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# A Benchmarking Service for the evaluation and comparison of scheduling techniques

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**Abstract**

Scheduling decisions constitute the last decision-making phase of the production planning and control process. From the industrial side, the adoption of highly reactive and efficient scheduling and control systems strongly affects the level of productivity and utilization of a manufacturing system, particularly under the pressure of shortened product cycles, reduced batch sizes and a broader variety of items to be produced. In the meanwhile, from the research side, there has been a considerable amount of works done in the area of manufacturing systems control, even if they still remain ''unheard voices'' in industry. Hence, in the scheduling world there is a risk of miscommunication between academics and industrial users.

Aim of the paper is to provide a comprehensive view of the rationale, the conceptual model, the development efforts and first applicative experiences of the Benchmarking Service, a research initiative which has been carried out within the activities of the Special Interest Group on Benchmarking and Performance Measurement of the IMS Network of Excellence. In particular, the paper details the PMS-ESS conceptual framework developed for assessing the level of quality of a scheduling solution in terms of efficiency, robustness and flexibility.


*Keywords:* Scheduling evaluation; Benchmarking; Performance measurement; Plant management

## 1. Introduction

Competitive firms are operating today in global and worldwide markets. Manufacturers are experiencing a lumpy market demand for their products, with ever shorter requested lead times and order quantities as well as frequent changes in product specifications. In this context, within the production planning and control process, scheduling plays undoubtedly a critical role. It is the final temporal decision-making phase where industrial managers have to act for fixing any short noticed variations preserving at the same time expected medium-term efficiency performance.

According to Kempf et al. [6], the most general definition of a scheduling problem is that of ''*assigning scarce resources to competing activities over a given time horizon to obtain the best possible system performance*''. Referring specifically to factory scheduling, the resources are machines and workforce, and the competing activities are jobs that require processing on the resources.

Several scheduling approaches exist, from the traditional off-line scheduling systems, which elaborate a production plan (e.g. according to static rules and algorithms) for a specific plan period, to on-line production scheduling systems, which are intrinsically able to modify an existing schedule or regenerate a completely new one for managing upcoming events which could alter the original plan.

Despite the flourish of heterogeneous proposals, a dichotomy is actually affecting the world of scheduling. Researchers are often detached from industrial reality, proposing answers to simple examples and toy cases. On the contrary, practitioners have clear difficulties in explaining their requirements and exploiting the opportunities which could come out from the industrial exploitation of the new advanced scheduling approaches.

The main purpose of the present paper is to provide a comprehensive view of a research initiative, carried out in the last years within the activities of the IMS-NoE Special Interest

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Group (SIG) on Benchmarking and Performance Measurement of Production Scheduling Systems. The research community involved in the SIG has been mainly interested in promoting the adoption of a Benchmarking methodology for testing and evaluating scheduling solutions in order to identify the best solution for one industrial problem.

This idea has turned into reality with the instantiation of the Benchmarking Service within the IMS-NoE web site [7], freely accessible to all the registered members. The available prototype of the *Benchmarking Service* is a web-based arena, where production systems would be described and different production scheduling policies would be evaluated and compared under a common simulation environment.

The paper is organized as follows: Section 2 summarizes the rationale behind the developed *Benchmarking Service*; Section 3 introduces the framework developed for supporting the description of a test case; Section 4 explores the main requirements of the evaluation of a scheduling system; Sections 5 and 6 illustrate the proposed PMS-ESS with an applicative example; Section 7 provides the main conclusions of the paper.

## 2. Rationale of the Benchmarking Service

Finding a scheduling system as a panacea for solving all the issues which could arise in a production environment is quite pretentious. Indeed, one of the main sources of miscommunication between the research and the industrial world is the difficulty to clearly and objectively ascertain the real domain of applicability of a scheduler for a specific industrial problem.

In literature, there are several approaches to the scheduling problem, which can be classified using alternative criteria, referring in particular to shop-floor layouts (from single-machine problems to complex job-shops), to scheduling techniques (ranging from elementary dispatching rules to multi-layered holonic systems) or to the level of uncertainty of the production environment (deterministic models versus event-triggered reactive schedulers) [21–23].

However, a clear understanding of the performance of scheduling systems and their impact on the outcome of the manufacturing system as a whole is still missing [6]. The need for suitable Benchmarking platforms is not unique to production scheduling; other research communities, as is the case of artificial intelligence, have in the past pointed out similar needs [24,25].

In particular, what is still missing today is [15]:

- a set of emulations of underlying production systems that is representative for industry; this set cannot be restricted to the typical Operations Research models but addresses issues such as the handling of empty containers, batching, matching, uncertain processing outcomes;
- a set of scenarios for those underlying systems that adequately reflects the dynamics of industrial systems; this includes breakdowns, maintenance, processing time variations, inaccurate data, missing data, late data, rush orders, cancellations;
- a standardized interface to connect control/scheduling systems to such emulations of underlying systems;
- a Benchmark management system that supports the user in defining and executing Benchmarks; this includes a user-friendly Graphical User Interface (GUI)-based subsystem, that could significantly lower the threshold for novel users, and more advanced facilities in which expressiveness is the main concern.

The *Benchmarking Service* (BS) aims to overcome these issues by providing a framework, which should enable developers of control systems and production engineers to meet in the virtual world and test/evaluate how well they match up (Fig. 1). Within this vision, there are three main involved actors: (a) industrial users, (b) researchers and (c) technology vendors. The involvement of the three profiles of actors derives from the different point of views that each of them has on the design of production plants and connected management logics.

The architecture of the *Benchmarking Service* is structured into three inter-connected elements, each related to a specific project objective and integrated on the same web-enabled virtual environment (Fig. 2):

- *Test-bench assistant*—a visual interactive environment for assisting the designer of a test-bench case in inputting all the

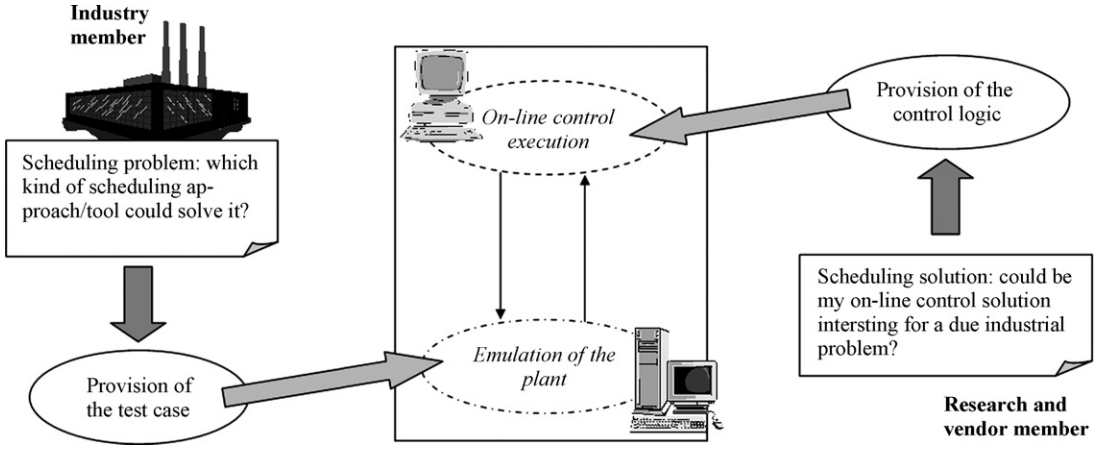


Fig. 1. The Benchmarking Service vision.