SOBA: A self-organizing bucket architecture to reduce setup times in an event-driven production

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MARTIN KROCKERT is a research associate at the Dresden University of Applied Sciences. His research focuses on self-organizing systems. Before starting his career in research, he accumulated industrial experience from being a business process developer at Howden Group, where he was responsible for the introduction of the ERP-System APPlus and its adaption to the requirements of the company. In addition, he led several software projects concerning system integration and automating information workflows. He received his master's degree of Applied Information Systems at the Dresden University of Applied Sciences. His email address is

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Vision of Industry 4.0

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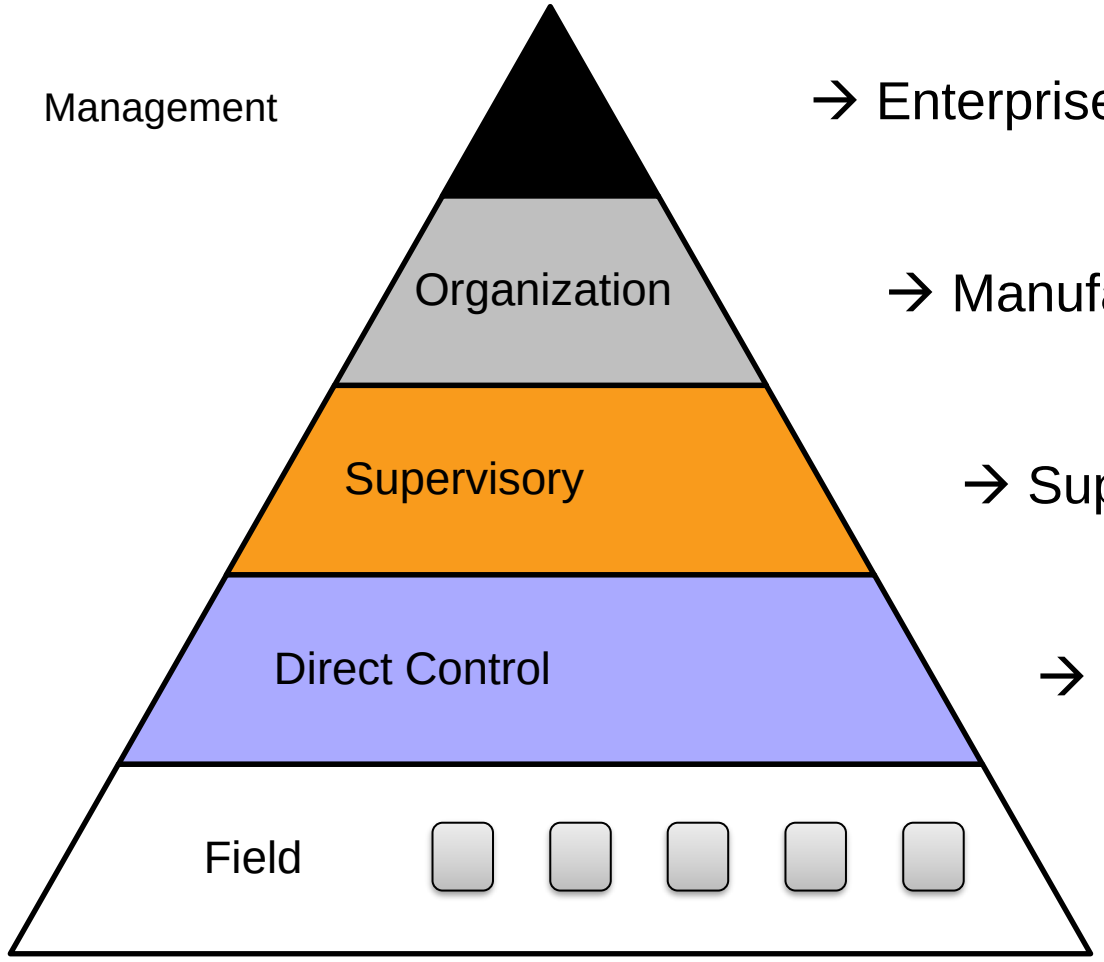


