Management of Time Constraints Tunnels in Semiconductor Manufacturing : A Decision Support System

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Keywords: *Production control, Time constraints, Semiconductor manufacturing, Discrete-event simulation, List scheduling, Decision support*

1 Context, problem statement and motivation

To ensure the quality of integrated circuits, semiconductor manufacturing companies need to respect *Time Constraints* (TC). *Time constraints* are critical times not to exceed between two operations or steps in a product route. More broadly, a set of consecutive steps under at least one TC is called *Time Constraint Tunnel* (TCT). These quality requirements, added to other challenges in a High Mix/Medium Volume (HM/MV) fab (e.g. long cycle times, re-entrant flows and heterogeneous complex machines) become stressful for operators regulating TCTs in real time. Moreover, understanding the effects of mid-term changes can be difficult to qualify and quantify given the high complexity in semiconductor manufacturing facilities (fabs). This paper focuses on the management of releasing lots in TCTs at the operational and tactical levels using a simulation-based approach.

In the related literature, the management of time constraints is a relatively recent problem. TCs have been considered in different problems, that can be regrouped in three categories : **(i)** *scheduling* [2] : To assign lots (jobs) to resources subject to TCs and other constraints, while optimizing a given criterion, **(ii)** *capacity planning* : To determine the maximum number of work-in-process lots respecting TCs [3, 6], and **(iii)** *production control* [5] : To determine production rates respecting TCs. Because handling TCT management by classical scheduling approaches is most often irrelevant, recent works have been dedicated to supporting the context-aware dispatching regulation of lots in a given TCT [4, 5]. Based on these previous studies, a simulation system and its decision support capabilities are presented in this paper to help operators in taking decisions in real time when processing lots under TCs in TCTs. Perspectives on the use of the system for tactical decisions are discussed.

2 Solution approach

To help in taking decisions at the operational and tactical levels, an improved discrete-event simulation approach based on the work of [4, 5] has been developed. The improvements are the modeling of more complex machines, the extraction of Key Performance Indicators (KPIs), and the addition of new dispatching policies that better match the actual dispatching in fabs.

The simulation approach is based on a disjunctive graph representation, in which the nodes represent the steps of the routes of the lots being simulated, and the arcs represent the assignment of lots to machines as well as the route of the lots. Figure 1 gives an overview of the simulation procedure. First, an initialization step is required to retrieve the state of the fab (i.e.

lots, machines and their respective states) and to create the disjunctive graph for all the lots currently in the fab. This disjunctive graph is then used to start N different simulations runs. Each simulation run applies a list scheduling approach to generate feasible schedules based on a dispatching policy with a random component. During the simulation, different features are extracted and used at the end of the simulation procedure to generate KPIs related to TCs, machines, lots and steps.

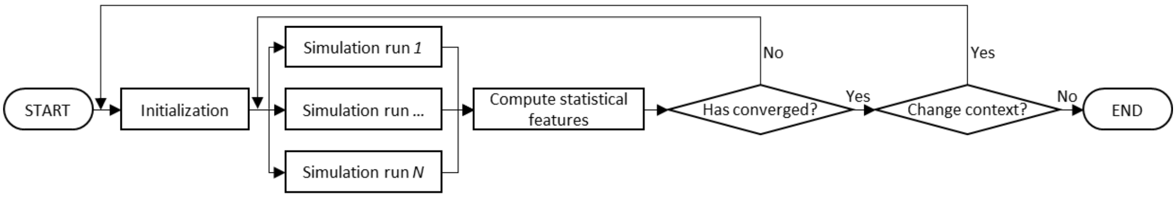

FIG. 1 – Overview of the simulation procedure

In the framework of the proposed simulation-based decision support system, multiple scenarios can be explored in N simulation runs and statistical studies conducted to understand what could happen in the fab. However, in a high-mix fab, the variability of machine states, or processing times or even the choice of the lot to process among the set of lots waiting in front of a machine, can be impossible to characterize and handle for operational or real-time purposes.

3 Conclusions and perspectives

The simulation approach of [4, 5] has been improved in different ways. Adjustments consistent with the ground truth have been performed and continue to be done in order : To validate the representation of the considered fab, to identify improvement directions and to tune simulation parameters.

At the operational level, more KPIs need to be extracted in short computational times, while guaranteeing the desired accuracy of the results. To support tactical decisions, more complex optimization-based dispatching policies should be proposed to better support the achievement of production targets. Another perspective is to develop and validate production planning models with time constraints to study their impact, using for example linear programming models with flexible lead times as in [1].

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