STW-project Effective Process Time: an overview

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Motivation

Performance analysis of manufacturing systems.

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Performance analysis of manufacturing systems

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Models of manufacturing systems

Performance measures:

- Throughput δ
- Flow time φ
- Work-in-process w

Shopfloor realities:

- Machine downs, repairs, setup, product mix, operators, batching, product recipes, priority lots, ...

Modeling approaches:

- Queueing (network) analysis (exact/approximation)
- Discrete-event simulation

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Models of manufacturing systems

Queueing (network) analysis (exact/approximation):

- Computationally efficient: ideal for what-if and optimization studies
- Limited applicability due to restrictive assumptions regarding shopfloor realities

Discrete-event simulation:

- Shopfloor realities may be modeled in detail
- Computationally intensive

Model parameters:

- Can we obtain all required data to set the model parameters?

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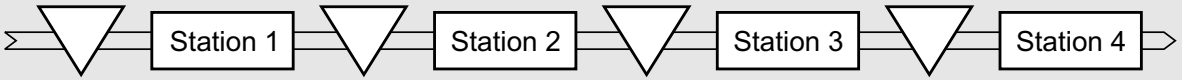
Example: a production flow line



Flowline characterisics:

- Infinite buffers, single-server stations, single-lot machines.

Shopfloor realities:

- Process mix, setup-times, recipes, operator availability, machine downs, repair,rework, hot-lots, sequencing, scheduling, shopfloor control, ...

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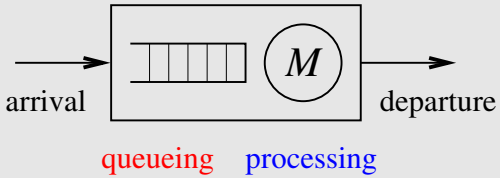
Zooming in: single-server workstation



Reality: Natural processing

Random failures (preemptive): e.g. machine downs

Planned process delays (non-preemptive): e.g. setups

Aggregation: Effective process time

(EPT parameters t_e and c_e^2 may be estimated by adding natural processing and preemptive and nonpreemptive outages)

Queueing model: $CT = \frac{c_a^2+c_e^2}{2}\frac{u}{1-u}t_e + t_e, \qquad u = \frac{t_e}{t_a}$

[Hopp, Spearman, 2000]

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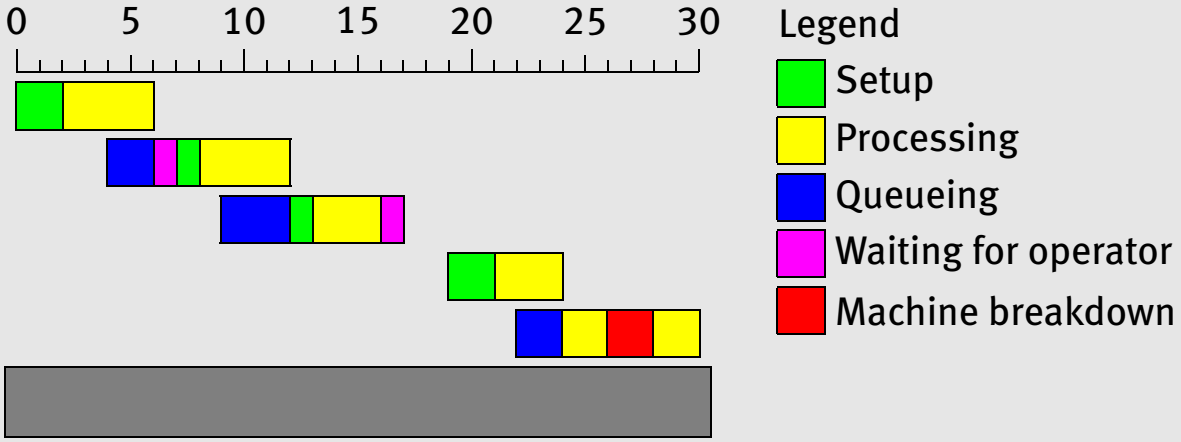
Idea: Measure EPTs from arrival/departures