→ Enterprise Resource Planning

→ Manufacturing Execution Systems

→ Supervisory Control and Data Acquisition

→ Programmable Logic Controller

→ Sensors & Actors

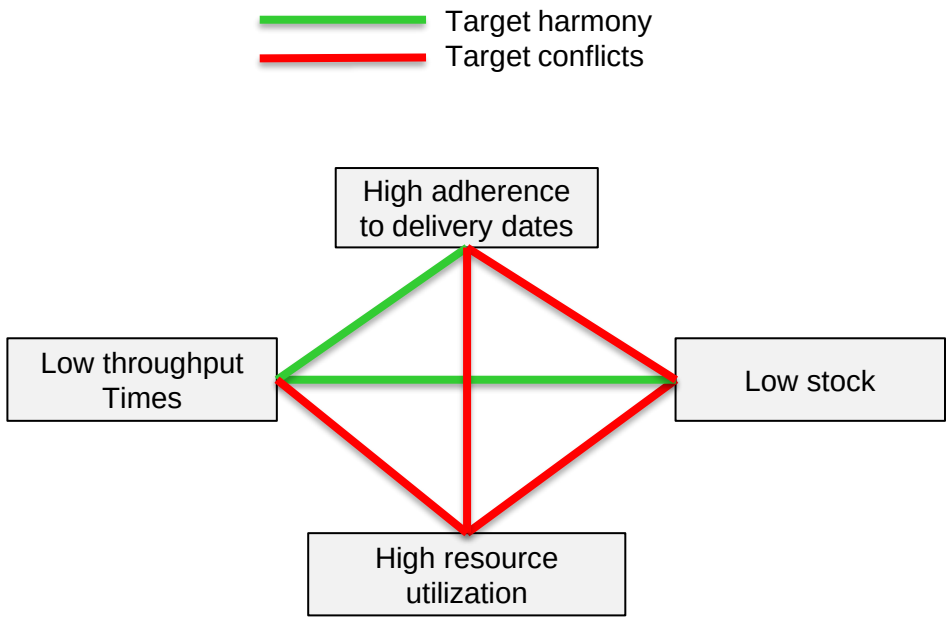
Planning and Control

Data Acquisition/Aggregation

Source: „Thesen und Handlungsfelder: Cyber-Physical Systems: Chancen und Nutzen aus Sicht der Automation“, VDI April 2013

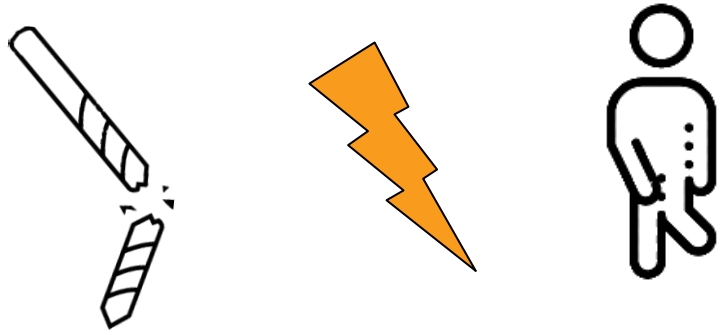
Why is self organization in production good thing?

General goals of production planning and control



„You want to make God laugh,
tell him your plans “

— Blaise Pascal



Self organizing production is:

- Flexible
- Robust
- Scaleable

Source: „Logistik“, Andreas Huber, Klaus Laverentz (2018)

State of the art

Centrally planned production

- Static
- Interval
- Time consuming – especially if you treat every product individually

