TECHNISCHE UNIVERSITÄT DRESDEN

Fakultät Informatik Institut für Angewandte Informatik

Improved Simple Simulation Models for Semiconductor Wafer Factories

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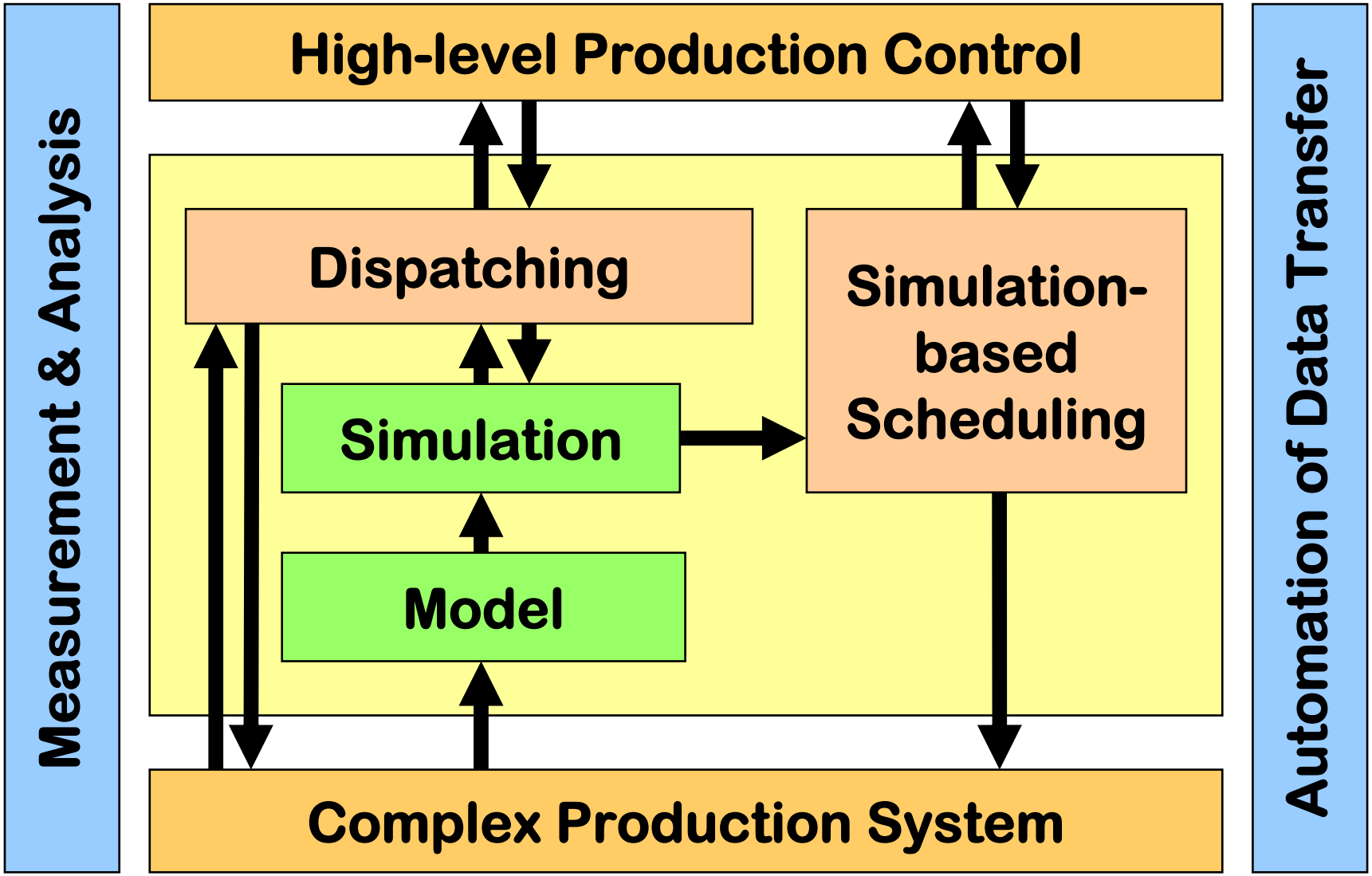
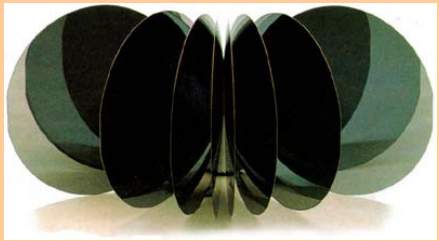
Bremen, January 11, 2008