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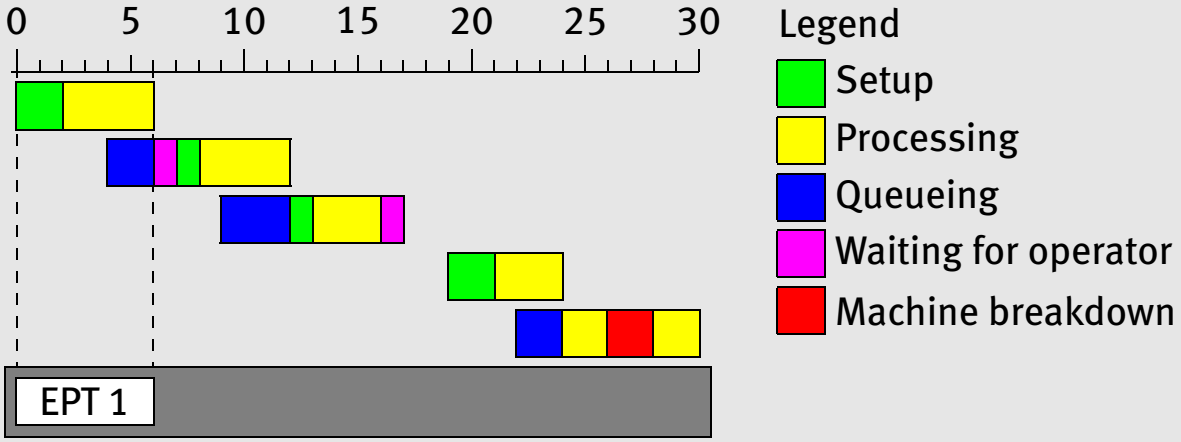

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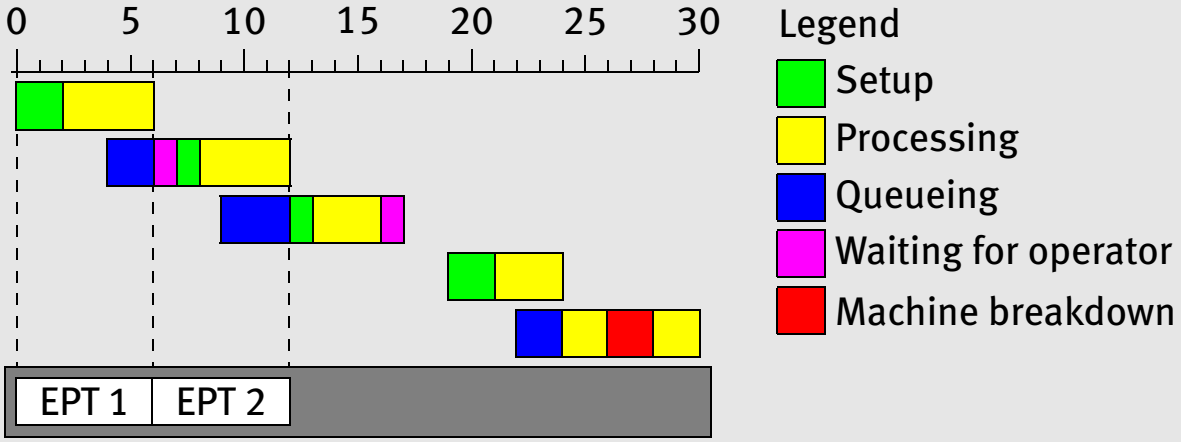