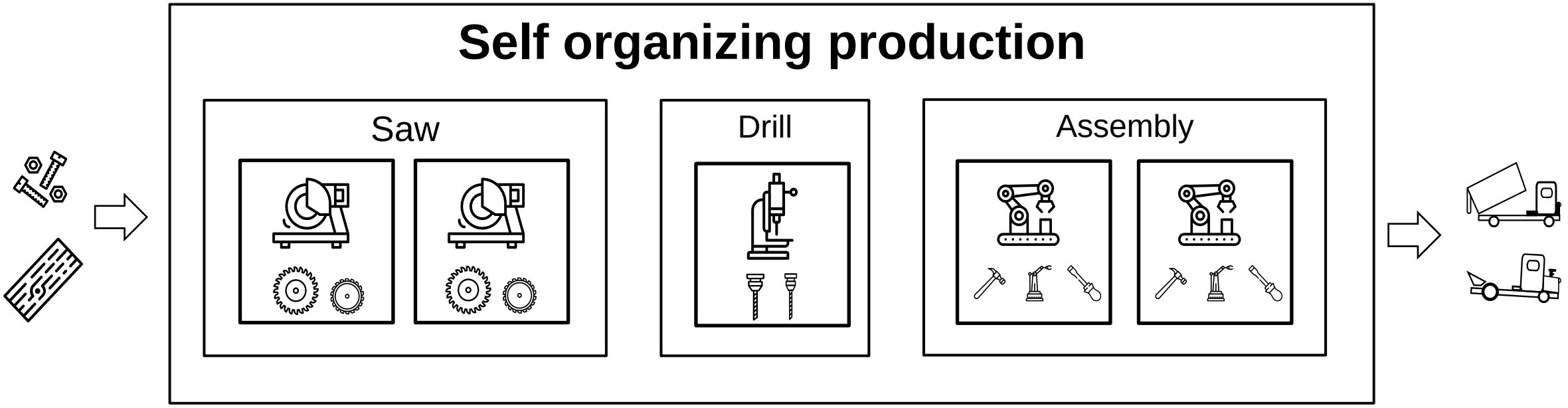
Effects

- No real time planning possible
- Inaccurate at the time of deployment

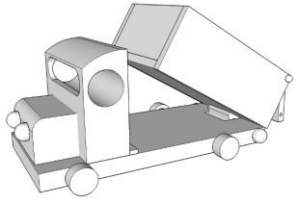
The production scenario

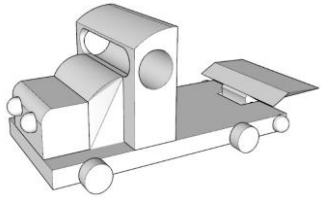
Wooden toys for everyone

Example Production



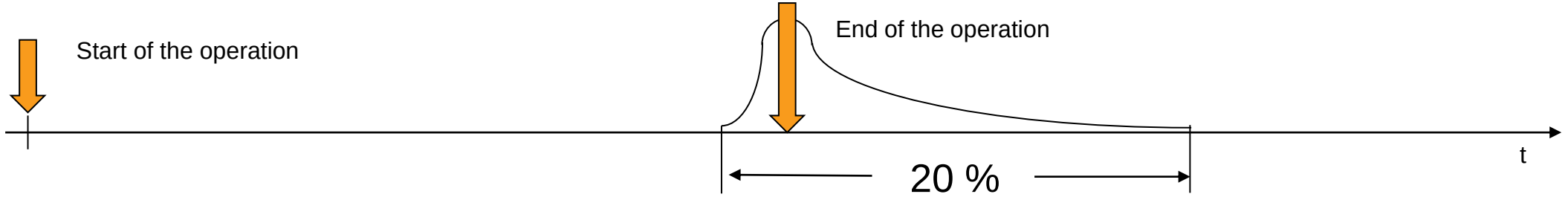
Test scenario





- Two products, with 3-level deep bill of materials
- 24 hours production
- Exponentially distributed interarrival times of customer orders
- Normal distributed deadlines

- Lognormal distributed work time to simulate disturbances

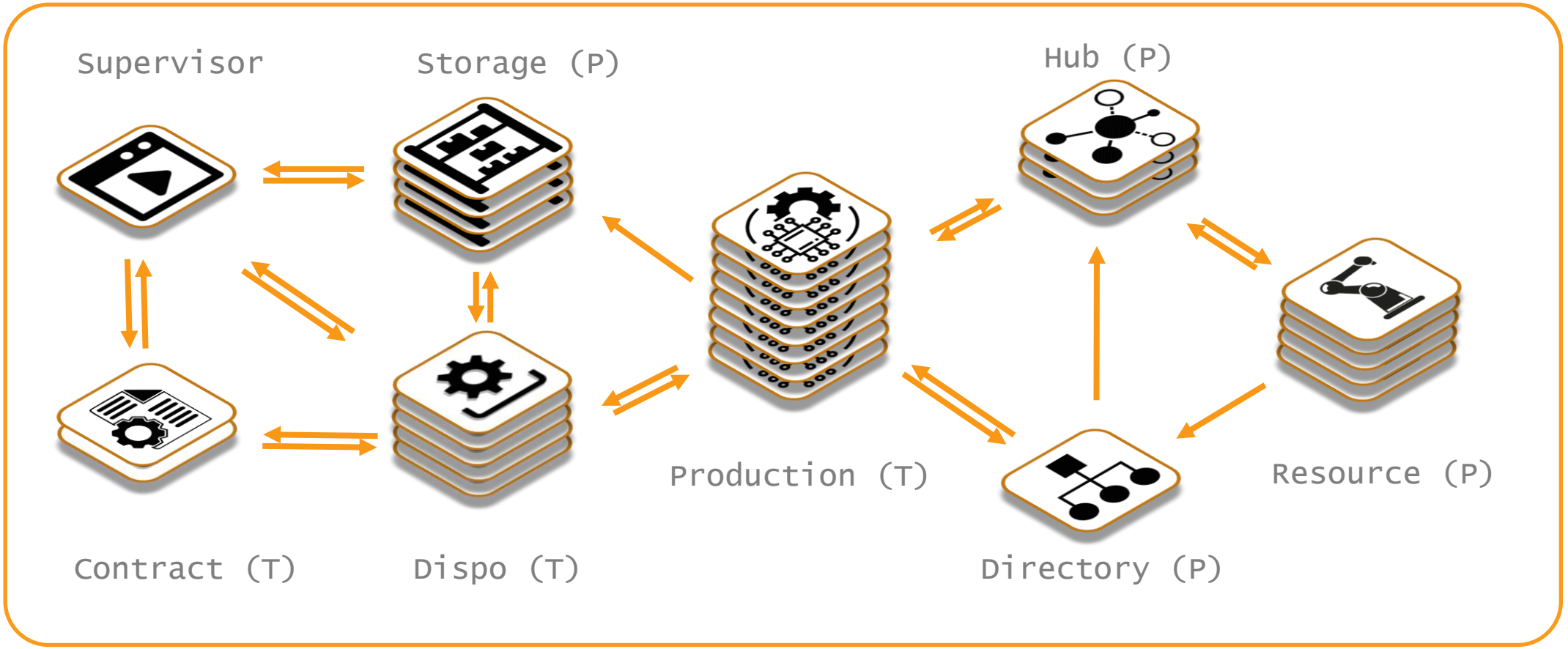


Source: „Scheduling dynamic job shop manufacturing cells with family setup times: a simulation study"; Armin Klausnitzer , Janis S. Neufeld , Udo Buscher; (2017)
„Network Performance Analysis.", Thomas Bonald Mathieu Feuillet, (2013)

