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INTEGRATING SIMULATION BASED SCHEDULING WITH MES IN A SEMI-CONDUCTOR FAB

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ABSTRACT

This paper discusses how simulation was used to evaluate and characterize the scheduling issues in a semiconductor fab and the subsequent implementation of an integrated scheduling solution.

The scheduling system was integrated with the fab MES and a number of other data sources including an integrated machine standards database, preventative maintenance scheduling and a Kanban stage calculation worksheet. It generates the schedule automatically at intervals throughout the day, 7 days per week and is used directly by the shop floor operators.

The solution enables the same data to be used for both scheduling and off-line simulation to provide continuous improvement by refining the simulation rules through "what-if" analysis

1 INTRODUCTION

One of the essential differences between <u>simulating</u> the flow through a factory and <u>scheduling</u> production is <u>data</u>. A simulation uses a representative load, to predict the behavior of the factory with statistical and other variations to build a level of confidence in the results. Scheduling takes a snapshot of the actual factory status and predicts future events. In a semiconductor fab, the rate of change in shop floor status means that status data cannot be more than a few minutes old and the total turn-around time from when the snapshot is taken to when the schedule is produced must be small. Even relatively static data such as routing, equipment performance metrics and tooling may change frequently.

The main output of a shop floor scheduler is a dispatch list which describes the sequence of events to be performed at each piece of equipment. This is a list of when each lot or job will be started. For a scheduling system to be successful, the dispatch list must be credible to the operators on the shop floor. This means that it must accurately reflect the actual routing that a lot is following, the actual equipment and tooling available etc. as well as the current status of the lots and equipment. If the dispatch list tells an operator to process a lot at a step which has already been completed or to execute a step that is incorrect, the schedule loses credibility and operating procedures to use it become difficult to enforce.

A scheduling system requires basically the same data that is maintained in an MRP II/ERP system and an MES or some combination of the two. This leads to the potential problem of data duplication and the associated maintenance headaches. This data is often obtained from a variety of difference sources and controlled and maintained by a number of different people or departments.

Additional information is also required that is specific to scheduling and not normally found in an ERP or MES system. e.g. Kanban stages, task selection rules, detailed machine performance metrics. This information must be maintained somewhere and merged with the ERP/MES data in order to create a schedule.

The problems of multiple data sources combined with the availability of current status information and the ability to coordinate it and feed it to a scheduling package in a timely fashion is one of the main barriers to implementing a shop floor scheduling system. At Sony Semiconductor, this problem was solved by the Wisdom™ project.

2 SITUATION

Fab activity is controlled and monitored by a PROMIS™ MES. It contains the relatively static data relating to the fab: equipment, tooling, part types, routings, preventative maintenance schedules, etc. This data is manually maintained by a variety of personnel that control the operation of the fab. The fab has a relatively high product mix with very complex routings consisting of at least 400 steps.

The MES controls and tracks the lots through the fab. When a piece of equipment becomes idle, the operator checks the PROMIS system for the lots that are available to be worked on, picks one, and "trackin" to the system which tells the MES that the lot is now being processed at a given step in the routing at the selected equipment. When the step is finished, the operator will "trackout" to tell the MES that the lot has completed that step and is ready to do the next step in its routing.

The MES has most of the data required to schedule the fab. However, there are a few essential deficiencies.

- *Preventative Maintenance Counts*
  Accurate PM scheduling is essential because it is a significant activity in a fab. The calculations involved are complex because PM intervals may depend on the recipe, voltage, plasma, part type and other variables which vary with every step performed. The problem of accurately defining the complex preventative maintenance requirements and tracking the status was solved by enhancing the MES and by special rules added to the scheduling system.

- *Machine Standards*
  The time to setup, load, process and unload a lot of a given part at a given piece of equipment is critical and varies with many parameters such as equipment type, recipe, tooling, etc. This information could not be accurately entered into the MES and was being maintained in a separate MS Access® database (known by Sony as TACT).

- *Kanban*
  The basic philosophy of scheduling at Sony employs Kanban which is not available in the MES.

- *Wet Stations*
  Some steps in the MES are actually a series of steps through wash tanks are modeled more accurately in the scheduling system to produce correct results.

- *Miscellaneous*
  There are various other scheduling parameters including task selection rules which are not available in the MES and have to be maintained in the scheduling database.

The activity in the fab (status changes) is relatively high with multiple transactions per minute, so that the time to produce a schedule from a snapshot of the status must be short to minimize the possibility that the schedule will plan events that will have already taken place by the time it is available and may have been performed in a different way, invalidating the schedule to some degree. This is compounded by the fact that many process steps can be performed at a variety of equipment or could even follow alternative routing and that rework, lot splitting and scrap occurs frequently. Status changes include WIP, equipment, PM counts and tooling status.

In summary, the "static data" resided in a number of different places or did not exist and was maintained by a number of different personnel. The fab status changes rapidly requiring a fast turnaround by the scheduling system.

3 WISDOM™ SYSTEM

3.1 Simulation

The first step was to build a simulation model to determine whether simulation based scheduling would help and what the key factors would be. The AutoSched package was used for this. This effort showed that scheduling could be effective but complex issues such Preventative Maintenance needed to be accurately modeled.