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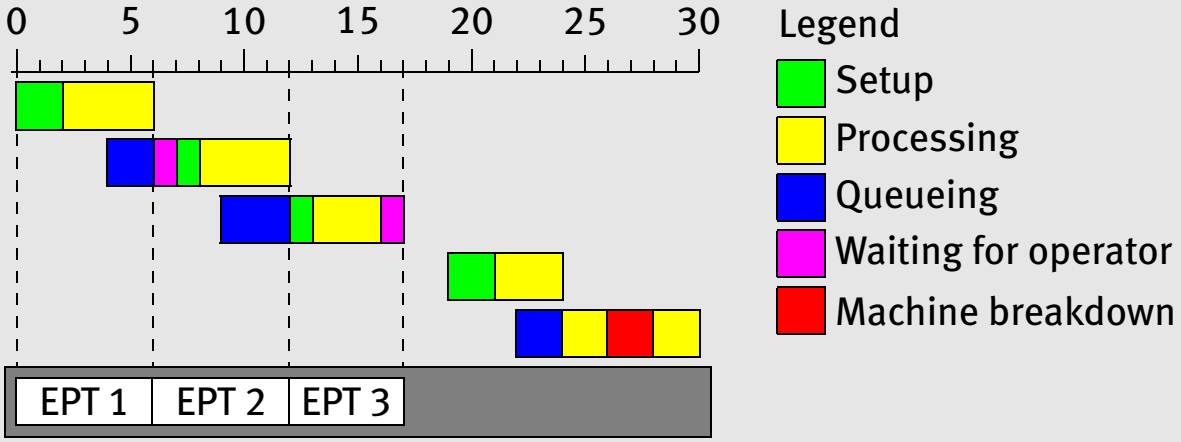

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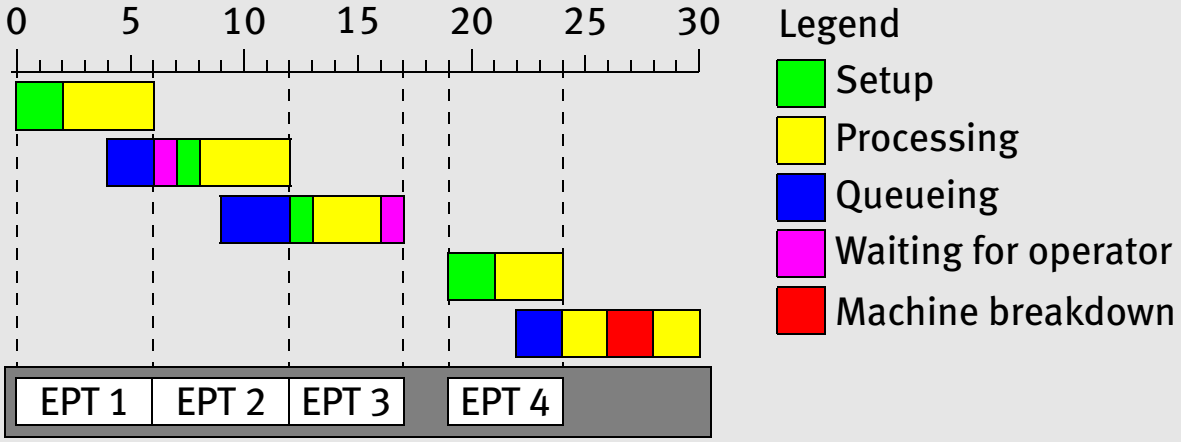

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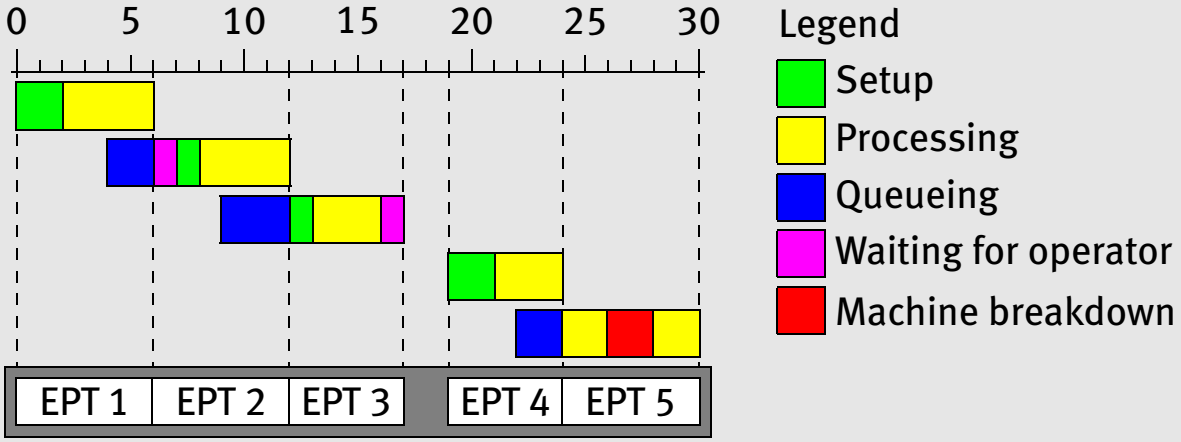

