Industrial automation
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Advanced automation and control

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Course schedule

- Lectures:
  Industrial automation
  - Monday: 14-16 (room C7), Thursday: 16-18 (room A1)

  Advanced automation and control
  - Wednesday: 14-16 (room E1)
- Office hours: Wednesday 11.00-12.30 (Office: Dipartimento di Ingegneria Industriale e dell'Informazione, floor F) … or by appointment (giancarlo.ferrari@unipv.it)
- Website:

  http://sisdin.unipv.it/labsisdin/teaching/courses/ails/files/ails.php

Textbooks and exams

- Texbooks:
  - W. L. Winston & M. Venkataramanan “Introduction to Mathematical Programming: Applications and Algorithms”, 4th ed., Duxbury Press, 2002. ISBN: 0-534-35964-7
  - C. Vercellis “Ottimizzazione: Teoria, metodi, applicazioni”, McGraw-Hill, 2008. ISBN: 9788838664427
- Exam:
  - Closed-books closed-notes written exam on all course topics
  - Date/time/room on the website of the Faculty of Engineering

  No graphic or programmable calculators are allowed
- Registration to exams:
  - Through the university website. *Usually, registrations end 7 days before the exam date*

Industrial automation

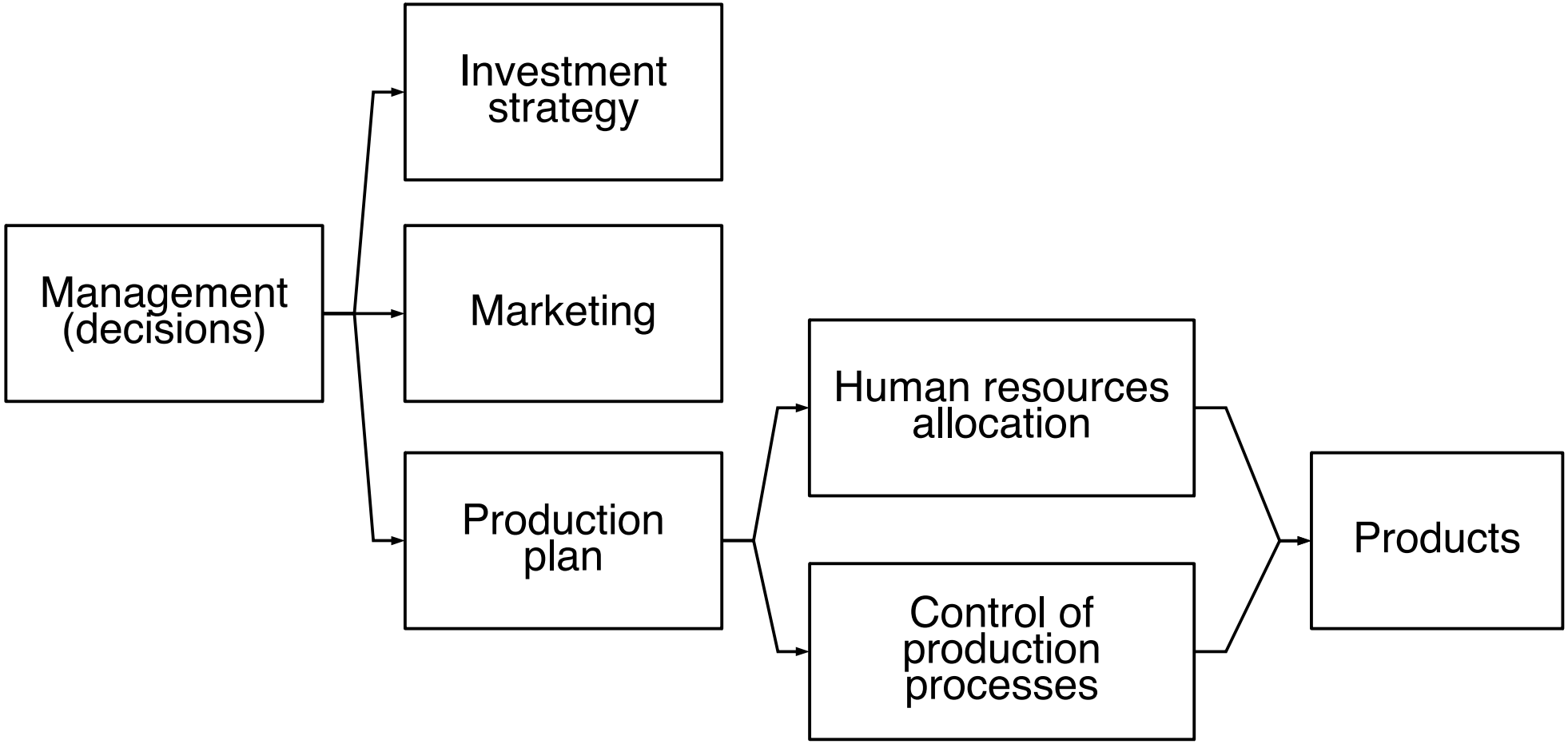
Study of methods and technologies for controlling energy, material and information flows in production processes

