **Bill Of Materials (BOM):** Allows the creation of a Parent-Child relationship between two parts. In addition, PROVISA can automatically create orders for component (child) parts.

- Stores: Allows limits to be placed on Inventory and Work In Progress.
- Stock Levels: Specify the quantity of parts that are available for use (useful for BOM relationships).
- Maintenance: Schedule planned and unplanned downtime.
- Work Patterns: Define the usable time for Work Units and resources.
- Holidays: Provide mechanisms to shut down the plant outside the Work-Pattern mechanism
- Customers: Provides the ability to calculate penalties that are customer specific.
- Resources: (Not Work Units described above). Usually used to model labor, however it is not limited to such.
- Resource availability: Specify the quantity of the resource per work pattern.
- Resource adjustment: Takes into account fluctuations in the work pattern data over time.
- Fixtures: Model tooling used for manufacturing.
- Free Fixtures: Specify the quantities of fixtures available.
- Features: Allows parts to have discrete classifications assigned.
- Feature Arrays: Using the feature classification set up relationships between parts with different feature levels.

These optional data types are combined with the base data and shown in Figure 3.

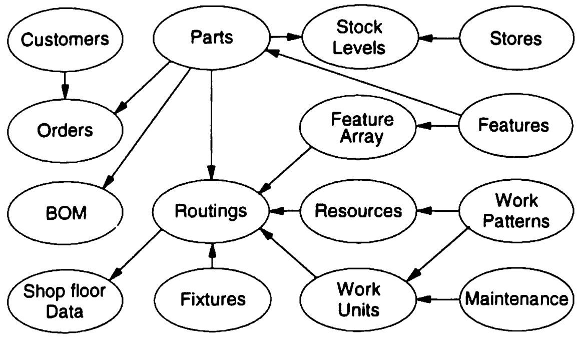

Figure 3: Detailed Data Relationships

3.2 PROVISA ENVIRONMENT

PROVISA provides a graphical frame work that operates at two levels. To the model builder, PROVISA provides a rich set of options and integration capabilities so that an accurate model can be constructed and maintained. For the end user (scheduler), PROVISA provides an easy to use environment to see the results of various "what if" scenarios so that the most advantageous schedule can be chosen.

PROVISA can be functionally broken down into four major elements; database, schedule generation (simulation engine), planning board, and report generator. These elements are encapsulated in a Graphical User Interface (GUI) that provides easy to follow menu navigation to the end user and an environment to rapidly construct prototypes to the model builder.

For model development, the system provides complete access to the database and model building elements. PROVISA allows the model builder to manipulate the data at several levels based on his needs. In a prototype environment the model builder can test concepts individually, with a minimum of effort. If the prototype work goes beyond testing concepts, then the spreadsheet "DIF" interface can be used to create larger volumes of data for extensive experimentation. While the DIF method could be used to integrate PROVISA to existing systems, most users prefer the ASCII interface methods. The ASCII interface methods allow the specification of the filename and record structure of the data files as they are created in the external system(s). This mechanism allows PROVISA to integrate with multiple systems simultaneously.

The customized interface and MACRO capabilities of PROVISA enables the model builder to combine several interface and execution steps into a single menu choice for the user. For example, a MACRO to import new orders from MRP, collect the shop floor status, create a schedule, run a set of reports and then display the planning board (Gantt chart) would be a typical use of a MACRO.

The goal of a PROVISA system is to provide an intuitive and easy to use tool for a scheduler. This person lives in the world of Gantt charts, hot lists and production reports. PROVISA provides this information pro-actively by using simulation technology. While the MACRO listed above simplifies the scheduling process for the user the philosophy of PROVISA provides much more. When used as a "What If" tool the scheduler is able to experiment without the associated cost of actually producing product thereby minimizing the risk of non-standard approaches.

The PROVISA planning board gives the production scheduler the ability to automatically create a Gantt chart, a long term wish. While the feedback from the planning board is helpful in identifying problems with a schedule, the ability to change these outcomes is critical. Using PROVISA, the user is able to create a better schedule by "changing the rules" when needed (for example choose an alternate manufacturing route). To assist in such decisions PROVISA gives the user the capability to interact with the simulation to see the status of the work stations and manufacturing lots. In addition to the planning board and the simulation interactions, PROVISA provides a menu driven report generator to create reports designed for the model and to define custom ad-hoc reports.