$$EPT_i = d_i - \max(a_i, d_{i-1})$$

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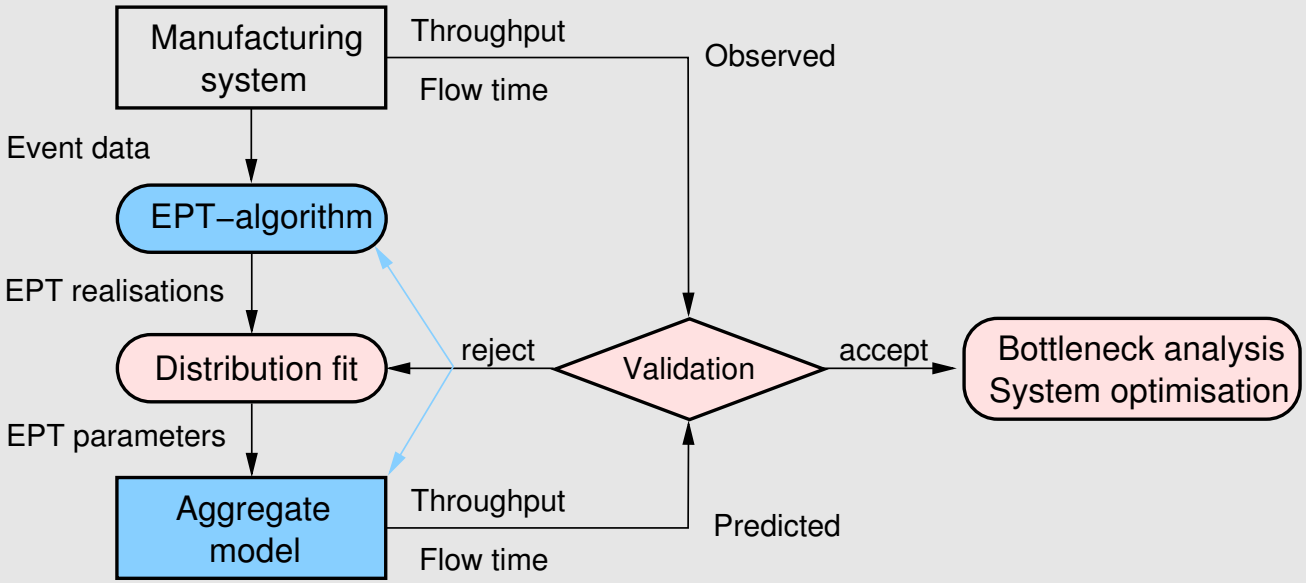
Generalization of the idea



Effective process time modeling framework

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Research objective and approach

Goal:

- To build simple yet accurate models of manufacturing networks using operational factory data *without* the need to characterize all contributing disturbances and shopfloor realities.

Approach:

- Effective process time paradigm in aggregate modeling and parameter identification
- Efficient queueing network approximations through iterative algorithms based on decomposition

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Challenges

Machine:

- Single-lot, batching, conveyor, assembly, other types, ...

Workstation (multiple parallel servers sharing a buffer):

- Dispatching, recipes, unequal machines, lot overtaking, ...

Network:

- Blocking (finite buffers), assembly lines, re-entrant flow lines, general queueing network, production control, ...