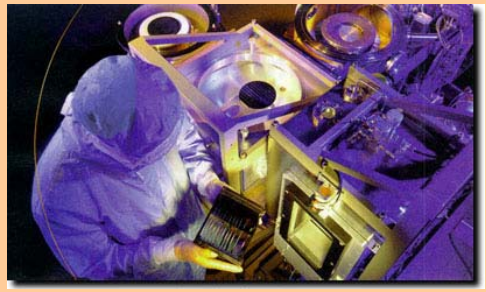
Research overview



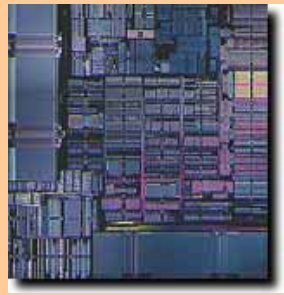
Semiconductor manufacturing

Front End

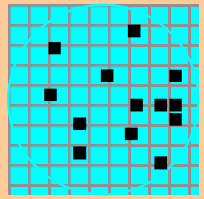


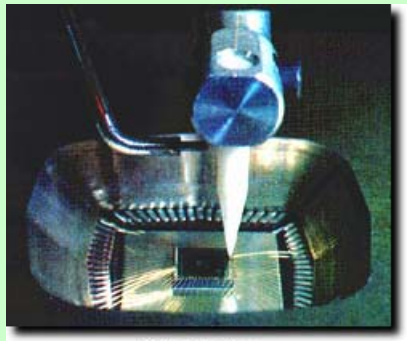


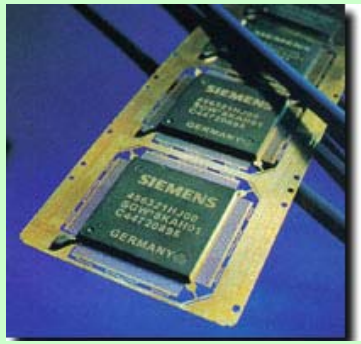
Wafer Fab

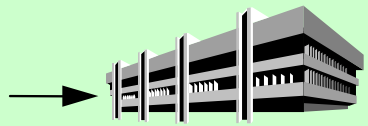


Probe







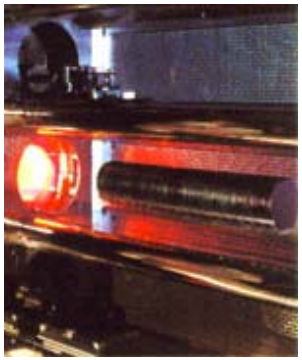


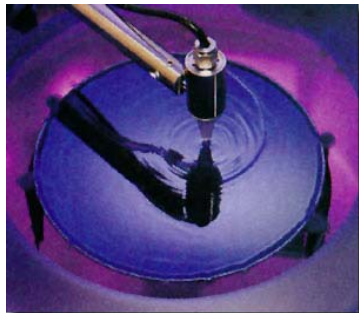
Assembly

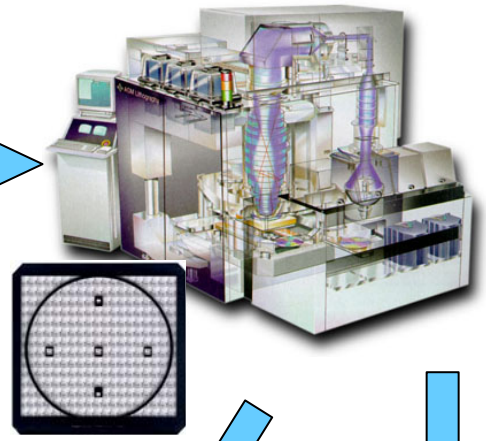
Test

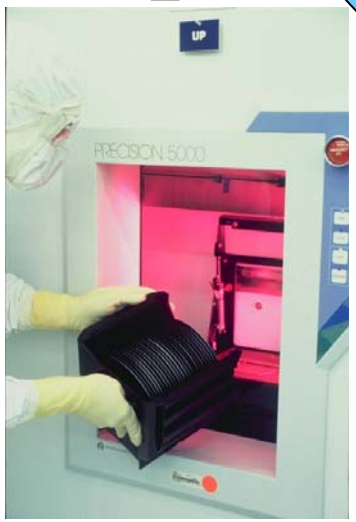
Back End

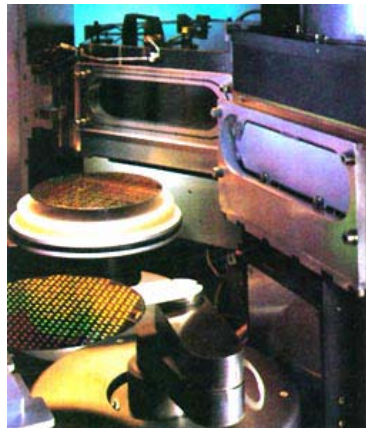
Flow of material

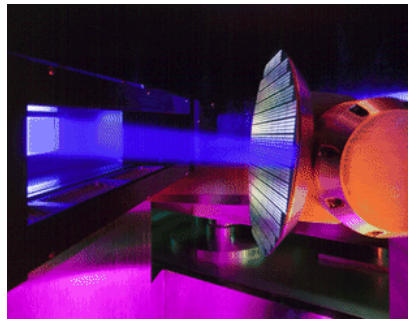












Fotos: Fullman-Kinetics, Varian, Sematech International

There are still humans involved!

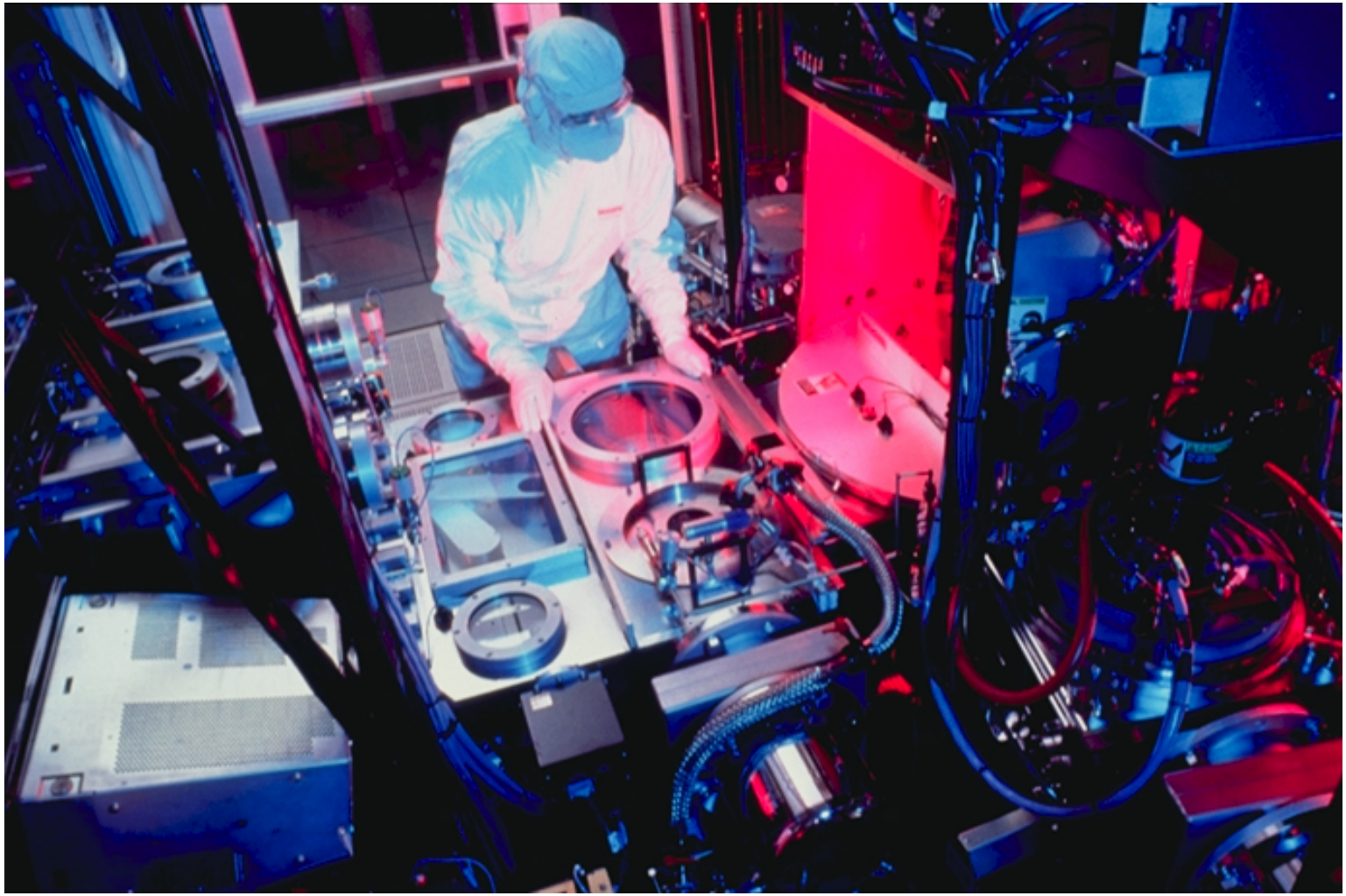


Foto: Sematech International

How do the tools usually look like?

Fotos: Firma Varian

Characteristics of wafer fabs

- Large number of processing steps, typically several hundreds
- Large number of tools of different types: photo equipment, ovens, etching equipment, ion implanters, …
- Wafer are build up in layers: reentrant flow of material, jobshop-like way of production
- Frequent machine breakdowns (typical availability: 70-90%)
- Auxiliary resources, e.g., reticles (photo masks)
- Batch tools with complex batching criteria
- Sequence dependent setups
- High level of automation
- Operators with different types of skills

Control factors

- Factory load
- Product mix
- Number of machines and operators
- Preventive maintenance policies
- **Production planning & control policies:**
  - scheduling vs. dispatching,
  - lot release vs. shop-floor control,
  - ...

