05281 Abstracts Collection
Simulation & Scheduling: Companions or Competitors for Improving the Performance of Manufacturing Systems
— Dagstuhl Seminar —

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Abstract. From 10.07.05 to 15.07.05, the Dagstuhl Seminar 05281 "Simulation & Scheduling: Companions or Competitors for Improving the Performance of Manufacturing Systems" was held in the International Conference and Research Center (IBFI), Schloss Dagstuhl. During the seminar, several participants presented their current research, and ongoing work and open problems were discussed. Abstracts of the presentations given during the seminar are put together in this paper.

Keywords. Simulation, Scheduling

05281 Executive Summary – Simulation & Scheduling: Companions or Competitors for Improving the Performance of Manufacturing Systems

In July 2005 the conference on "Simulation & Scheduling: Companions or Competitors for Improving the Performance of Manufacturing Systems" was held in Dagstuhl. This is the summary of the outcome of this week.

Joint work of: Fowler, John; Rose, Oliver; Pinedo, Michael; Nelson, Barry

Keywords: Simulation, scheduling

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2006/409

An FPTAS for two-machine scheduling problems with nonlinear objectives

Sergei Chubanov (Universität Siegen, D)

We study a two-machine scheduling problem with a nonlinear objective function satisfying certain conditions. The problem generalizes such NP-hard scheduling problems as the problem of minimizing the sum of cubed job completion times on two machines and the problem of minimizing the sum of total weighted completion times. The problem of minimizing the sum of job completion times on two nonidentical parallel machines with time-varying speeds also reduces to the problem we consider. A recursive function on which a dynamic programming formulation of the problem is based possesses some attractive properties allowing us to convert a dynamic programming procedure into a fully polynomial time approximation scheme.

Design and Evaluation of Online-Scheduling Algorithms with Computational Intelligence

Carsten Ernemann (Universität Dortmund, D)

This talk presents a methodology for automatically generating online scheduling algorithms for a complex criterion defined by a machine owner. This research is focused on online scheduling with independent parallel jobs, multiple identical machines and a small user community. First, evolutionary algorithms are used to create a 7-dimensional solution space of feasible schedules of a given workload trace. Within this step no preferences between different basic criteria need to be defined. This solution spaces enables the resource providers to define a complex evaluation criterion based on their specific preferences. Second, optimized scheduling algorithms are generated by using two different approaches. On the one hand, an adaptation of a Greedy-Scheduling algorithm is generated which uses weights to create an order of jobs. These job weights are extracted again from workload traces with the help of evolutionary algorithms. On the other hand, a Fuzzy rule based scheduling system will be applied. Here we classify a scheduling situation which consists of many parameters like the day time, the week day, the time, the waiting queue length etc. Depending on this classification, a Fuzzy rule system chooses an appropriate sorting method for the waiting job queue and a suitable scheduling method. Finally both approaches, the Greedy scheduling and the Fuzzy rule based scheduling system, will be compared by using again workload traces.

Scheduling Approaches for Manufacturing

John Fowler (ASU - Tempe, USA)

In this talk, we compare and contrast the two major approaches for controlling manufacturing operations: deterministic scheduling and dispatching. An introduction to the Graham et al. notation for deterministic scheduling is provided.

Keywords: Deteministic Scheduling, Dispatching

Experiences with Simulation Based Scheduling

Sanjay Jain (Virginia Tech - Falls Church, USA)

This presentation will describe my experiences with implementing simulation based scheduling in the industry in US and Singapore. These include implementations in automotive and semiconductor manufacturing industry. The methodology used has been varied and includes: direct schedule generation from simulation, use of simulation concepts within an expert system scheduler, and use of backward simulation. Both periodic and near real-time interaction with the shop floor have been explored. The issues faced in the development and implementation efforts will be presented. Both successful and unsuccessful efforts will be described to help highlight the potential success factors and pitfalls to watch for.

Keywords: Simulation based scheduling, automotive, semiconductor, manufacturing, backward simulation, expert systems

Joint work of: Jain, Sanjay

About the Difficulty to Solve Operational Real-World Problems with Simulation

Peter Lendermann (SIMTech - Singapore, SGP)

For manufacturing and service systems, simulation has traditionally been used for strategic and to some extent tactical decision-making. This presentation discusses challenges and implications with regard to making simulation applicable also for tackling operational and particularly real-world operational challenges. The question of how to synergize with scheduling techniques is elaborated as well. Lastly, some related ongoing research activities that are currently being pursued at SIMTech as part of the Integrated Manufacturing and Service Systems (IMSS) Programme in Singapore will also be presented.