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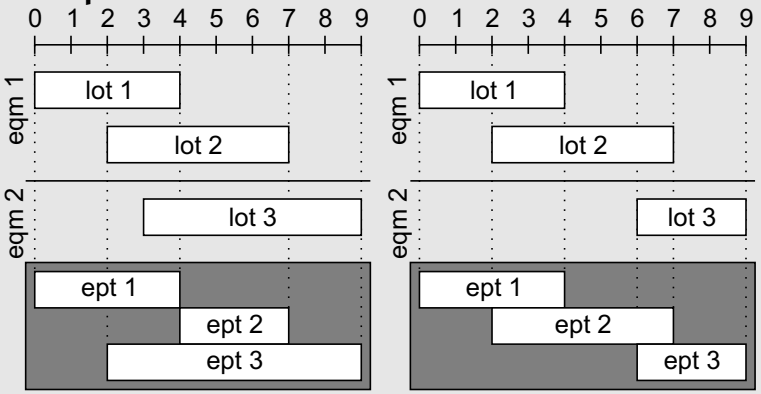
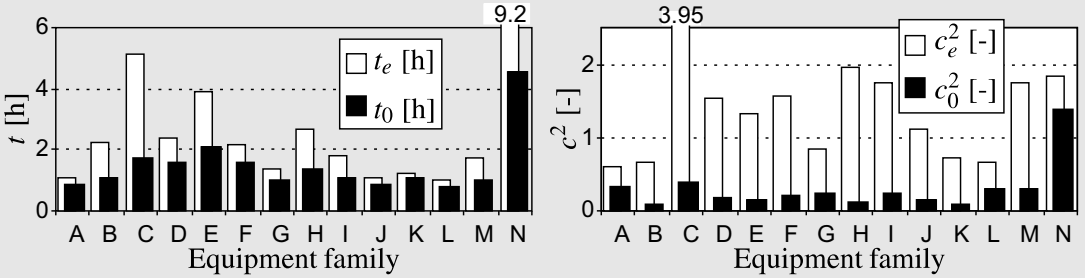
Single-lot machine workstation

EPT parameter estimation



Application



[Jacobs, Etman, Van Campen, Rooda, 2001, 2003]

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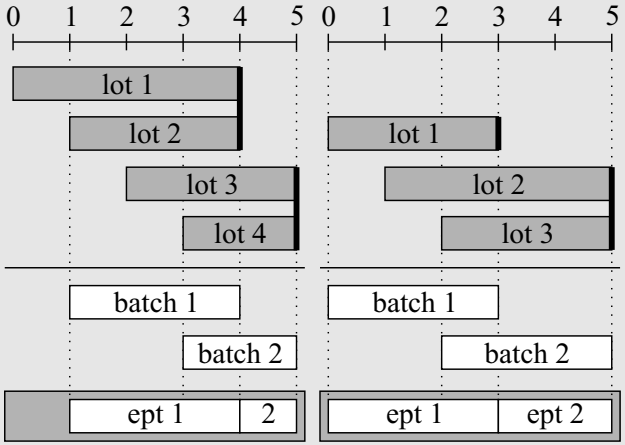
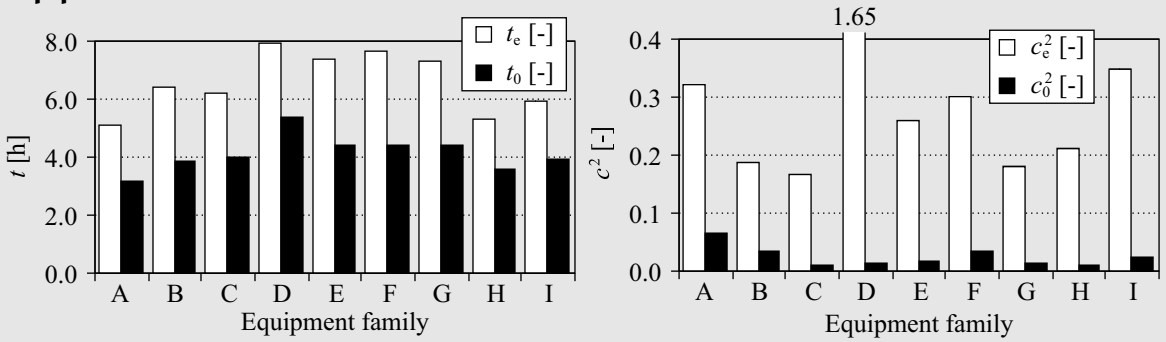
Batch machine workstation

EPT parameter estimation



Application



[Jacobs, Van Bakel, Etman, Rooda, 2006]