Operational modeling

- Model components
  - Tool set: type of tool, setups, breakdowns, …
  - Secondary resources: worker, photo masks, …
  - Products: lot sizes, arrival patterns, …
  - Product recipes: lists of operations
  - Material flow control: lot release rules, dispatching rules
- Most tools seen as blackbox
  - Internal behavior of tool not modeled
  - Exception: cluster tools

Important operational questions

- Most appropriate dispatching rule
- Most appropriate lot release rule
- Output prediction
- Cycle time prediction
- Lateness prediction
- Forecast of short-term material flow problems
- Workarounds after random events (breakdown, operator unavailability, …)
- Effect of product mix changes (surge analysis)
- Practical relevance of schedules (robustness, stability)

No alternative to simulation as a decision support tool!

Motivation for simple models

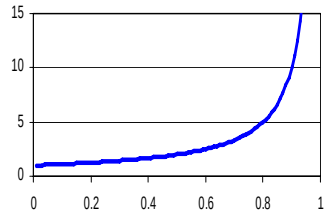
- Traditionally, only full detail models used for operational planning and control of semiconductor fabs

- Consequences:
  - Long run times of simulation experiments
  - Long run times of scheduling algorithms
  - Too complex to be included in enterprise models for SCM (Supply Chain Management)

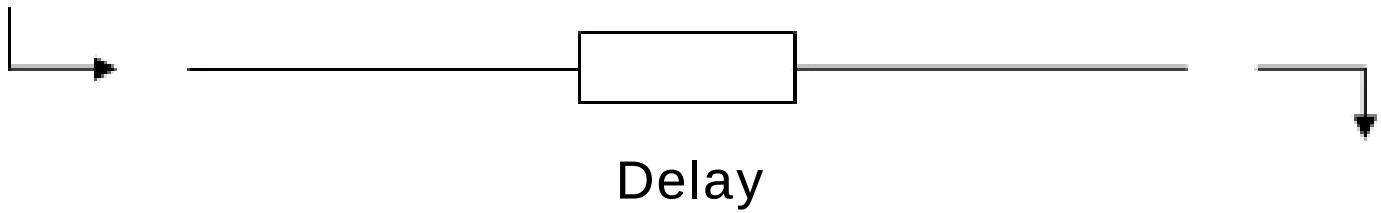
- Need for simple fab models

Simple modeling approaches

- Requirements
  - Correct representation of characteristic curve (cycletime-over-utiliziation curve), i.e., typically 1/(1-utilization) shape
  - Same cycle time distributions as for real fab
  - Mimic typical behavior of fab over time

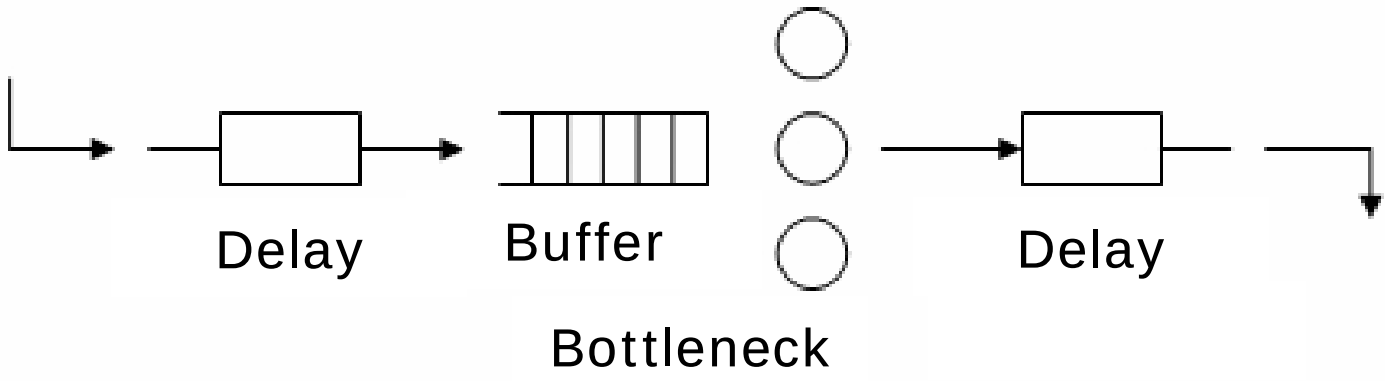


- Very simple model: cycle time distribution
  - Does not depend on utilization
  - Has infinite capacity



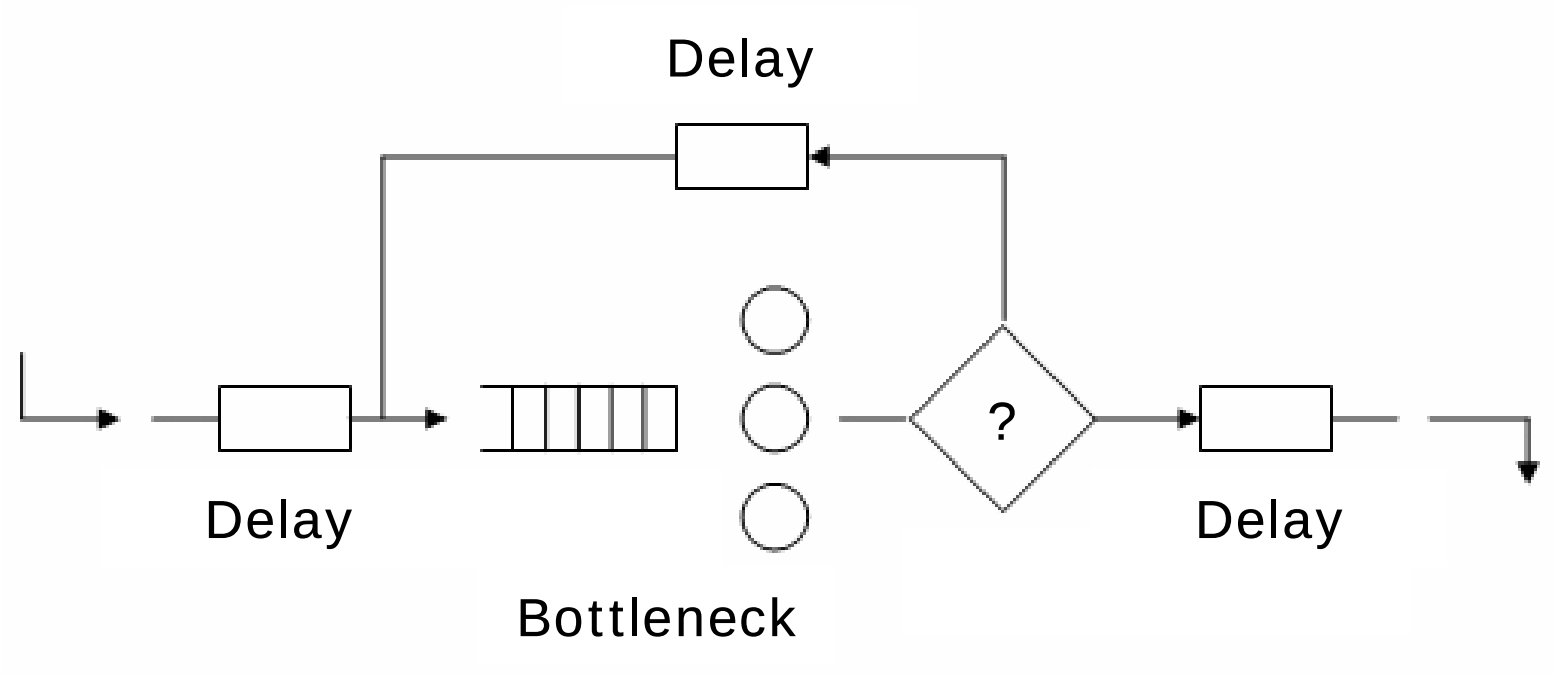
Simple modeling approaches

- **Simple queuing system**
  - Behavior over time not appropriate
  - In general, shape of characteristic curve problematic