Advantages due to the automation of production processes:

- Better product quality
- Improved *flexibility* (use of the same plant for building multiple products)
- Reduced production time and costs
- Reduced time for complying with new laws
- Better use of available resources

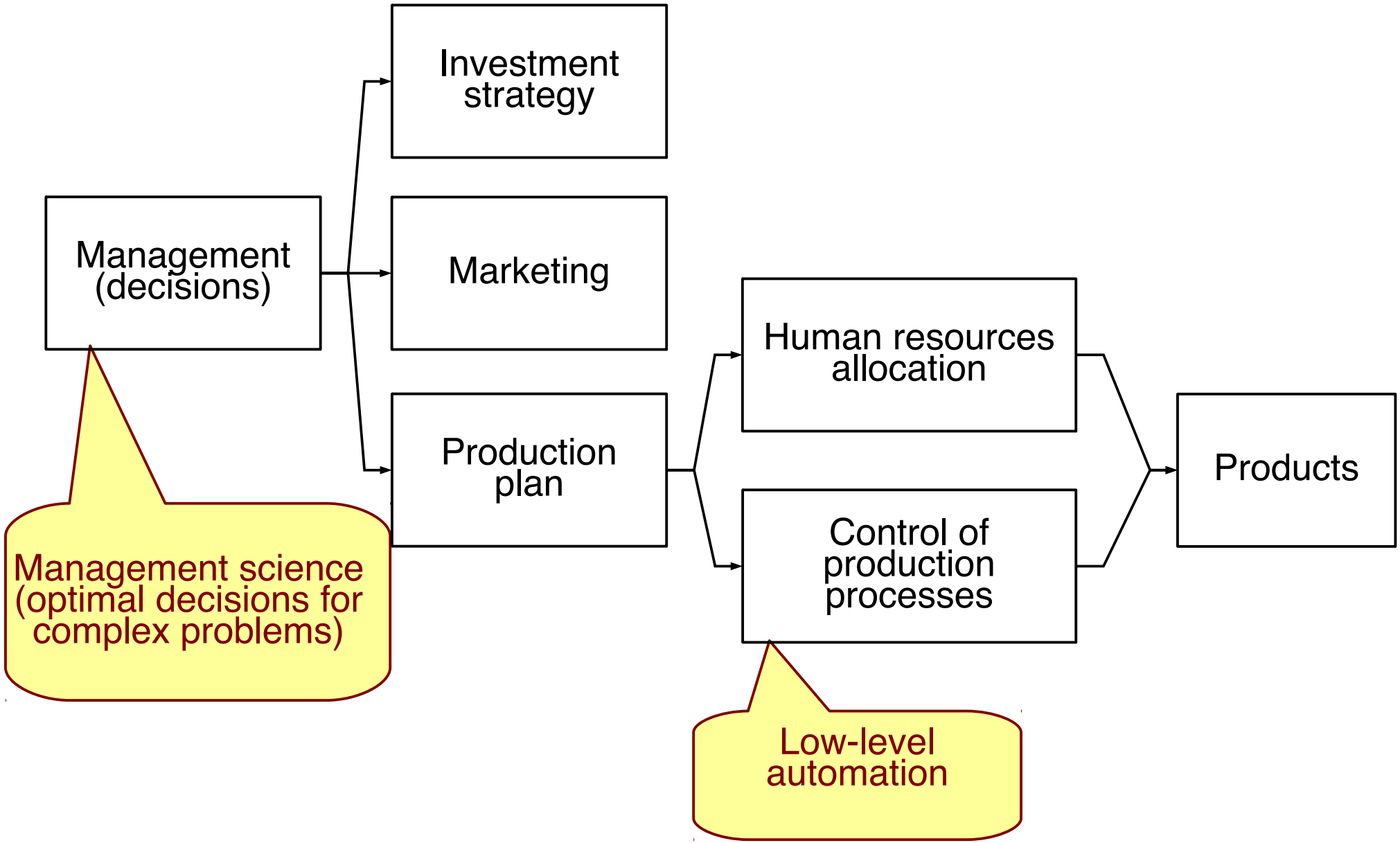
Improved competitiveness of the company