Functional insights

into the self-organizing production

Agent based planning and control



	Supervisor Agent
	(T) → Transient - Agents
	(P) → Persistent - Agents
	Comunication Paths

Interaction of disposition and production agents during bill of material explosion

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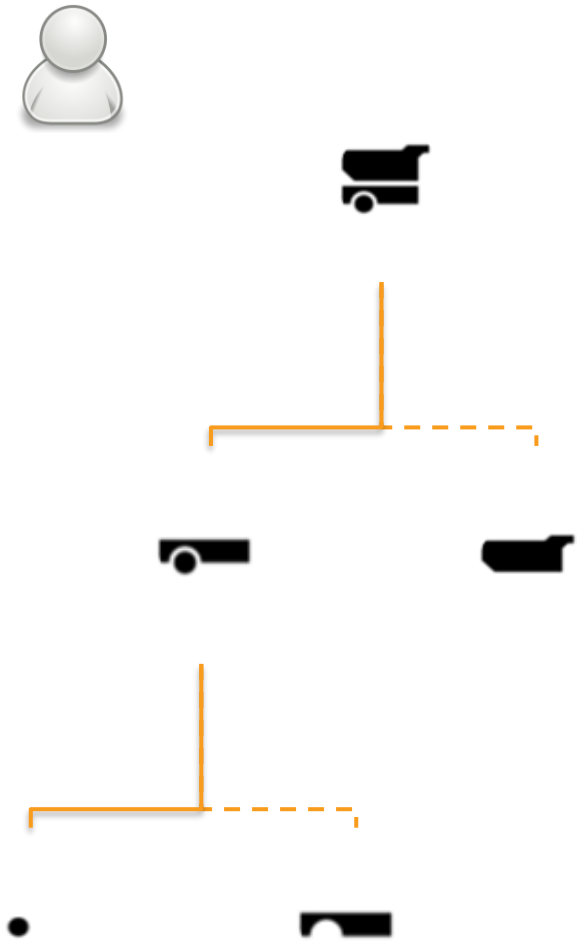
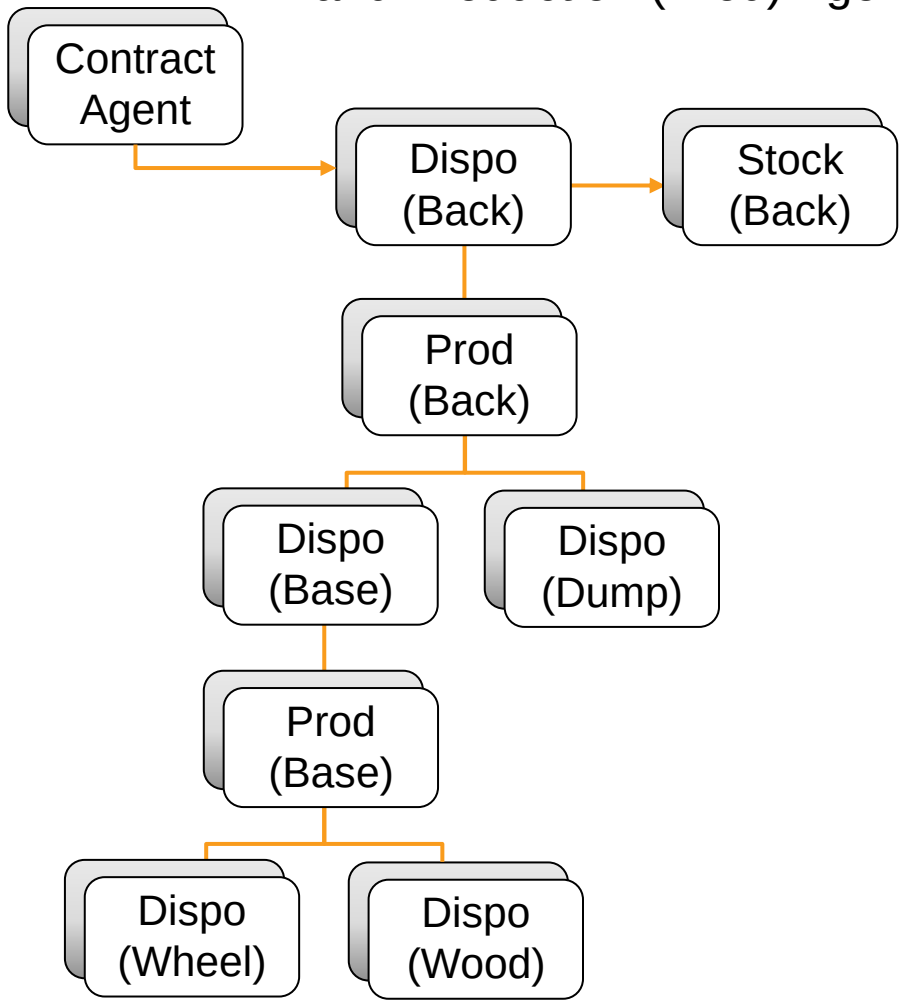


How the structure is transferred into Disposition (Dispo) and Production (Prod) Agents

