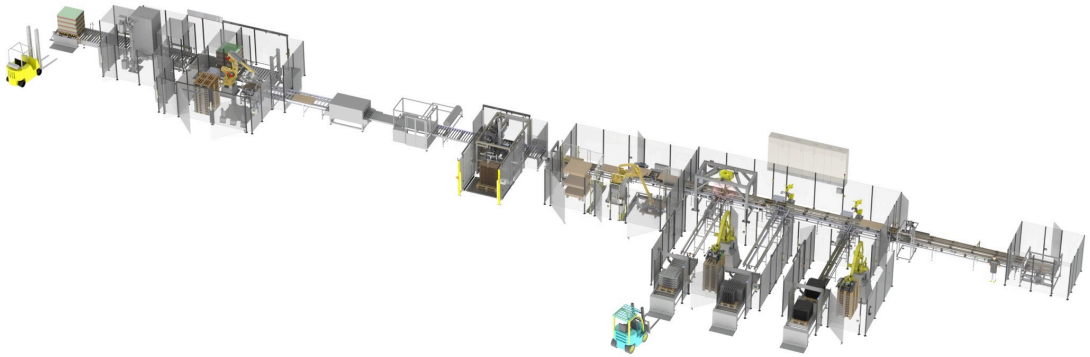


MANUFACTURING SYSTEMS AND SUPPLY CHAIN DYNAMICS

Chapter 1: Introduction

EPFL, Master MT

Roger Filliger (BFH), Olivier Gallay (UniL)

Course Content

1. ***Introduction***
2. *Inventory Theory*
3. *Safety Stock in Manufacturing Systems*
4. *Elements of Queueing Theory*
5. *Productions Flows*
6. *Production Dipole*
7. *Production Lines and Aggregation*
8. *Cooperative Flow Dynamics*
9. *Introduction to Queueing Networks*
10. *Supply Chain Analysis*
11. *Elements of Reliability Analysis*
12. *Maintenance Policies*

General Context

- Derive systematic and generic analysis of **mass production systems**
- Unveil typical challenges that arise in **manufacturing systems and supply chains**
- Use fundamental mathematical results in:
  - **Applied probability and queueing systems**
  - **Dynamical systems and stability**

Definitions

- **Supply Chain:** entire process of making and selling commercial goods
- **Manufacturing:** reapatable transformation of material, energy and information into something useful and portable
- **Manufacturing system:** set of machines, transportation elements, computers, storage buffers, and other items, that are used together for manufacturing product items.
- **Machine**: localized work station which is able to receive and operate on goods during a limited amount of time
- **Production Rate**: number of parts that is produced per time unit.

Definitions (continued)

- **Capacity:** maximum production rate
- **In-Process Inventory:** material found within a manufacturing system: in machines, in storage areas, in transportation subsystems, in inspection stations, etc.
- **Cycle Time**: amount of time which separates the output of two successive finished goods out of the manufacturing systems, recriprocal value of the production rate
- **Lead Time**: amount of time that a part spends in the manufacturing system
- **Takt Time:** theoretical cycle time needed to complete a given bunch of parts in a given amount of time

https://www.youtube.com/watch?v=isu6MG3v0-s

Manufacturing Systems: Practical Illustrations

Manufacturing Systems: Practical Illustrations

Manufacturing Systems

- **Industrial Production** of merchandise for sale using labour or machines (**operators**)
  - **Raw materials to finished goods**
  - **Large scale**

- **Examples**:
  - Pharmaceutical products
  - Cars
  - Electronic components

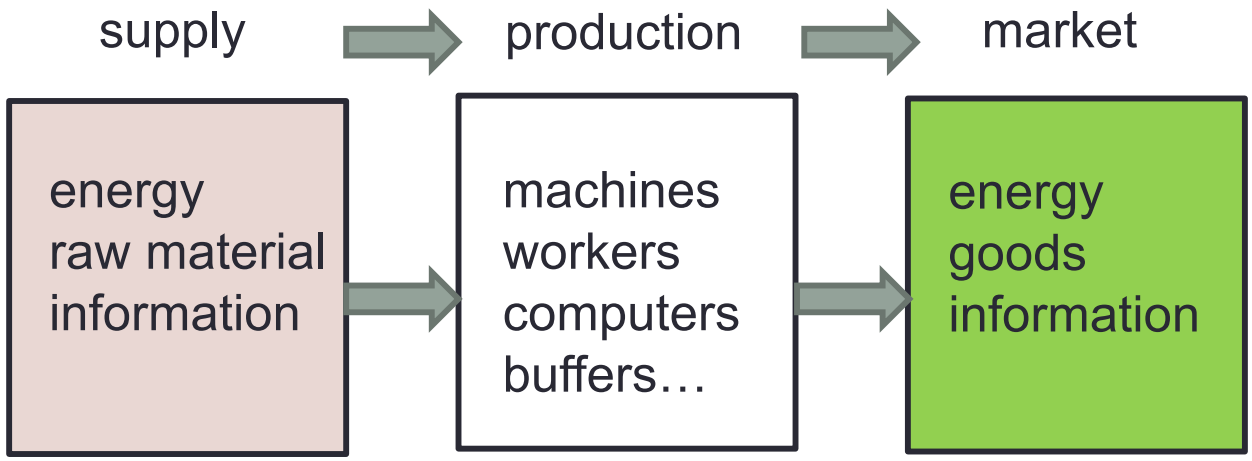
- **Recipients**:
  - Other manufacturer (for end product, e.g. plane)
  - Wholesaler -> retailer -> end consumer