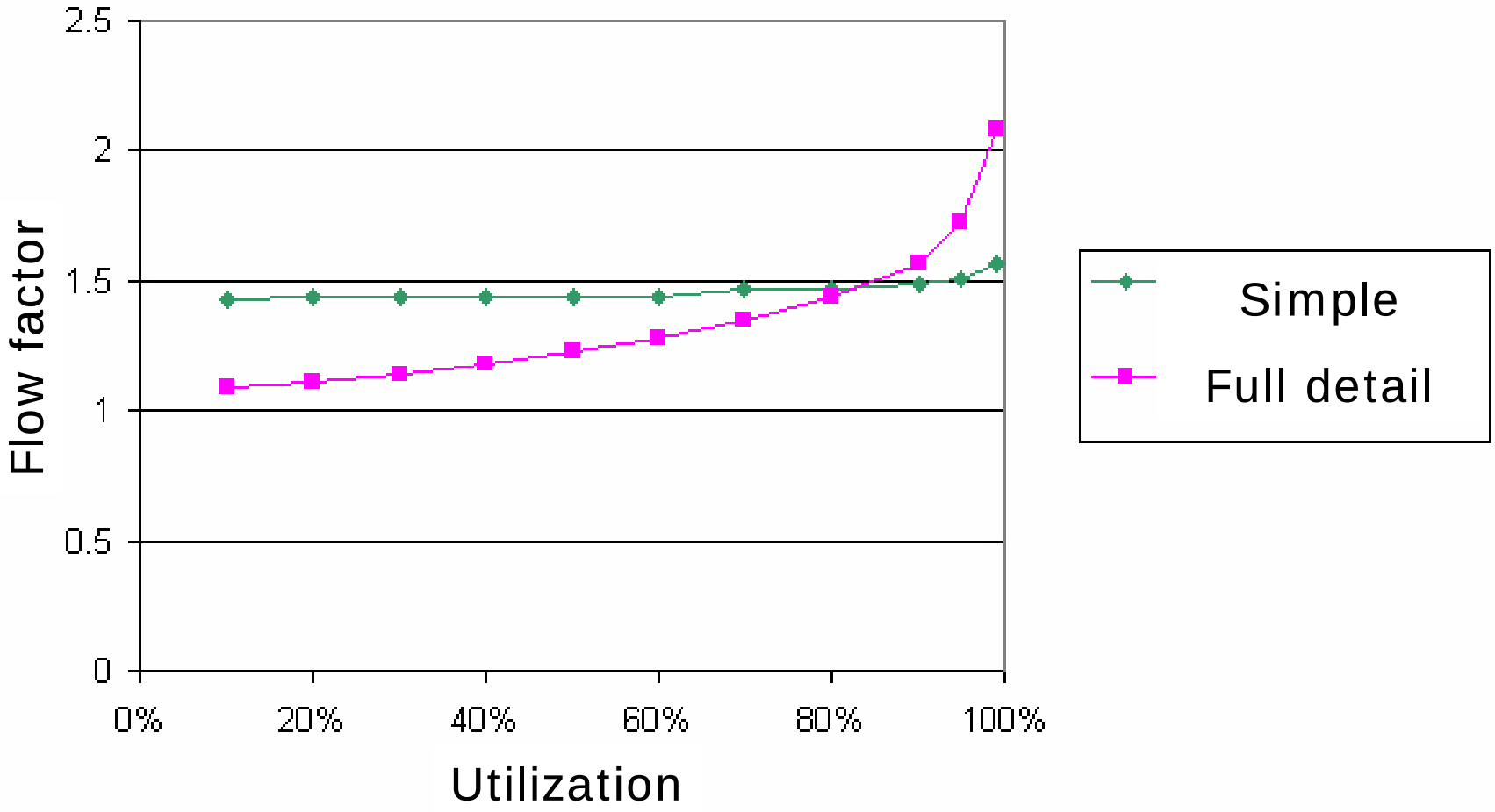


Simple modeling approaches

- **Simple queuing system with loop**
  (re-entrant flow of material)