Planning of production processes

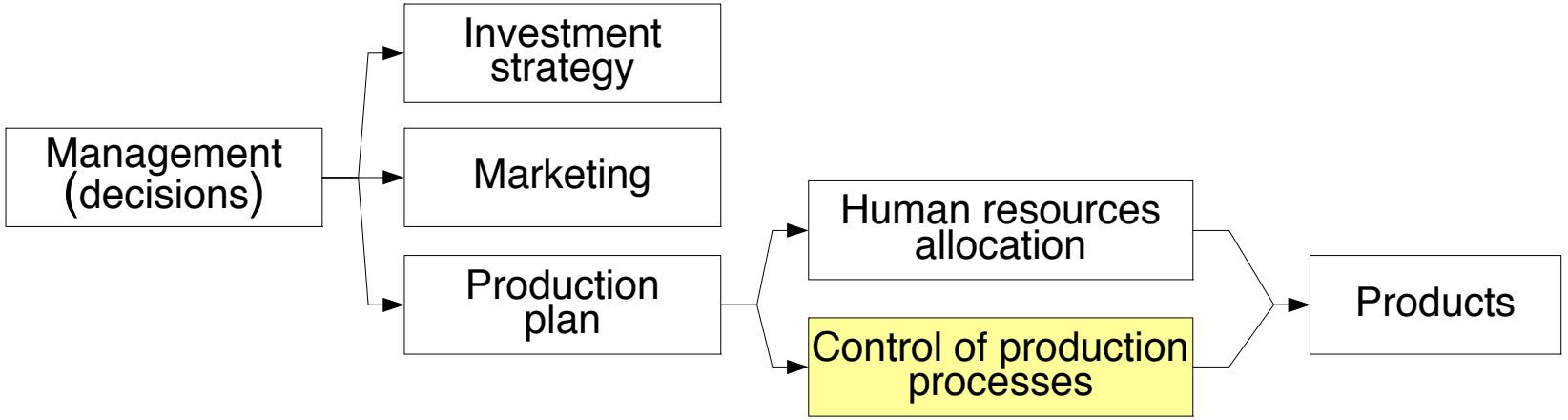


There are also feedback paths from nodes to higher levels

Role of automation



Flexible manufacturing systems

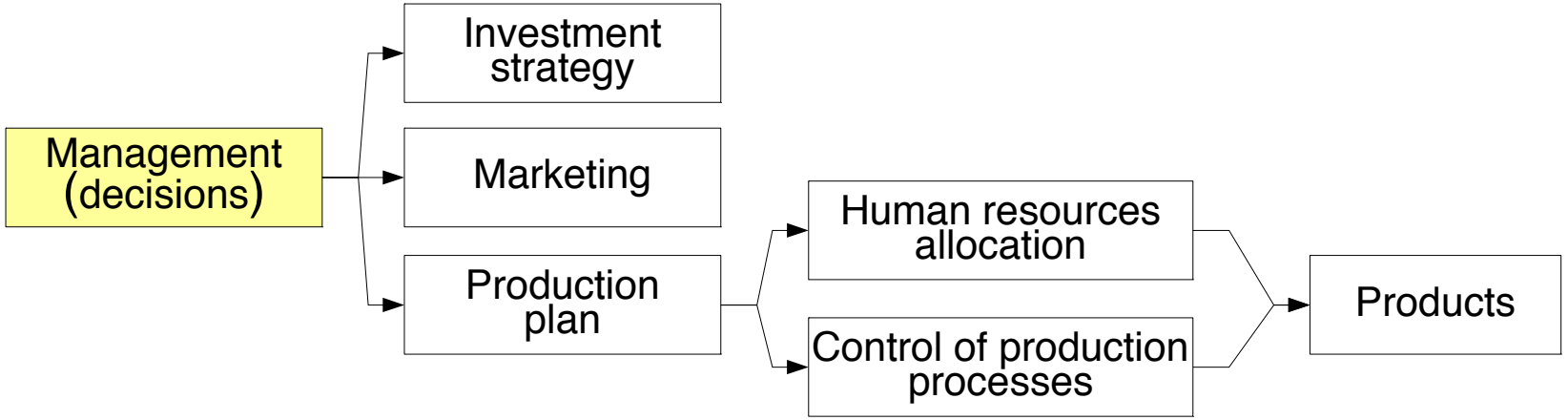


Control of production processes

- Main problem: products become obsolete ⇨ companies have to quickly adapt production processes