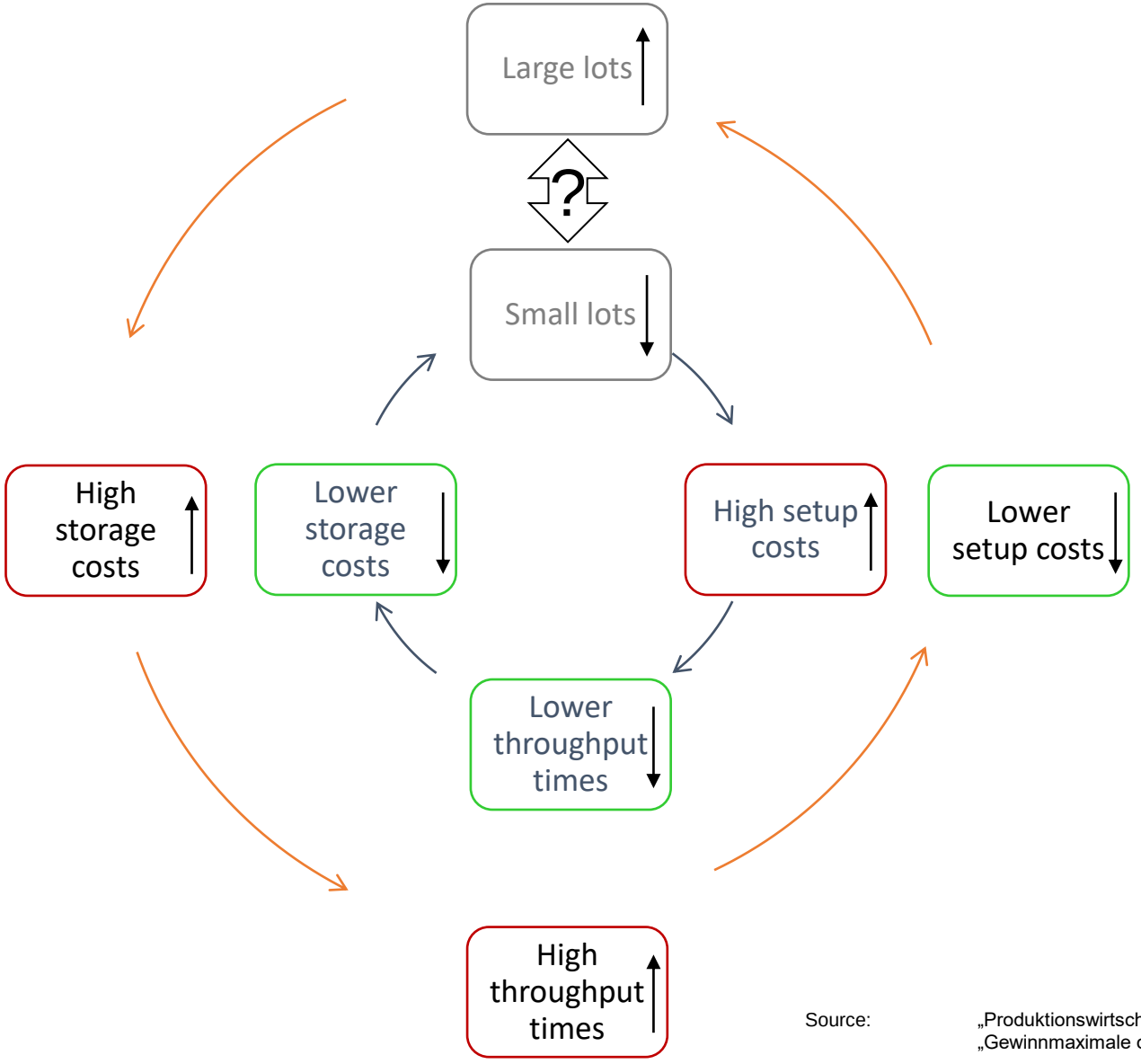


Source: Material-Logistik, Horst-Tempelmeier, 2006

Self-organizing bucket architecture

in the self-organizing production

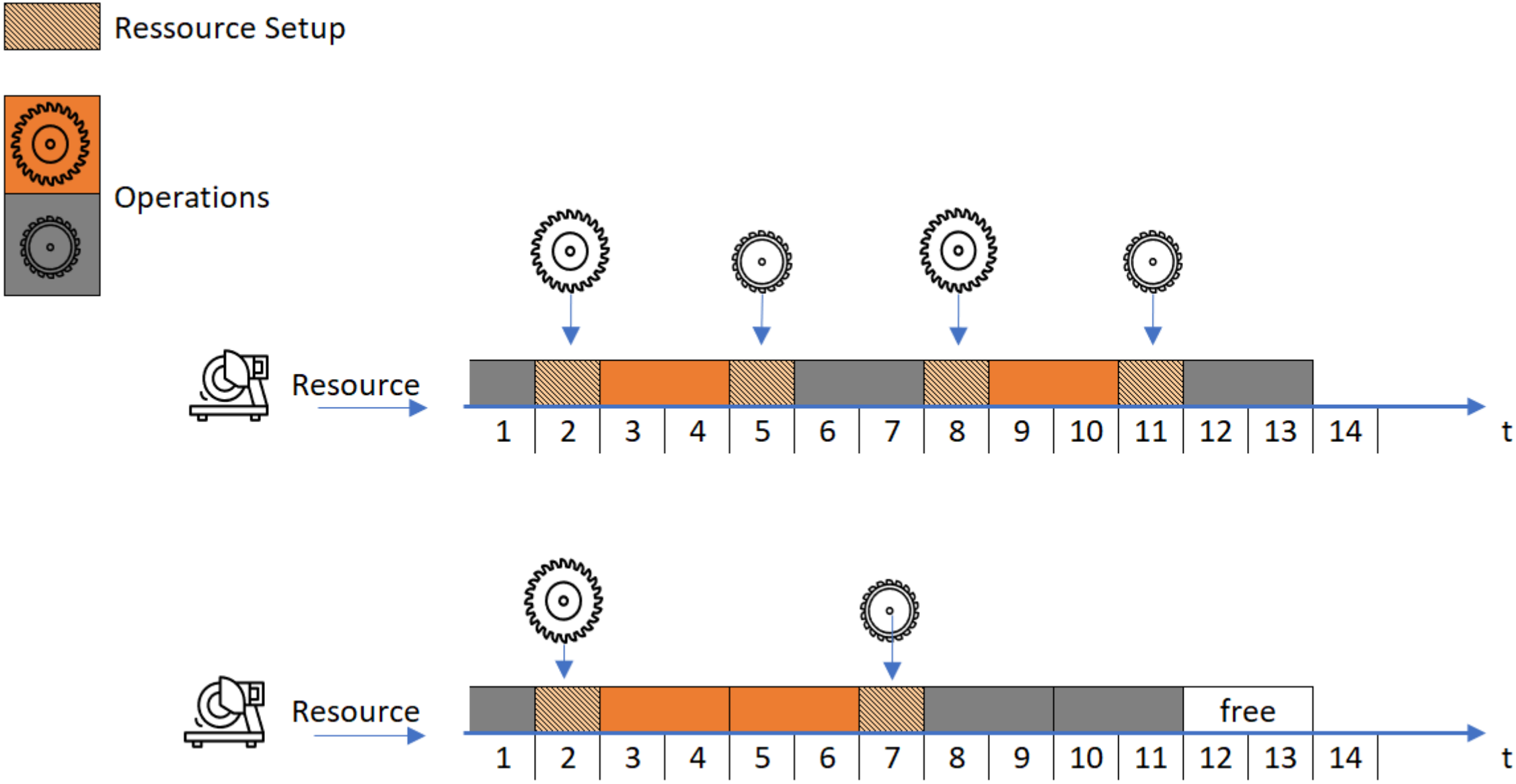
Economic effects of lot sizing in a production



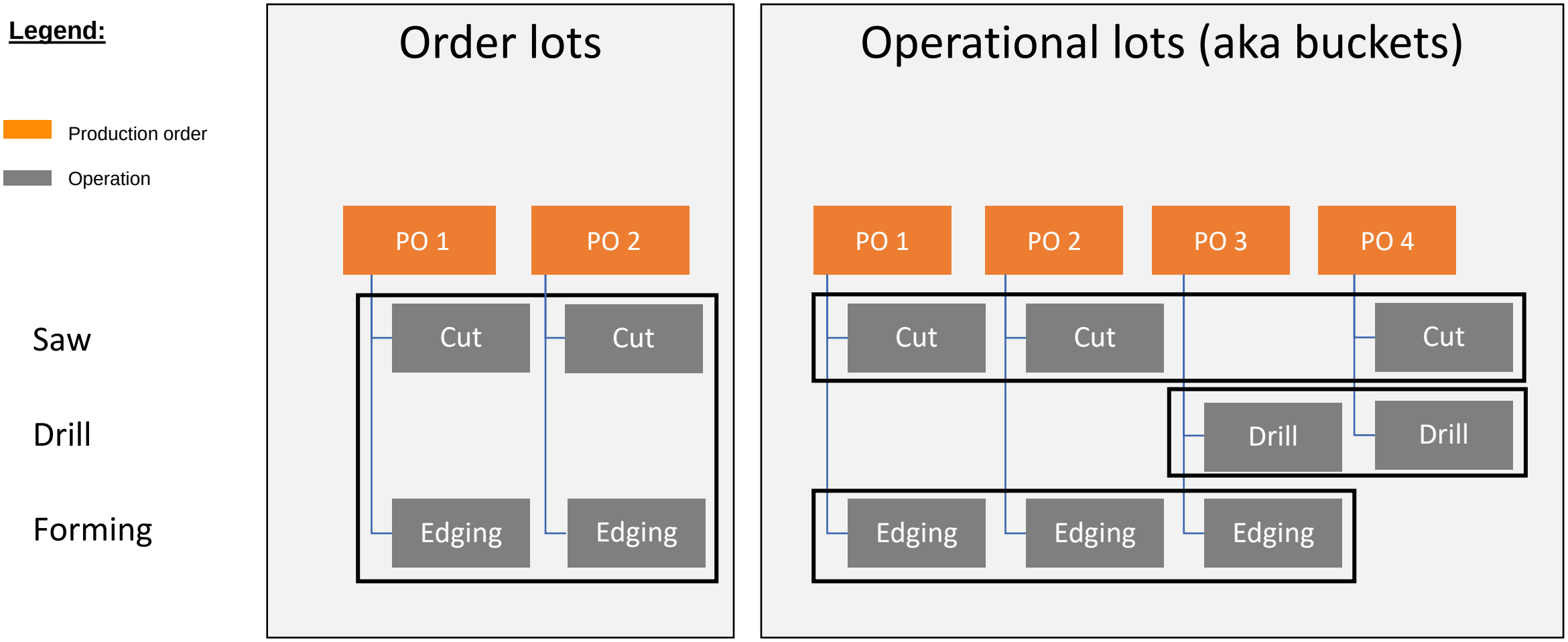
- A lot is a quantity of equal parts that are processed continuously.
- Lot size is always a question of company objectives
- Due to pooling of production orders with the same technology requirements, setup costs are reduced.
- Huge lots lower the flexibility.