Keywords: Simulation, Decision-Making, Operations Management

Joint work of: Lendermann, Peter

Integrated Semiconductor Manufacturing Scheduling and Simulation

Scott J. Mason (University of Arkansas - Fayetteville, USA)

We present a summary overview of a previously published Shifting Bottleneck (SB)-based heuristic approach for scheduling lots in semiconductor wafer fabrication facilities to maximize on-time delivery of the wafer fabs customers orders. Next, we provide some discussion on research efforts carried out to implement the deterministic SB heuristic in a discrete even simulation software package, AutoSched. Finally, the concept of non-critical tool "black boxing" is discussed in terms of an approach for decreasing the computational requirements of the SB-based fab scheduling heuristic, albeit at potentially some cost of reduced solution quality.

Keywords: Semiconductor, scheduling, heuristic

Scheduling and Simulation Research: A Little Academic Incite

Leon F. McGinnis (Georgia Institute of Technology, USA)

For large-scale, complex, stochastic, customer-driven discrete event systems, such as semiconductor wafer fabs or global supply chains, scheduling and simulation would seem to be essential technologies for success, and therefore attractive opportunities for investment. The relatively moribund state of R&D for simulation and scheduling belies this apparent promise. What is the problem?

Keywords: Scheduling, simulation, issues

Iterative Simulation: a Simple Technique to Improve the Performance of Complex Manufacturing Systems

Lars Mönch (TU Ilmenau, D)

Based on the lead time iteration concept, we obtain good waiting time estimates by using exponential smoothing techniques. We describe a data-base driven architecture that allows for an efficient implementation of the suggested approach. We present results of computational experiments for reference models of semiconductor wafer fabrication facilities. We also describe the usage of our method in a hierarchical production control approach within the multi-agent system FABMAS.

An overview of current research on optimization via simulation

Barry Nelson (NW University - Evanston, USA)

This will be a high-level tutorial on methods that researchers in the simulation community have been developing for optimization via simulation (optimizing the expected performance of a system represented by a stochastic simulation model).

Keywords: Optimization via simulation; stochastic simulation; random search; ranking & selection

Joint work of: Nelson, Barry

Flight Gate Assignment and Pareto Simulated Annealing

Yuri Nikulin (Universität Kiel, D)

This talk addresses an airport gate assignment problem with multiple objectives. The objectives are to minimize the number of ungated flights and the total passenger walking distances or connection times as well as to maximize the total gate assignment preferences. The problem examined is an integer program with multiple objectives (one of them being quadratic) and quadratic constraints.

We tackle the problem by Pareto simulated annealing in order to get a representative approximation for the Pareto front. Results of computational experiments are presented as well.

A brief success story from GM, and a few comments on practical considerations for simulation and scheduling

Jonathan Owen (General Motors -Warren, USA)

The talk begins with a brief overview of work at General Motors aimed to improve manufacturing operations performance. The modeling and analysis tools created at GM for production system performance estimation and throughput improvement are described, with commentary emphasizing the importance of defining the right level of model abstraction and the need for an appropriate infrastructure to support large-scale deployment to diverse user communities. Additional comments underscore the need for consistent models and analyses that comprehend the lifecycle and/or hierarchical decision processes of the target application setting. Finally, a few comments describe practical complications that must be addressed (and not "assumed away") at a fundamental level in order for simulation and scheduling to have wide-spread impact in practical settings; example scenarios are drawn from the author's own experience.

Keywords: Production system modeling

Methodologies for Parameterization of Composite Dispatching Rules

Michele Pfund (ASU - Tempe, USA)

In this talk, a design of experiments based regression methodology is proposed to set the scaling parameter values for composite dispatching rules. Using a Face Centered Cubic design, the number of experiments needed for data collection is dramatically reduced in the experimentation phase while still guaranteeing enough information for fitting a quadratic model. Further, the fitted regression models help to reveal the empirical relationship between the scaling parameter values and the problem instance characteristics.

In addition, a scheme to find robust scaling parameter values is developed. Using robust scaling parameters can achieve good performance for most problem instances with the minimal computation time and effort. Therefore it is very helpful for situations that require rapid decisions.