- Solution: flexible manufacturing systems, i.e. ability to produce different product types and adapt to new products

The control of manufacturing systems is split into several subproblems of different nature.

Management science



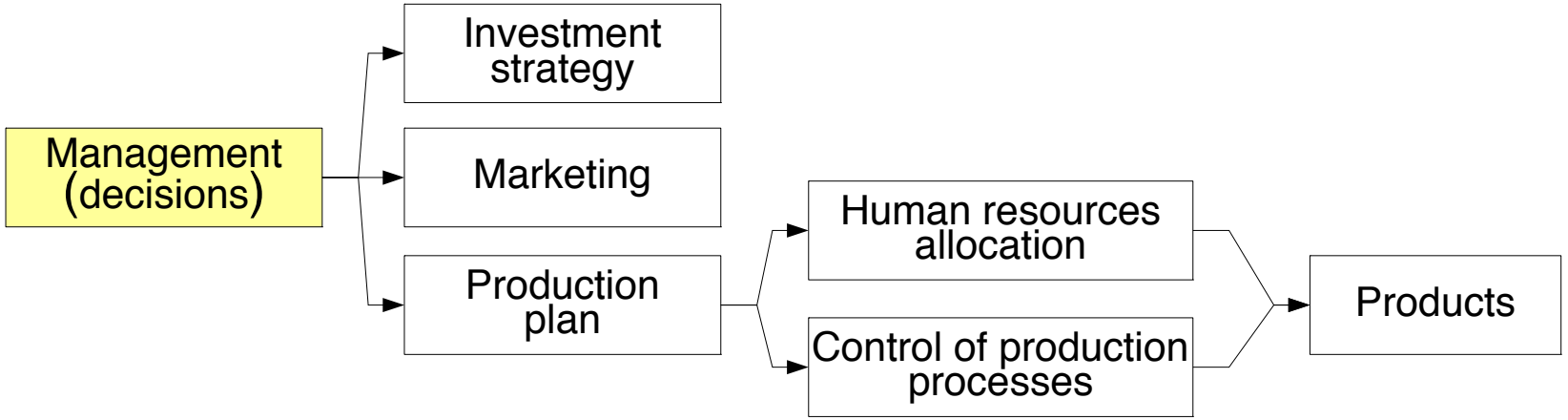
Management: decisions can be either “instinctive” or structured