Manufacturing Systems: Operators

Manufacturing Process

- **Intermediate steps** through which a finished goods is built
- **Prior stages**:
  - Product design
  - Material specifications -> definition of the manufacturing steps
  - Demand forecasting -> line balancing

Black box approach to manufacturing systems and supply chain modeling:



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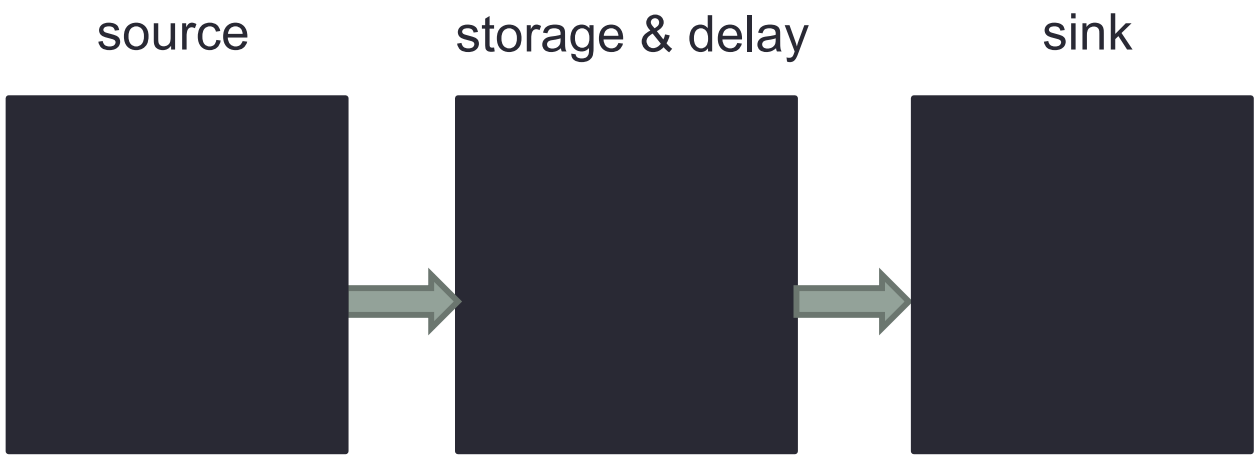

Task: Analyzing, optimizing, and controlling flows of energy, material and information

Goal: meet both, product and scheduling specifications, at minimum costs

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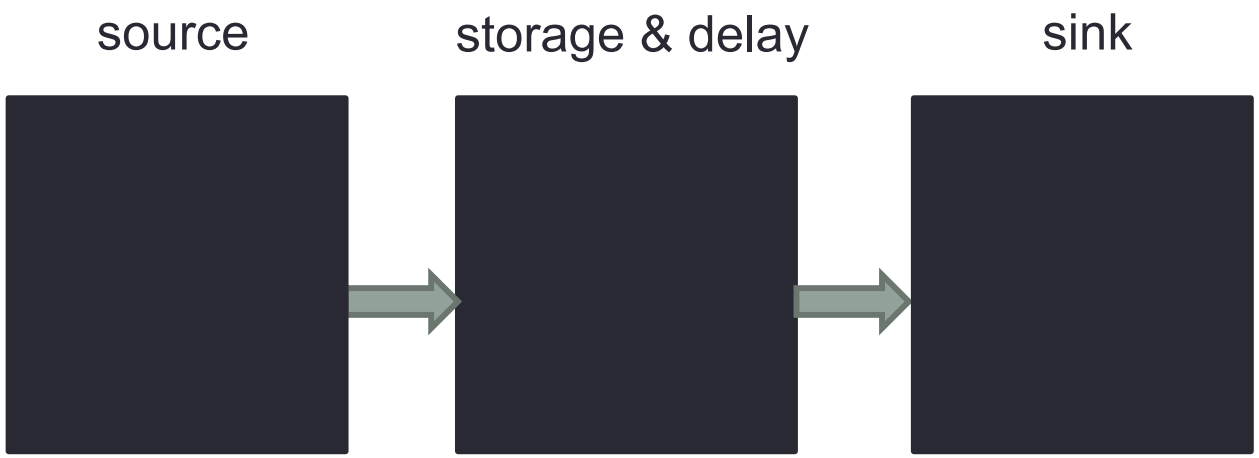

