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A resource portfolio model for equipment investment and allocation of semiconductor testing industry

K.-J. Wang [a,*], S.-M. Wang [b], S.-J. Yang [c]

[a] Department of Industrial Management, National Taiwan University of Science and Technology, Taipei 106, Taiwan, ROC
[b] Department of Industrial Engineering, Chung-Yuan Christian University, Chung Li 320, Taiwan, ROC
[c] Australian Graduate School of Management, The University of Sydney & The University of New South Wales, Australia

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Abstract

Profitable but risky semiconductor testing market has led companies in the industry to carefully seek to maximize their profits by developing a proper resource portfolio plan for simultaneously deploying resources and selecting the most profitable orders. Various important factors, such as resource investment alternatives, trade-offs between the price and speed of equipment and capital time value, further increase the complexity of the simultaneous resource portfolio problem. This study develops a simultaneous resource portfolio decision model as a non-linear integer programming, and proposes a genetic algorithm to solve it efficiently. The proposed method is employed in the context of semiconductor testing industry to support decisions regarding equipment investment alternatives (including new equipment procurement, rent and transfer by outsourcing, and phasing outing) for simultaneous resources (such as testers and handlers) and task allocation. Experiments have showed that our approach, in contrast to an optimal solution tool, obtains a near-optimal solution in a relatively short computing time.

Keywords: Production; Capacity planning and allocation; Genetic algorithms; Semiconductor testing

1. Introduction

The semiconductor testing industry constantly struggles for resource planning with constrained budget to invest, limited capacity of resources and lumpy demands. In the industry, simultaneous resources for processing an order are commonly considered, as indicated in Fig. 1. Testers are the main resource for testing semiconductor chips. Many other kinds of resources (such as handlers, load boards, tools, and testing programs) work simultaneously to conduct the test for a wafer/chip. Each resource may have several types resulting from

* Corresponding author. Tel.: +886 3 863 3018; fax: +886 3 863 3010.
E-mail address: kjwang@mail.ndhu.edu.tw (K.-J. Wang).

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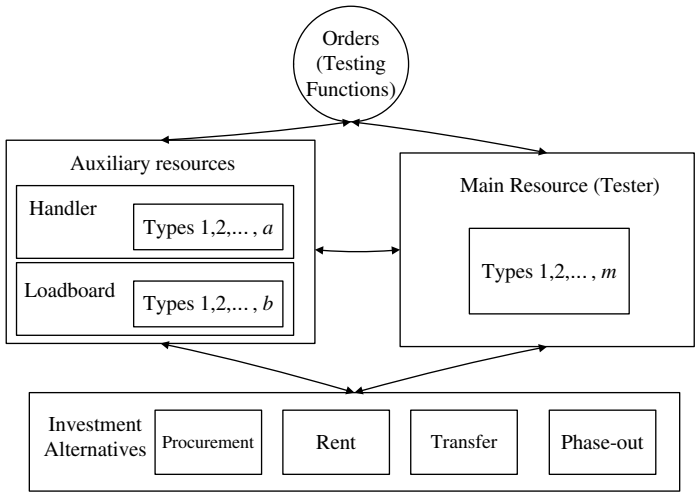

Fig. 1. Portfolio planning of simultaneous resources with consideration of equipment investment alternatives.

different functionalities and processing precisions. A tester performs the functional test and a handler feeds a wafer/chip material into the tester. Each testing task requires a specific temperature setting for the handlers.

The headquarter of a company in such an industry usually develops annual investment strategy based on market forecast and determine capital allocation to each individual cell. The equipment costs of a tester set usually range from three hundred thousand to two million US dollars. The cost of a handler is around one tenth of a tester. Slight improvements of capacity utilization can thus result in gains of millions of dollars per year.

However, capacity planning and allocation are extremely challenging in the wafer testing industry owing to characteristics of simultaneous resources and constrained budget for resources of testing operation. Besides, facility investment decisions and the resource capacity allocation decisions are highly coupled and complex. Efficient and effective approaches to addressing this issue are thus very important (Wang and Hou, 2003).

In such industry, alternatives of equipment investment typically include procuring new equipment, renting equipment from competitors, transferring it from other plants and phasing out equipments because of falls in its performance. Such decisions must be made often to respond to changing markets and satisfy forthcoming orders.

Furthermore, orders from semiconductor manufacturing fabs arrive at testing factories in a very lump demand. Therefore, an optimal solution for planned orders may be far from optimal for the realized orders. Thus, what a decision-maker of capacity planning needs is, on a basis of existing resources and budget on hand, to develop a plan of resource portfolio and allocation efficiently. The solution should be computationally fast (in a couple of days instead of weeks) and robust (to the changes in the demand). Furthermore, a testing factory must frequently examine such capacity plan based on both the known orders and future market forecast.

Our research concern focuses on long-term capacity planning instead of short-term scheduling decisions. We regard customers (i.e., semiconductor manufacturing fabs) as ''orders'' which represent certain long-term contracts rendering to the testing factory.

This study thus focuses on the issues related to the capacity planning of simultaneous resources involving investments in alternative equipment at a semiconductor testing facility. The following issues are addressed in particular.

(i) The optimal resource portfolio plan (including the type and number of resources such as testers and handlers that should be procured, rented, transferred and/or sold-out) accounting for the time value of capital.
(ii) The choice of the most profitable orders from pending orders.