- “Instinctive” decisions:
  - *Pros:* rapidity and flexibility
  - *Cons:* no quantitative model
    - limited number of the alternatives
    - limited understanding of decision criteria

} Suboptimal decisions

Drawbacks can be extremely critical if decisions are complex
(several alternatives / mutually dependent choices / limited resources)

Management science



- Structured decisions (based on a quantitative model):
  - *Pros:*
    - Better understanding of the problem
      - consideration of all possible alternatives
      - precise decision criteria
    - optimal decisions can be tacken even for complex problems
  - *Cons:* getting a mathematical model of a decision problem might be time and resource consuming
    - trade-off between time/resources for decision-making and benefits of optimality. Very often optimality wins !

Example: product mix

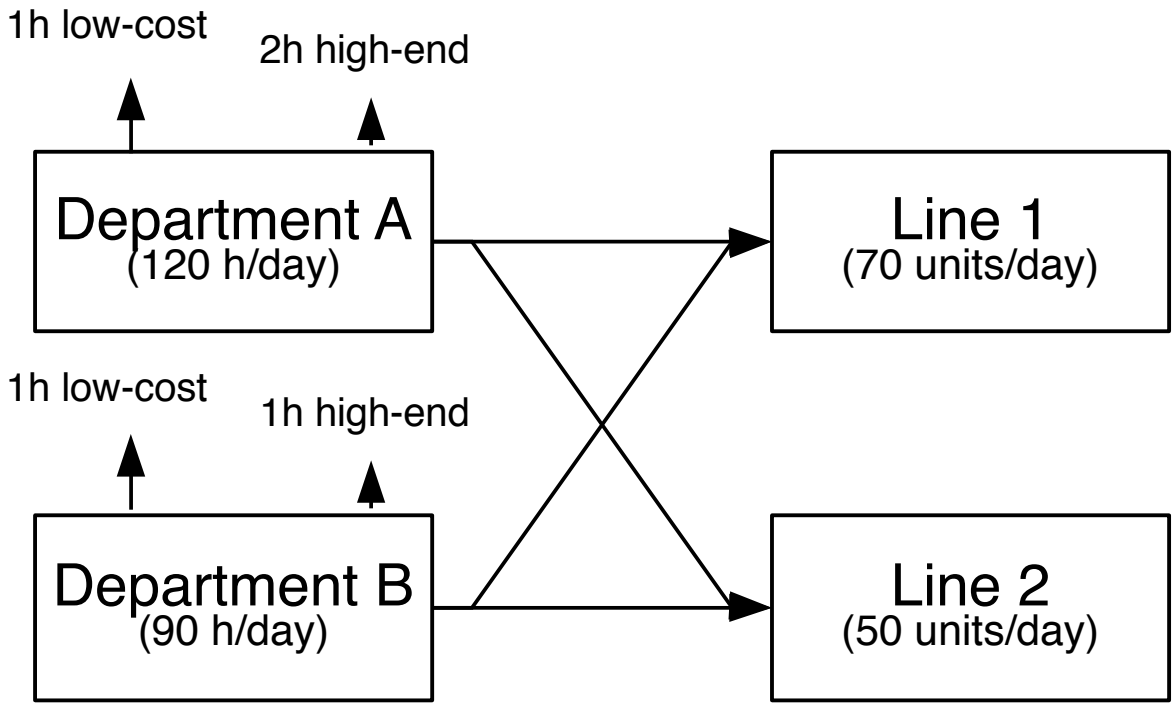
A company manifactures two radio models (low-cost and high-end) and produces two components