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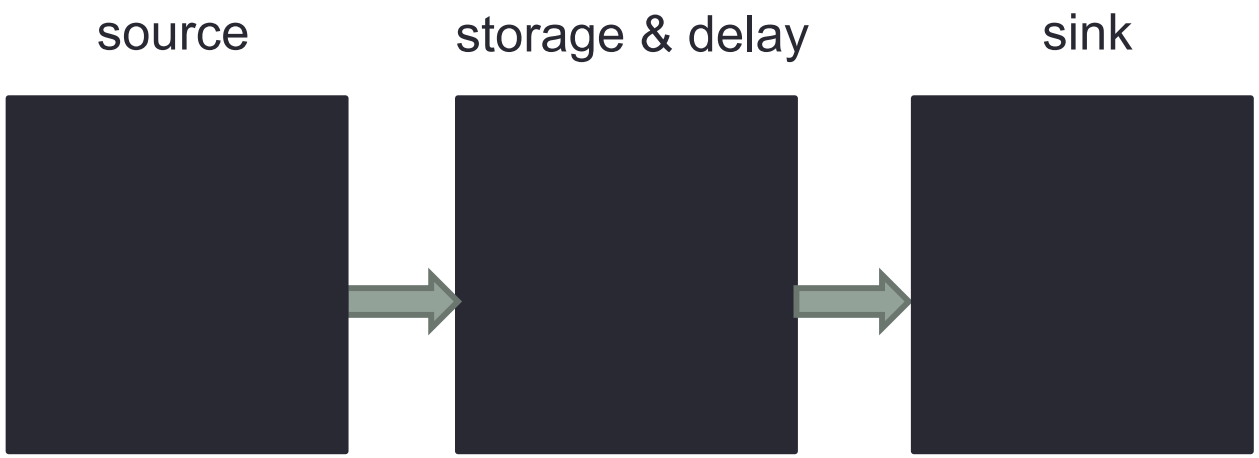

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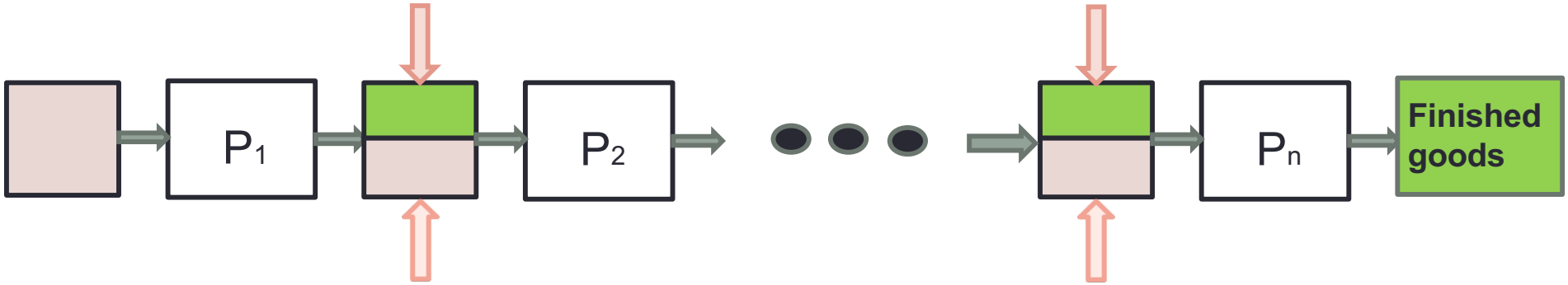
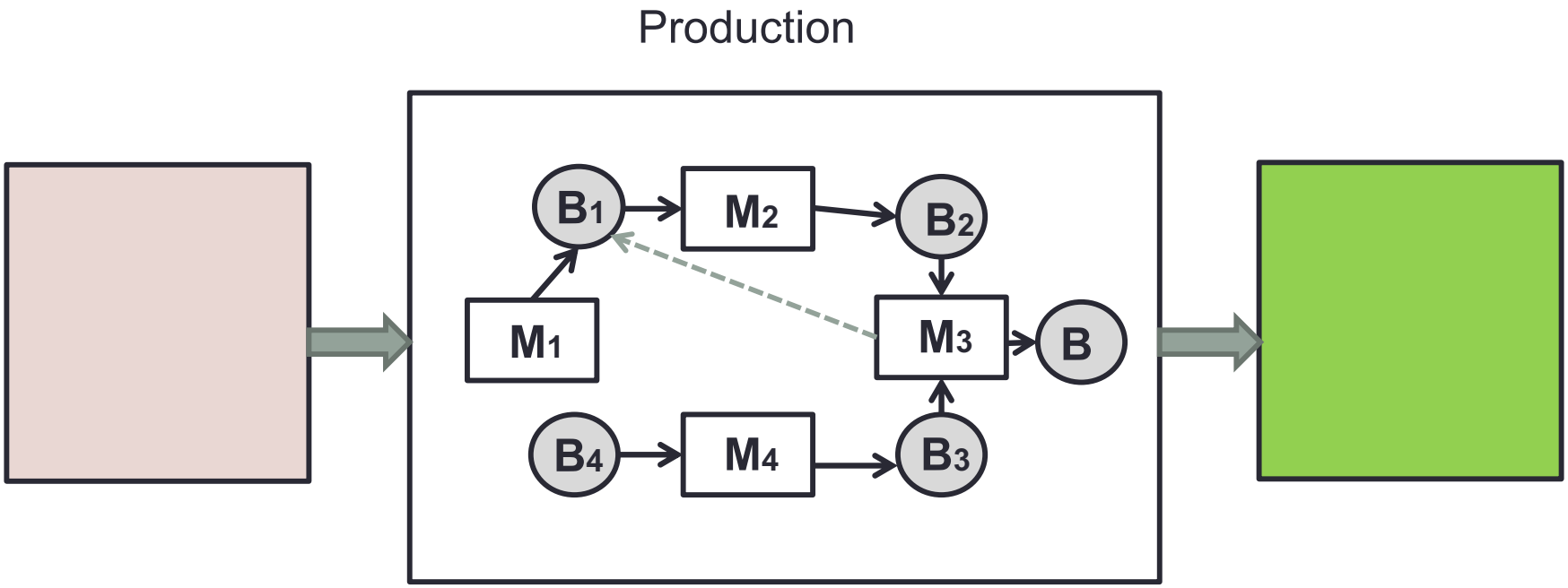
Zoom out: supply chain perspective