3.3 SCHEDULING INFRASTRUCTURE

While it is possible to have a "Stand Alone" PROVISA installation, most sites integrate the scheduling solution into other on-line systems. Figure 4 shows the most common systems that PROVISA gets integrated with, and the general class of data that is passed between them. What is important to understand is the general nature of the different types of systems. The planning systems, primarily MRP, MRP II and Order entry, provide the order or demand data (What to Make). In return, the scheduling system passes back the expected completion date for the orders. Manufacturing Execution Systems (MES) use the scheduled start times in dispatch processing to cause the work to be performed. The MES will provide to the scheduling system the status of the orders that properly initialize the model.

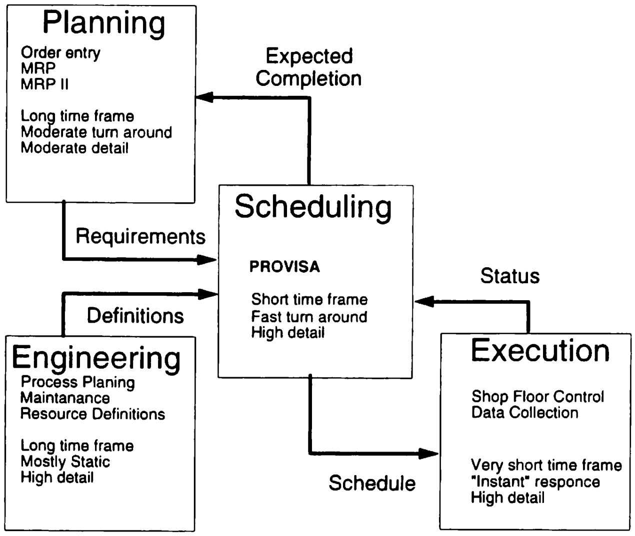

Figure 4: Manufacturing Systems Relationships

While this diagram shows a scheduling system that is fully integrated it is far more common to have a system that uses a sub-set of these links.

4 PROJECT LIFE CYCLE

A PROVISA installation will go through a cycle that can be summarized by the following milestones:

- **Identify Team:** This task is critical to the project. Since a scheduling system is dependent upon the data that is fed into it, there usually is a cross functional team involved in the project. The involvement of these people from the beginning will help to ensure a successful project.

- **Training:** Once the team is identified a training course on PROVISA will be held. This training course will provide the students with the understanding of the technology that will enable the scheduling model to be designed.

- **Design:** The design phase of the project involves determining what the requirements for a scheduling system are and what optional fields of data will be used in PROVISA. The design phase will also determine where this data resides and how to integrate it to PROVISA.

- **Model Completion:** With the built in database of PROVISA the model can be constructed and tested prior to the completion of the integration with the external data sources.

- **Integration:** The completion of the interfaces with external systems enables the model to be fully exercised.

- **Validation:** For the scheduling system to be accepted a period of time is usually set aside to validate the data that is being created. The new system will very rarely provide the exact same results as the existing system, but the differences between the two results can be identified and a decision as to the correctness of one over the other can be determined.

- **Going on line:** When the scheduling system is consistently providing a "Good" schedule it is time to go "on-line". This signifies the end of the project implementation and the start of the maintenance.

These milestones cannot guarantee a successful project. However, they do keep the project focused on completion and provide sufficient feedback to enable project management.

AUTHOR BIOGRAPHY

BOB MARRIOTT is a Senior Technical Consultant with PROVISA at AT&T ISTEL in Beachwood Ohio. He received a B.S. degree in Mechanical Engineering with a minor in Mathematics / Computer Science from the University of Lowell in Lowell, Massachusetts. After graduation he started his career with the General Electric Company on the Manufacturing Management Program. While at General Electric he held assignments in Production Control / Scheduling, Management Information Systems, Product Engineering and Manufacturing Engineering in the Military Electronics, Industrial Systems, and Consumer Products business sectors. His primary professional interest is providing computer based solutions in the manufacturing environment.