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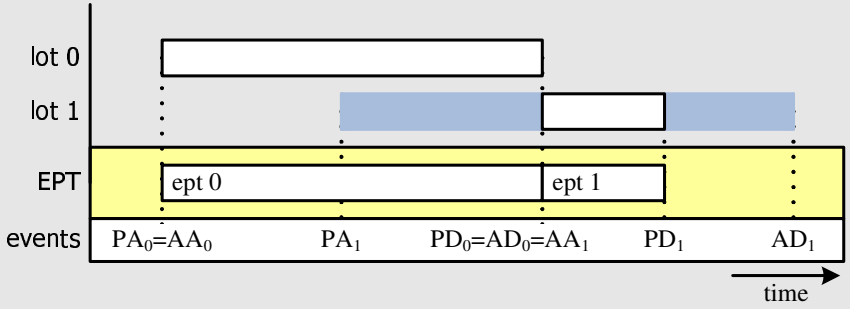
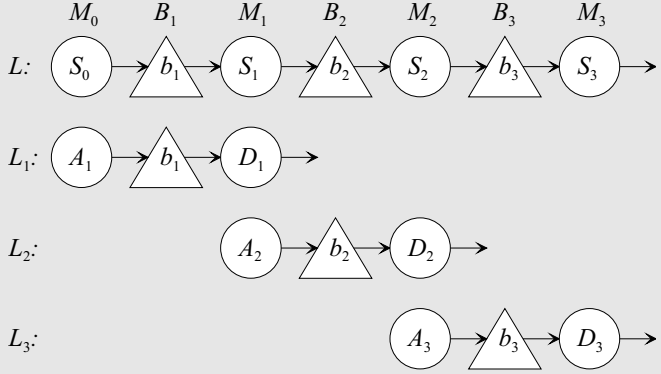
Flow line subject to blocking

EPT parameter estimation



Queueing network approximation (talk Van Vuuren)



[Kock, Wullems, Etman, Adan, Rooda, 2005]
[van Vuuren, Adan, Resing-Sassen, 2005]

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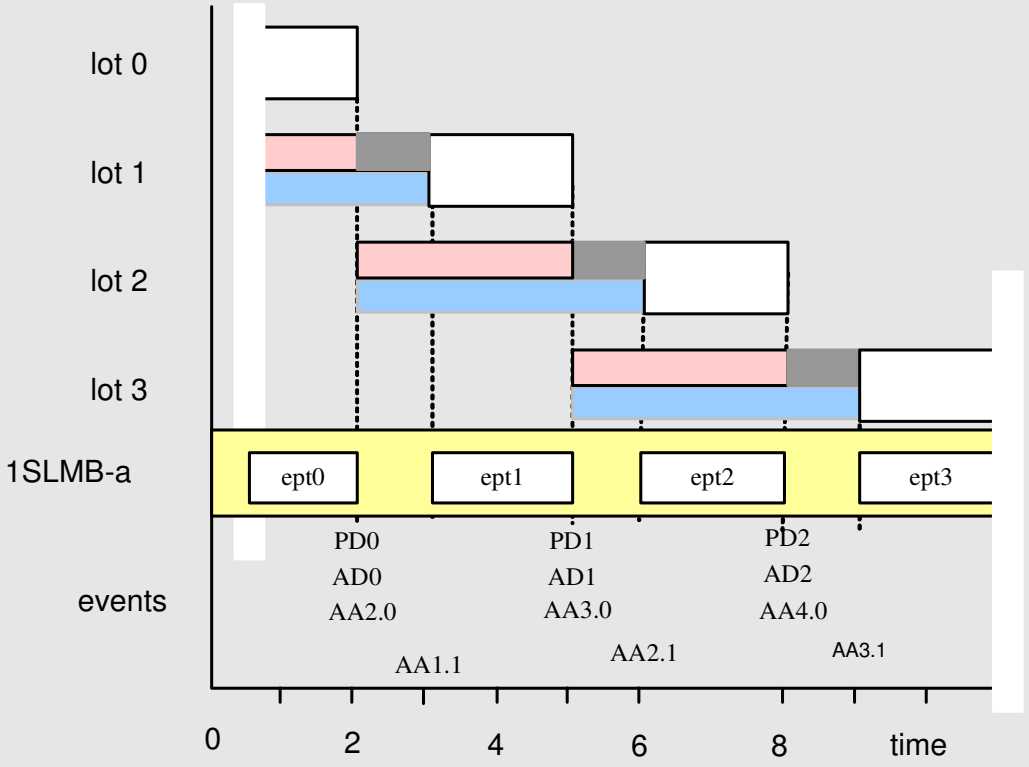
Assembly machine