Study production flows in supply chain

Zoom in: manufacturing system perspective (job floor)



Study production flows in manufacturing systems

Zoom in: manufacturing system perspective (job floor)

Study production flows in manufacturing systems

Zoom in: manufacturing system perspective (job floor)

Study production flows in manufacturing systems

https://youtu.be/HPSK4zZtzLI?t=20

Variability

Factories are subject to random events :

- Machine failures
- Quality failures
- Human variability

Economic environment is uncertain because of:

- Demand variation
- Supplier unreliability
- Changes in costs and prices

Variability is the enemy of manufacturing!

- Degrades the performance of a production system
- **Minimize the creation of variability**
- **Minimize the propagation of variability**

Variability (continued)

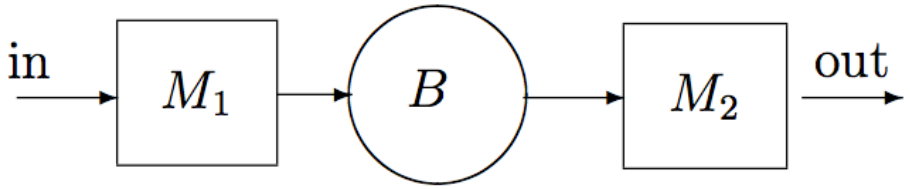


Figure 1.2: A generic picture of a buffered two-stage production line.

Exercise 2 Take a look at Figure (1.2) and focus on the content $h(t)$ of the buffer stock B. Suppose M_i produces m_i parts per time unit, $i = 1, 2$. Formulate the evolution equation for $h(t)$ in words and formally (you may, to start with, forget about boundary conditions). ⊙

Exercise 3 Interpret in Figure (1.2) M_1 and M_2 as 2 cars in 1-lane traffic and the content $h(t)$ of the buffer stock B as safety distance between the two cars. Discuss notions like maximum speed, mean speed, actual speed, crash, stop- and go traffic or traffic jam in the context of manufacturing systems modelling. What kind of parameter should we add to the model in order to describe the mean flow of parts through this buffered two-stage manufacturing system? ⊙

Discrete-Event Simulation

Introduction to ***AnyLogic*** basics:

- Source
- Delay
- Sink

Exercise 5 Using *AnyLogic*, implement the most basic example of a production line composed of a **source**, a **queue**, a **delay** and a **sink** element. This corresponds to a production line composed of a single machine that is not affected by any randomness and with fixed production rate. ⊙