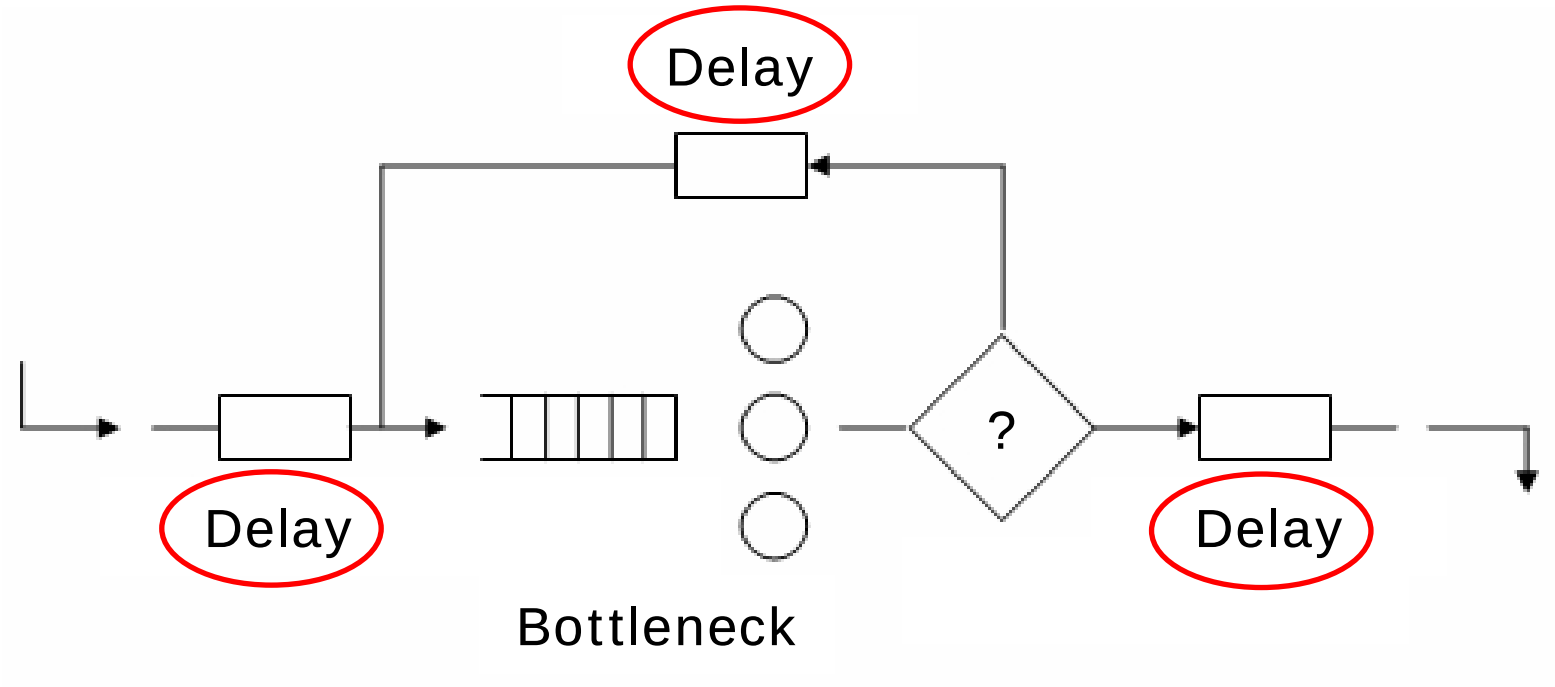
Characteristic curve



Model improvement approach

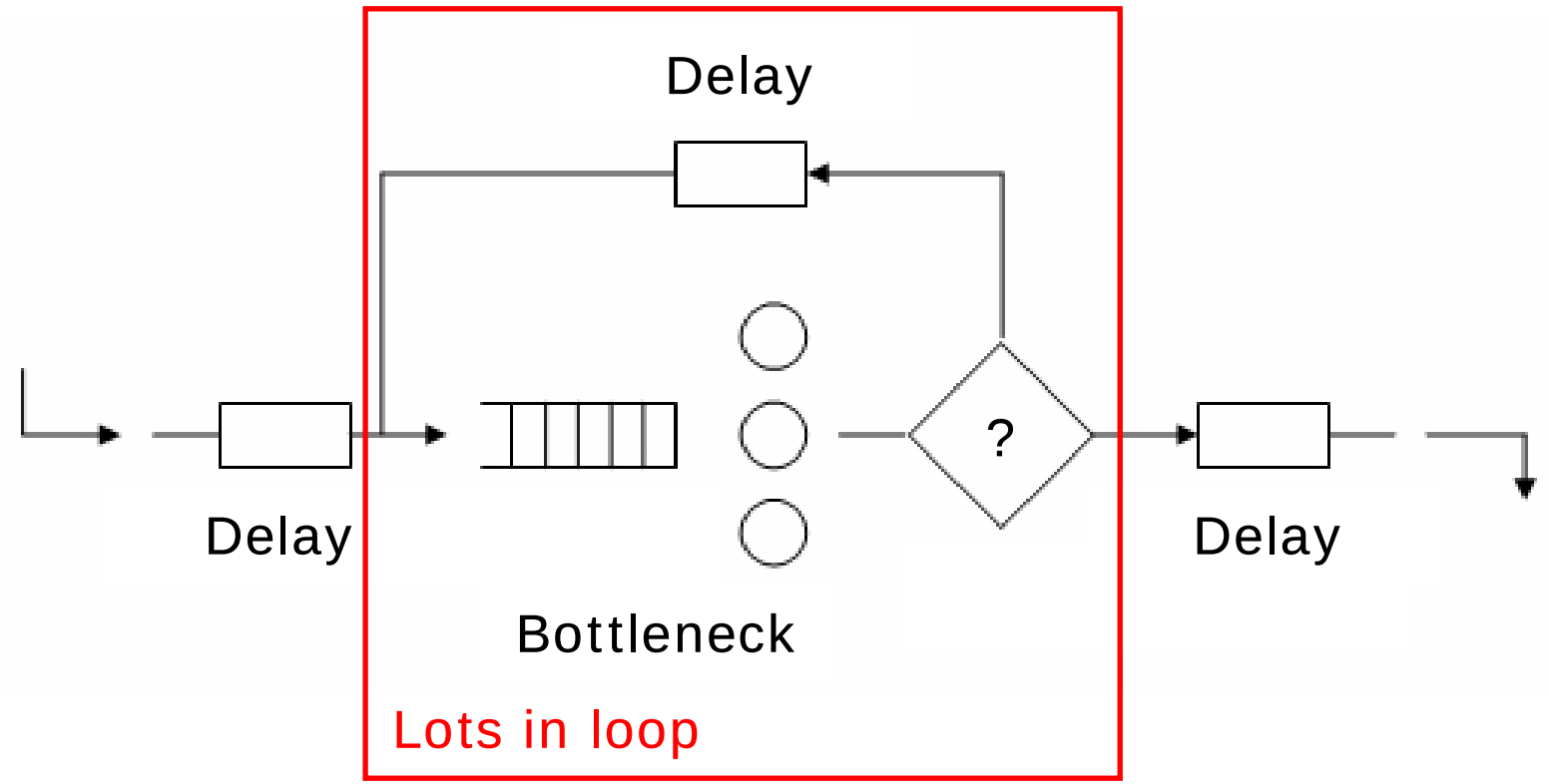
Make delays load dependent!

But how to measure load?