EPT parameter estimation



Queueing approximation (talk Van Vuuren)

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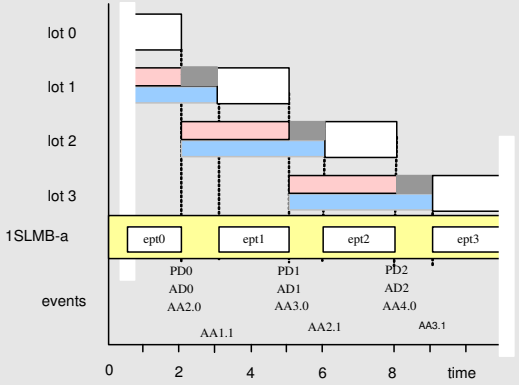
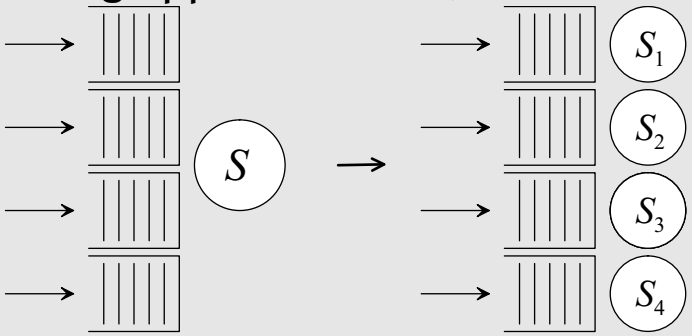


Queueing approximation (talk Van Vuuren)



[Vijfvinkel, 2005]
[van Vuuren, Adan, 2005,2006]

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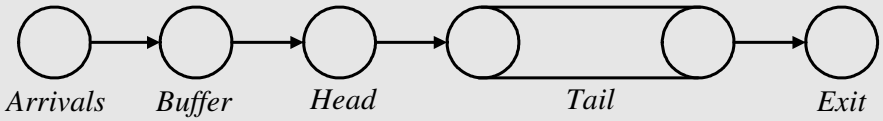
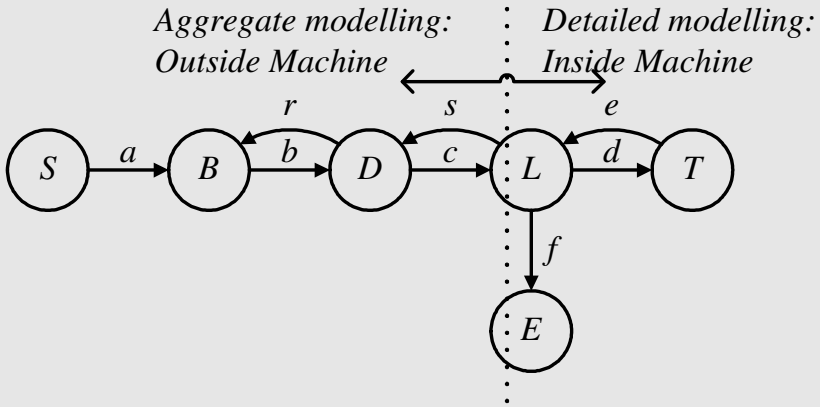
Lithography cell

Aggregate modeling and parameter estimation

Head-tail model (talk Van der Eerden)



Inside detailed, outside aggregate (talk Kock)



[Van der Eerden, Saenger, Walbrick, Niesing, Schuurhuis, 2006]
[Kock, Etman, Rooda, 2006]

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Industry:

- Automotive industry (talk Nijsse)
- Semiconductor industry (talk Van der Eerden)
  (talk Van Campen)
- Consultancy (talk Resing/v. Doremalen)
- ...

Research:

- Control of manufacturing networks (talk Lefeber)
- In work by our students and colleagues

Related research and work by others:

- See e.g. talks on Tuesday ...

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