Source: „Produktionswirtschaft“, Kurbel, (2016), S.79
„Gewinnmaximale oder rentabilitätsmaximale Losgröße bzw. Bestellmenge?“, Pack, L. in: ZfB, 1989

Why it is necessary to make lots?



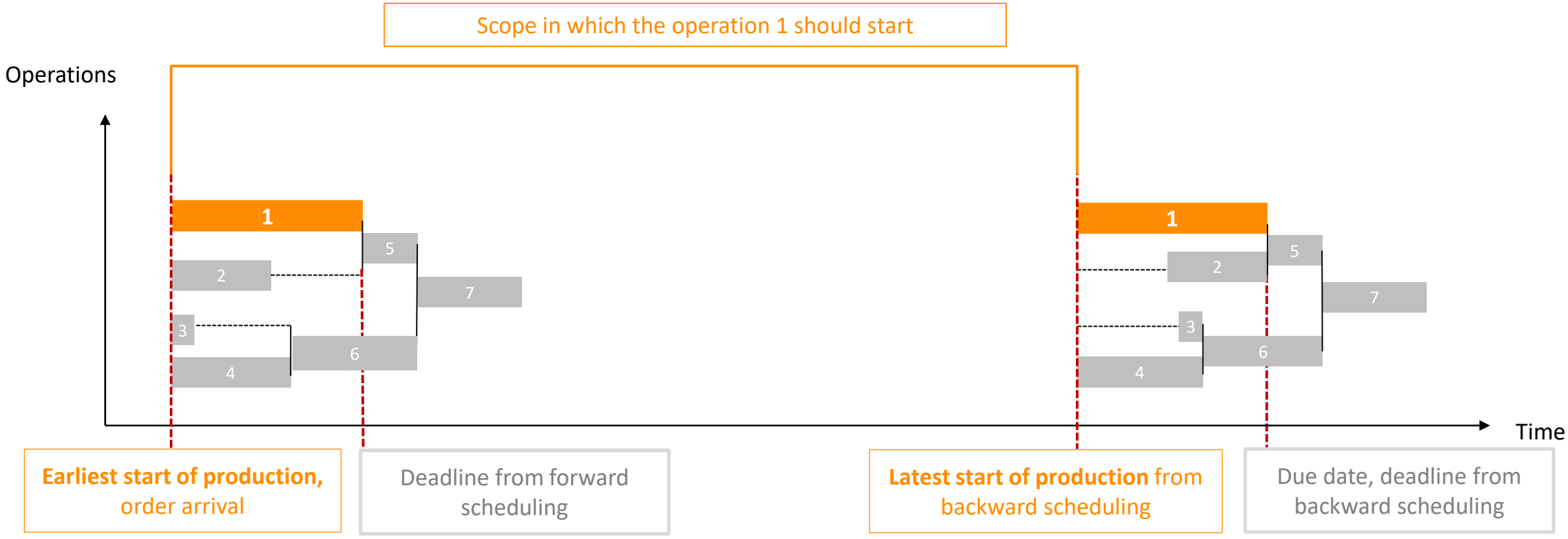
Challenge: Grouping operations horizontally and vertically