The simulation showed that Kanban based rules would be effective but, because of the large number of stages required, it would be unworkable using physical cards. However, Kanban rules could be used within the simulation to produce a "card-less" Kanban based schedule. The simulation was used to verify Sony production rules and determine the most effective Kanban strategy for the fab.

3.2 Scheduling

The maintenance and synchronization of data from the various sources was handled using ORACLE® relational database to create and maintain the scheduling model and results. The basic design goal was that data duplication was only acceptable if it was maintained automatically and never had to be entered manually more than once.

The maintenance of this data and the interface to the MES is performed using DB Client from AutoSimulations Inc. DB Client is a client application that runs on a PC that provides multi-user access to the data in the database and features to import and integrate data from other sources and format it for scheduling.

The Equipment performance metrics (TACT) database was moved into the ORACLE database and maintenance screens created in DB Client.

A Kanban Worksheet screen was built to calculate the Kanban stages for each route type using specific Sony rules but allowing flexibility for adjustments. These stages are applied to routings received from the MES to use the standard Kanban capability of the scheduler.

A data path between the MES and the machine on which the database resides was created using a network between the MES (VAX/VMS) and the ORACLE database (HP/UX). The AutoSched license used for automatic schedule creation was also placed on the HP/UX machine. An additional AutoSched license was placed on an SGI/UNIX machine for off-line simulation and "what-if".

Periodically (about twice per day) the static data is automatically extracted from the MES and sent to DB Client where it is processed and used to update the model in the scheduling database. This procedure may take some time so it is separated from the status data which has a critical download time.

Periodically (every 4 hours or less), the MES makes a snapshot of the fab status including equipment status, PM status and WIP and sends it to DB Client where it is processed and imported into the database. The fab model is then passed to the AutoSched package which produces a schedule. The results of the schedule run are then imported back into the database.

The resulting dispatch list shows all the steps that a lot will perform during the simulated period. However, the lot is only physically at one place and the operators want the dispatch list to show both what they should do next and what is actually available to work on. This is achieved by a Lot Status table in the database which maintained the lot status and next scheduled event. A direct link from the MES sends trackin/out information as each lot moves and the lot status table is updated to reflect the true status. When a lot completes a step, the system looks at the schedule to determine the time and location that the scheduler decided for the next step. This lot status display is viewed by the operators from the fab MES terminals through an ORACLE form on a window and can be filtered by equipment, equipment type, area, lot, and all lots.

The status changes so quickly that it would be common for the status passed to the scheduler to be out of date by the time the schedule is available. The users also required that the old schedule and status be available and and continued to be updated while a new one is being created. This issue was solved by staging the new schedule in the database, creating the new Lot Status table and reapplying all the transactions that arrived between the time the snapshot was taken and the current time. When this has been done, the new schedule becomes the active schedule. Relational database features which allow many changes to be made but not be visible to other users until they are committed along with guaranteed "read consistency" made these complex tasks relatively easy.

4 REPORTING

DB Client provides a number of built-in reports to view the schedule results. Sony was also able to create its own specialized reporting package because the information is maintained in a relational database. This is a major side benefit of the Wisdom system. It was difficult to create reports against the MES proprietary database but, because the schedule database is maintaining status in parallel with the MES, on-line fab status has become more accessible. The report package was created by Sony using PowerBuilder® tools. Some of these reports automatically update themselves to show actual status against schedule, WIP levels in Kanban stages, etc. These reports are displayed on large TV monitors in the fab (Fab Visual Control Monitor) and PCs on managers' desks.

5 INTERFACE ISSUES

The mapping of the MES data to the scheduling model was non-trivial, especially for routing and WIP status. This is a typical integration problem. Each MES and scheduling system represents items such as rework routes, lot splits and joins, etc. in different ways which necessitates complex mapping logic rather than simply mapping field A to field B. The finite state machines that describe the status of equipment and lots also vary considerably and require careful mapping. The logic must be flexible because it, as well as the data, changes frequently.

6 SIMULATION AND SCHEDULING

The ability to test hypotheses at any time using the actual fab production data was a requirement. This was achieved by placing a second AutoSched license on an SGI/UINX system and using the capability of DB Client to make copies of a model and allow them to be changed within the same database. Engineers were able to copy the production model and send it the AutoSched on the SGI system to run "what-if" scenarios using actual fab data.

7 CONTINUOUS IMPROVEMENT

Periodically, a team of managers, production personnel and engineering staff meet to discuss how the schedule is performing and pinpoint problem areas and suggest improvements. New rules can then be created and tested against past production data to see if the problem would be eased. The improved rules can then be applied directly to the actual shop floor scheduling system because they use the same package. This closed loop feedback from fab production to engineering and into scheduling rules is a primary reason for the success of the system which has produced a very significant decrease in lead time while maintaining production output.

The benefit of the scheduling system is not necessarily that any given schedule is better than a human can achieve, but that the same business rules are applied consistently every schedule, every time and is not dependant on the ability or personal preferences of any individual. It is this consistency that provides the basis for continuous improvement and is the major factor in the success of the project.

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