A case study also illustrates the use of these two methods against the methods used in the published literature using ATCs for the $Pm|s_{jk}|\sum w_jT_j$ scheduling problem. Results indicat that both perform significantly better: the regression models achieve more than 34

Keywords: Scheduling, dispatching

Some Models for Scheduling Problems in Finance

Günter Schmidt (Universität des Saarlandes, D)

We present some examples for modeling and solving scheduling problems related to the management of money and other assets. The focus is on questions related to liquidity planning, best buy, asset replacement, and portfolio revision. The analytical approach should be accompanied by simulation. Examples for a hybrid approach combining scheduling and simulation are given. The purpose of the contribution is to stimulate research in the area of simulation and scheduling to problems in finance.

Keywords: Scheduling, simulation, financial problems

Simulation, Optimization, Scheduling - Some Notes from Industrial Applications

Sven Spieckermann (SimPlan AG - Maintal, D)

The presentation gives a short overview on some application of combined scheduling and simulation in industries such as automotive, logistics, and transportation. Some ideas for future research are given and some obstacles on the way to an even more fruitful companionship of simulation and scheduling are pointed out.

Keywords: Simulation, optimization, scheduling, case study

Symbiotic Simulation of Semiconductor Manufacturing Operation using Agent Technology

Stephen John Turner (Nanyang Technological University - Singapore, SGP)

The rapidly changing business environment of high-tech asset intensive enterprises such as semiconductor manufacturing constantly drives production managers to look for better solutions to improve the manufacturing process. Although traditional simulation analysis can be used to generate and test out possible execution plans, it suffers from a long cycle-time for model update, analysis and verification. It is thus very difficult to carry out prompt "what-if" analysis to respond to abrupt changes in these systems. Symbiotic simulation has been proposed as a way of solving this problem by having the simulation and the physical system interact in a mutually beneficial manner. In this talk, we describe our work in developing a prototype proof-of-concept symbiotic simulation system that employs software agents in the monitoring, optimization and control of a semiconductor assembly and test operation. This work is part of a larger collaborative project with Singapore Institute of Manufacturing Technology (SIMTech) and other partners, funded by the ASTAR Integrated Manufacturing and Service Systems programme.

Keywords: Symbiotic Simulation, Agent-supported Simulation, Semiconductor Manufacturing

Simulation vs. scheduling - just a question of the viewpoint?

Gerald Weigert (TU Dresden, D)

We can understand the manufacturing process as a structured set of simple tasks. In this set two basic types of relations are defined:

1. Equivalence relations
2. Order relations

A typical equivalence relation is the (time depended) occupation of machines and jobs by the tasks. Tasks, which occupy the same machine are equivalent to each other in this sense. Both, machines and jobs are resources, in general with limited capacity. The typical order relation consists on the preferences of process steps in a technological sequence. To display the tasks with all their relations we can use a 3-dimensional Gantt-chart with a job- (or task-), machine- and time-axis. Unfortunately we are unable to look at the whole 3D-chart with our algorithms so that we must switch between two points of views:

1. The simulation point of view prefers the equivalence relations. From there the order relations are nearly invisible.

2. The scheduling approach prefers the order relations but has some more difficulties to consider the capacity demands than the simulation approach.

This conflict can be solved only by repeated and alternate use of both methods. Can the idea of 3D-Gantt help to develop better simulation/scheduling systems?

Keywords: Simulation-based Scheduling

Fluid approach to the control of processing networks: Continuous linear programs, virtual infinite buffers, and maximum pressure policies

Gideon Weiss (Haifa University, IL)

A fundamental problem in operations research is the control of many items whose evolution requires the use of shared resources over time. Manufacturing, vehicle traffic, communication networks, multiproject scheduling, and supply chain management, are among the areas in which this is crucial. This can be formulated as online control of a discrete stochastic processing network over a finite time horizon. We propose to solve it via a fluid approach: Approximate the system by a deterministic continuous fluid model, calculate the optimal fluid solution, and control the original discrete and stochastic system so as to track the fluid solution.

Two recent breakthroughs make this possible: I have invented a simplex algorithm for the solution of separated continuous linear programs (SCLP), a

problem which has been open for 50 years. This enables us to calculate optimal fluid solutions.

Dai and Lin have recently invented maximum pressure policies to control processing networks.

It guarantees stability, and is conjectured to be optimal on the diffusion scale. Maximum pressure policies can be used, in conjunction with the concept of virtual infinite buffers which I introduced recently, to track the fluid solution of a transient system. This provides us with a method of control which is asymptotically optimal on the fluid scale, as the number of items increases.

I shall discuss these topics, and discuss application to wafer fabs and to supply chain management.