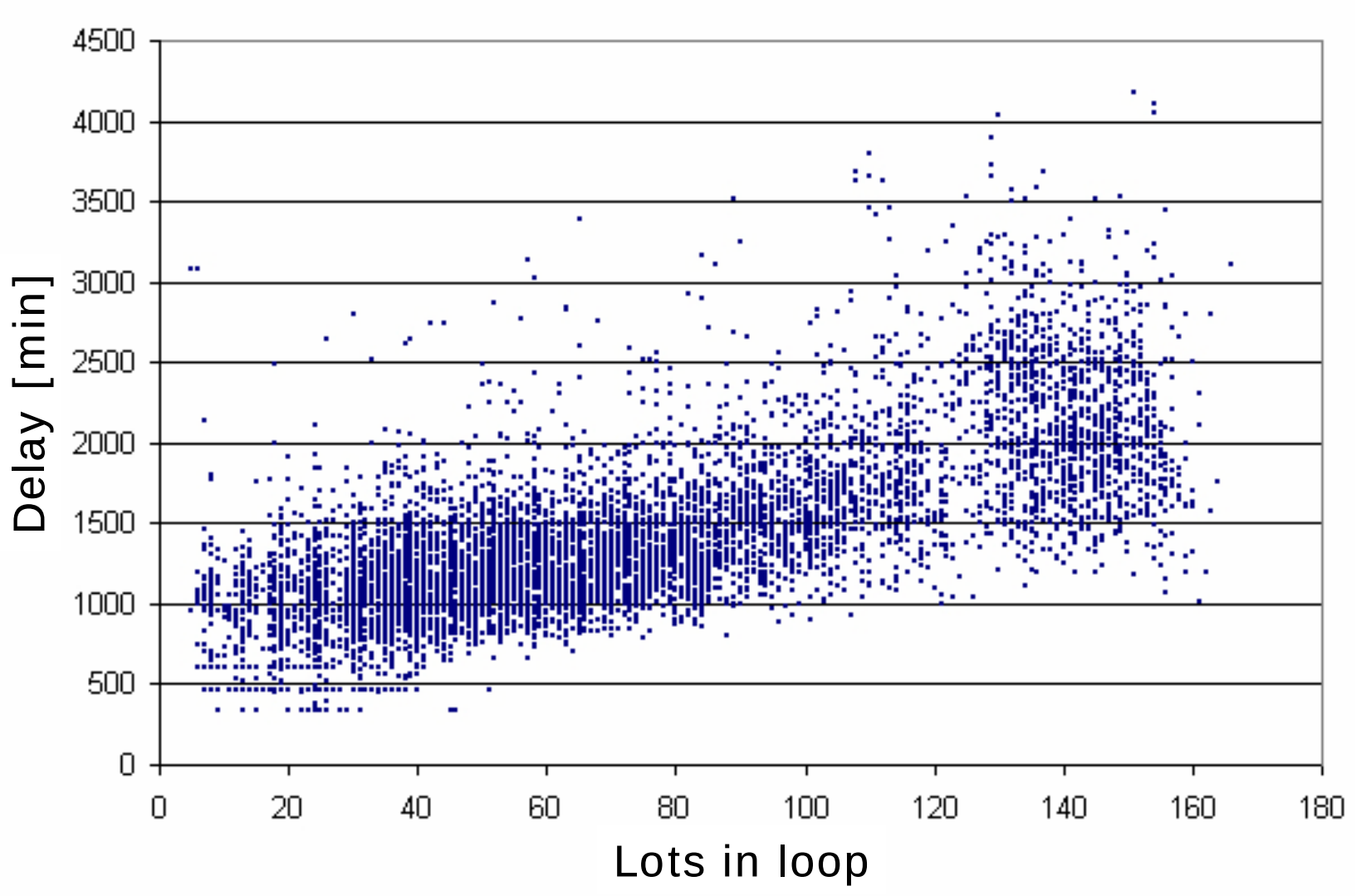


Load measurement

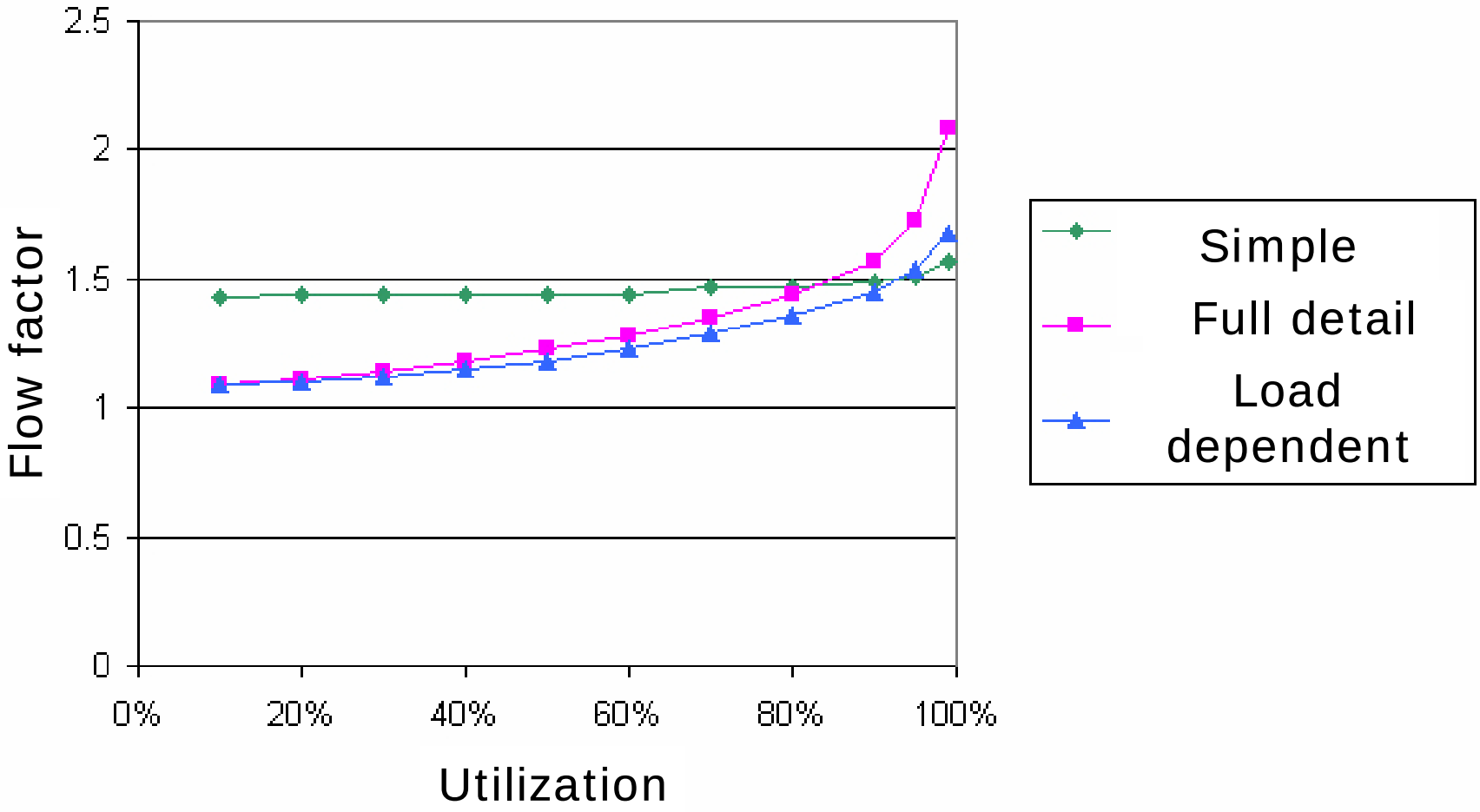
Simply count lots in bottleneck loop!