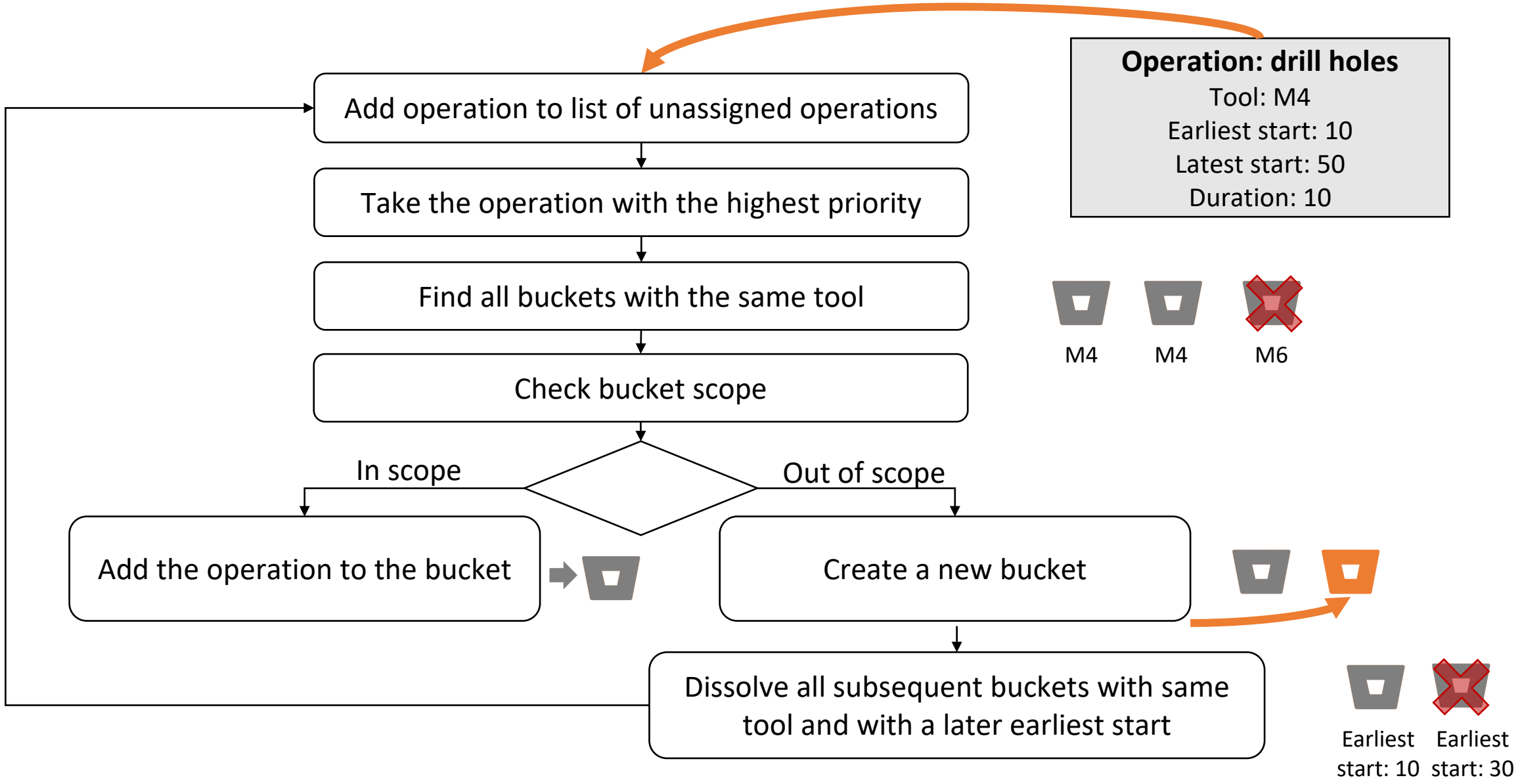
Requirements for self-organizing lots (Buckets)

- Keep decentralized structures
- Application of local knowledge and the communication of resources
- Keep the flexibility of the self-organizing production

Bucket model “Earliest and latest scope”



“Bucket building procedure”



Results of our empirical study

of SOBA

Results of our empirical study

Behaviour	Timeliness	Work in Progress	Throughput time	Average machine utilization time	Average machine setup time	Completed orders	Comparison to Stacked		
							△ Timeliness	△ Work in Progress	△ Average setup time
Default	21.00%	25.81	6882.27	52.00%	41.60%	652	-79.29%	-65.49%	118.95%
Stacked	99.28%	92.43	476.72	78.82%	18.74%	931	0.00%	0.00%	0.00%
Bucket 600	92.64%	83.08	483.84	78.94%	15.26%	931	-6.69%	-10.12%	-18.57%
Bucket 720	96.09%	85.37	503.93	78.82%	15.24%	931	-3.21%	-7.64%	-18.68%
Bucket 840	95.35%	82.87	509.79	78.94%	15.02%	931	-3.96%	-10.34%	-19.85%
Bucket 960	96.63%	79.41	522.64	78.94%	17.60%	931	-2.67%	-14.09%	-6.08%
Bucket 1080	94.35%	80.58	520.21	78.96%	14.80%	931	-4.97%	-12.82%	-21.02%
Bucket 1200	94.65%	80.07	506.82	78.96%	15.04%	931	-4.66%	-13.37%	-19.74%
Bucket 1320	94.49%	81.73	509.93	79.08%	14.64%	931	-4.83%	-11.57%	-21.88%
Bucket 1440	94.38%	83.48	493.03	78.98%	14.84%	931	-4.93%	-9.68%	-20.81%
Bucket 1920	93.63%	83.29	448.69	79.06%	14.74%	931	-5.69%	-9.88%	-21.34%
Bucket 2400	91.42%	83.59	443.22	79.34%	14.52%	931	-7.92%	-9.57%	-22.52%
Bucket ∞	88.68%	77.02	448.27	79.94%	14.14%	931	-10.68%	-16.68%	-24.55%

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Thank you!

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