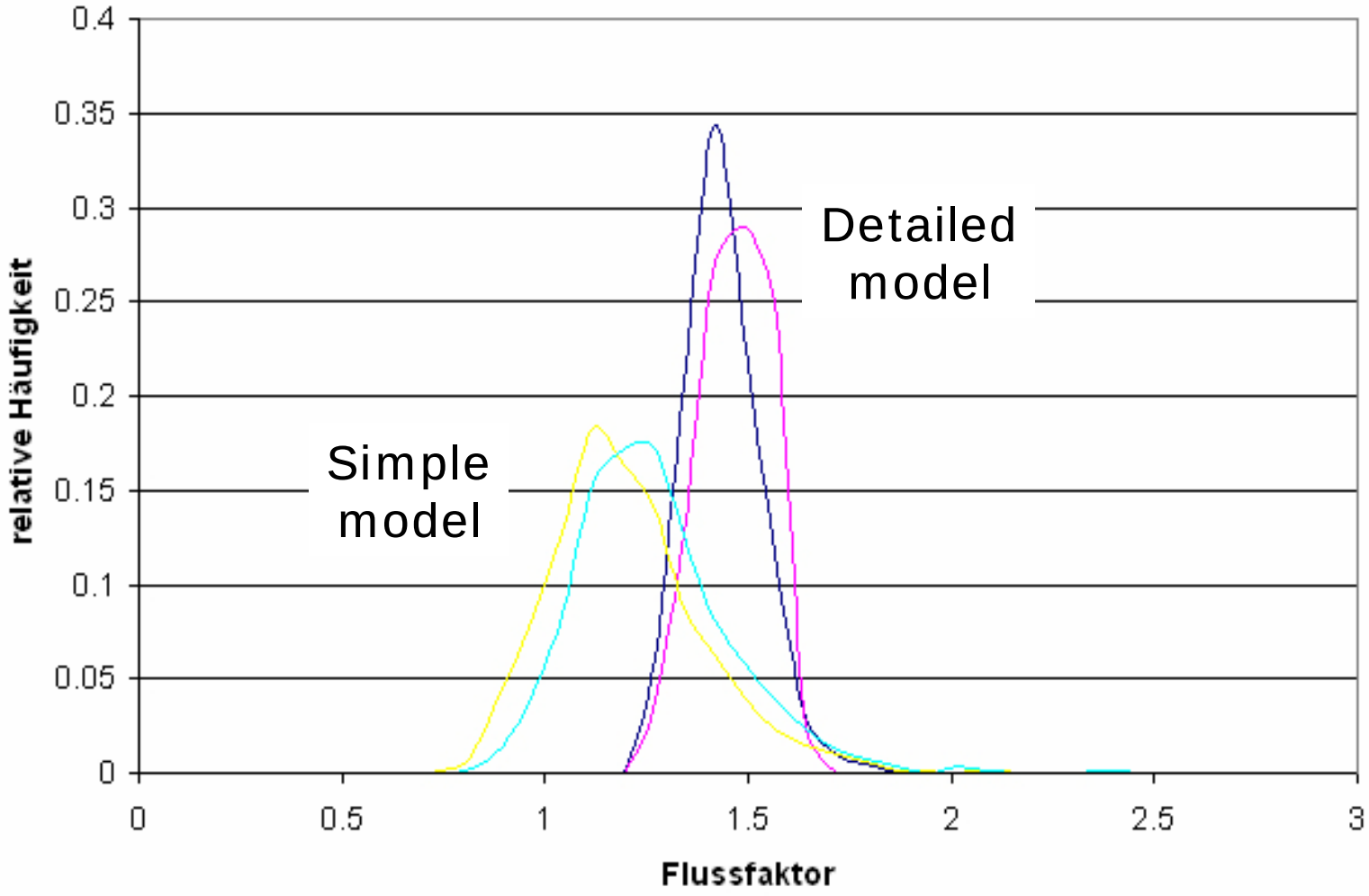
Load-dependent “loop” delays



Improvement of the char. curve

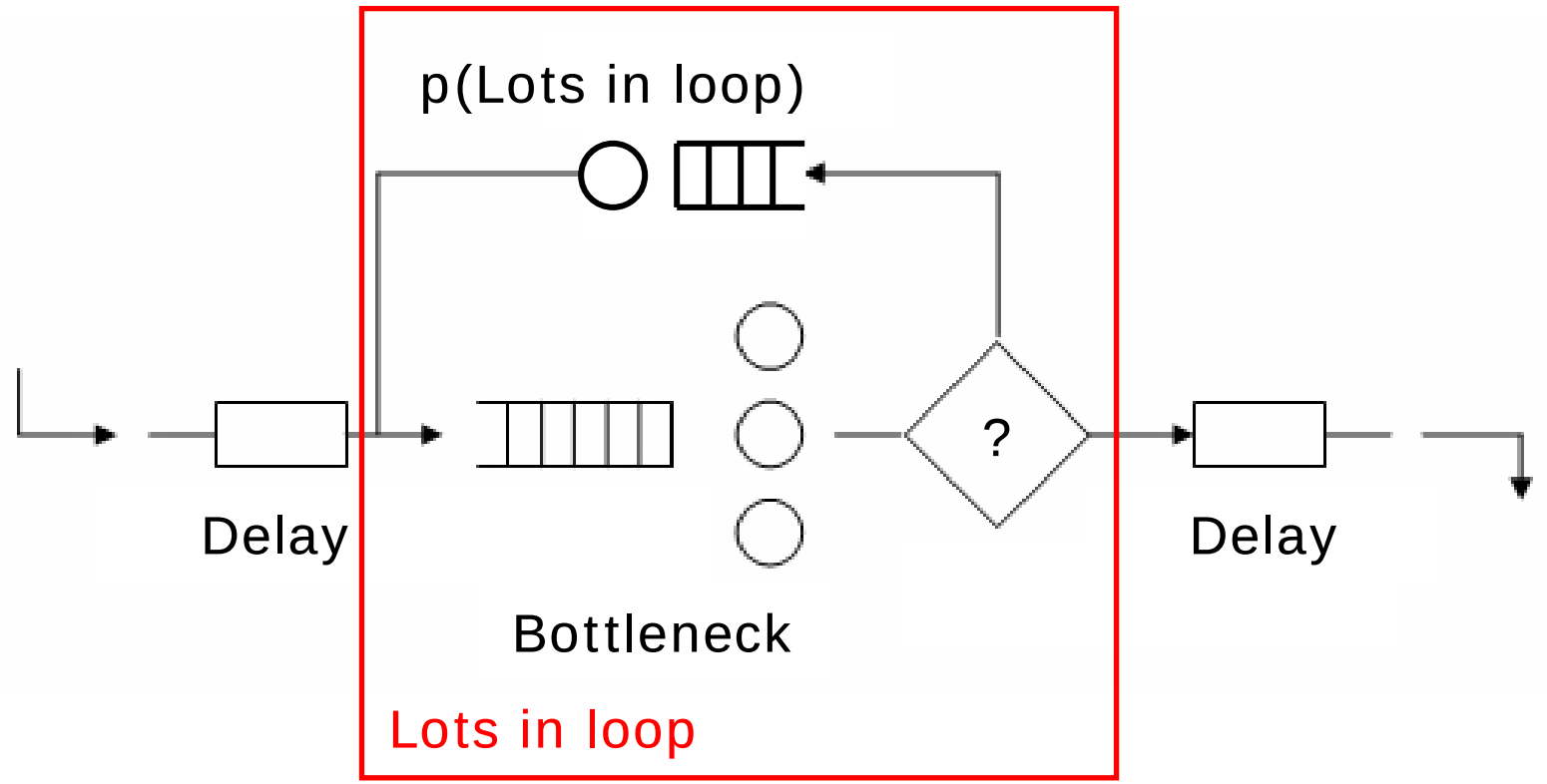


Cycle time distributions

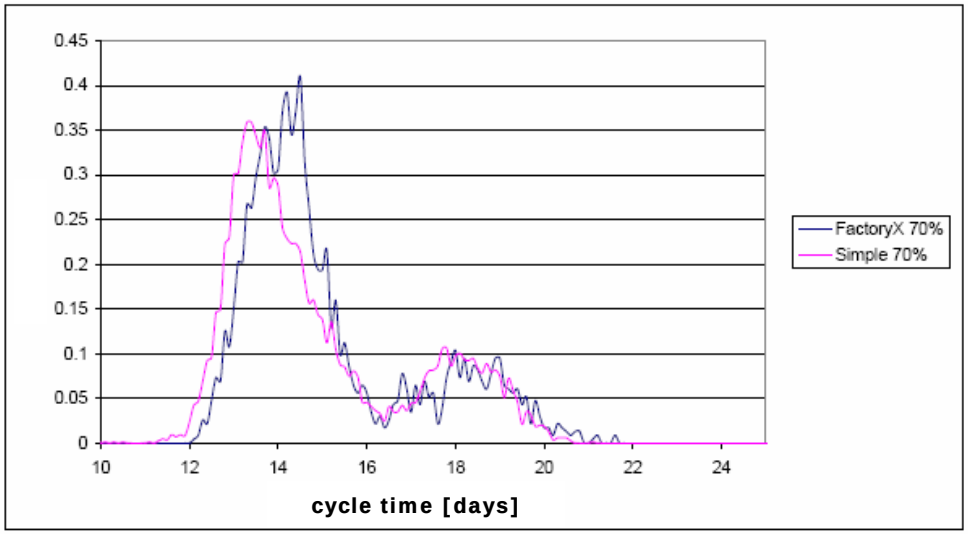


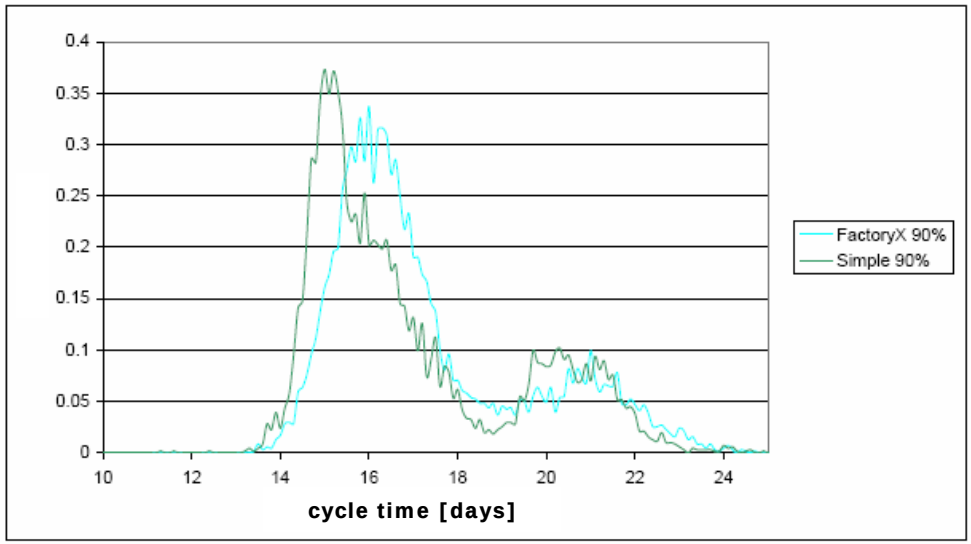
New approach

- Replace delay component by a single server component with load dependant service times
- Consequence: no more lot passing (overtaking)

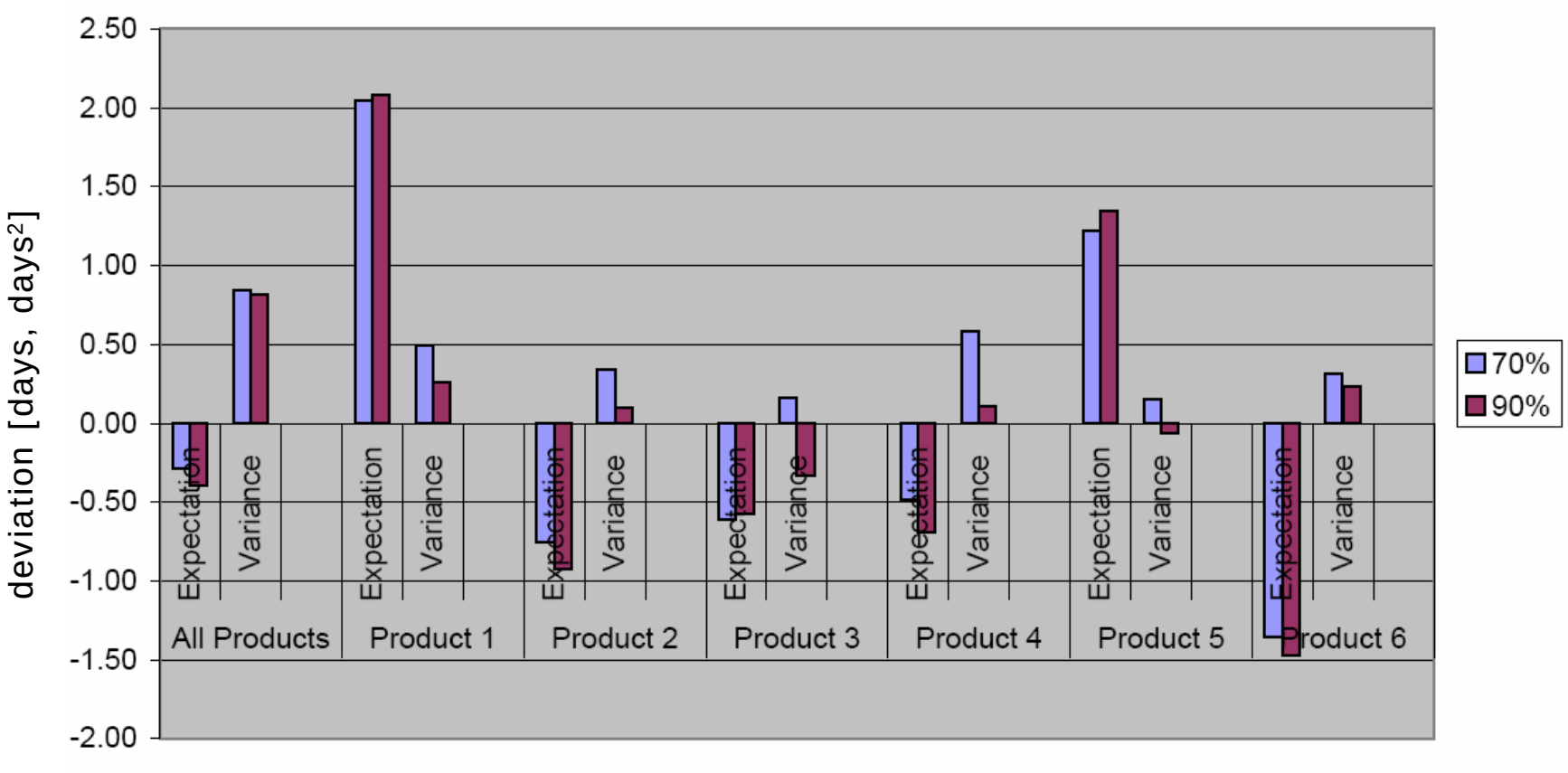


Cycle time distributions





Simple model deviations from full one



Conclusions for simple model study

- Seems possible to have it all: mimic fab behavior + characteristic curve + cycle time distribution
- Simple models useful for analyzing and understanding complex production systems
- Not a tool for beginners
- Not appropriate for all problems
- Pitfall of oversimplification
- Simplification must not be the goal but only the method to reach the goal
- Keep the model as simple as possible but not simpler!

Outlook

- Models for real fabs too large and too complex:
  You don't see the forest for the trees!

- Difficulties to formulate all material flow constraints of real systems, but:
  Is it really necessary to consider all details?

- Evolution in semiconductor manufacturing towards "lights out" fab
  - no operators but fully automated
  - even more decisions to be made by production control

- Still a lot of work to do to find
  - Better (useful!!!) models
  - Faster planning procedures

Questions?


Sigrid Wenzel · Matthias Weiß
Simone Collisi-Böhmer · Holger Pitsch
Oliver Rose
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