- Department A: antennas
  - no more than 120h hours of production per day
    - 1h of work for a low-cost antenna
    - 2h of work for a high-end antenna
- Department B: cases
  - no more than 90h hours of production per day
    - 1h of work for a low-cost case
    - 1h of work for a high-end case

The company has two assembly lines (1 radio=1 antenna + 1 case)

- Line 1: production of low-cost models. No more than 70 units/day
- Line 2: production of high-end models. No more than 50 units/day

Example: product mix

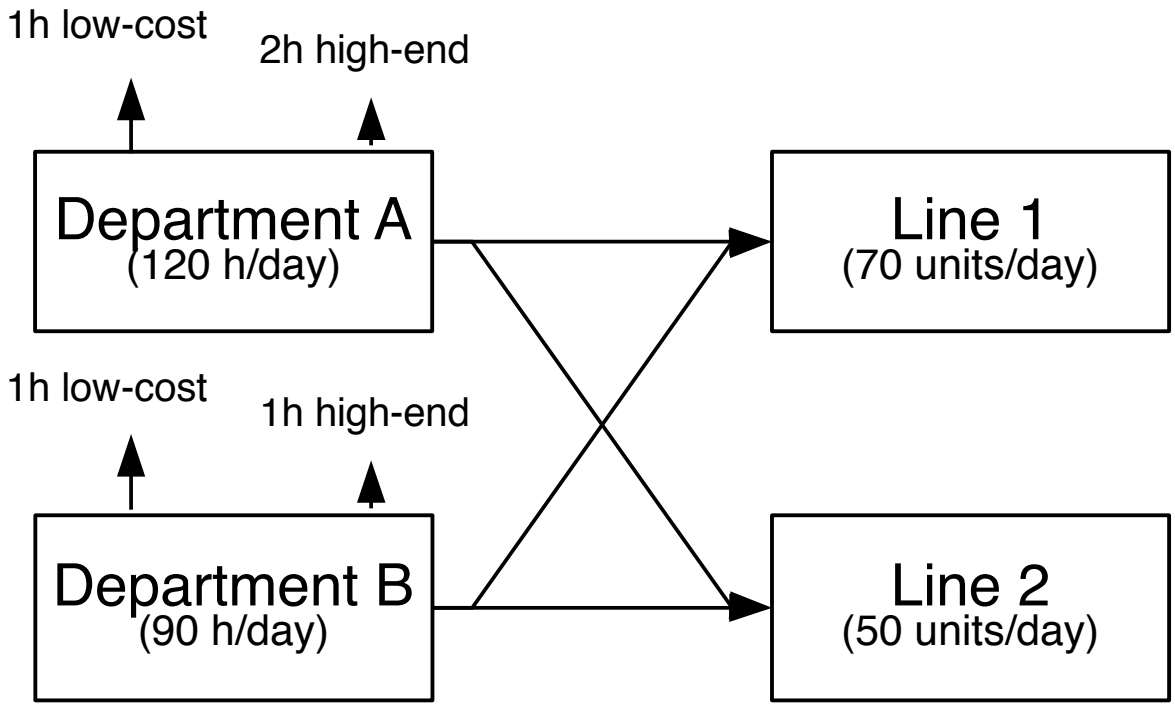


Profits: 20 Euro for a low-cost radio and 30 Euro for a high-end radio

Assuming the company will sell all the radios, which is the optimal number of units, for each model, that must be produced daily for maximizing the revenue?

Optimal daily production plan = mix of two products

Example: product mix



Instinctive (and greedy) manager: higher profits for high-end models ⇨ maximize their production (50 units/day)

Department A: 100h for high-end antennas (50 antennas) ⇨ 20h for low-cost antennas (20 antennas)

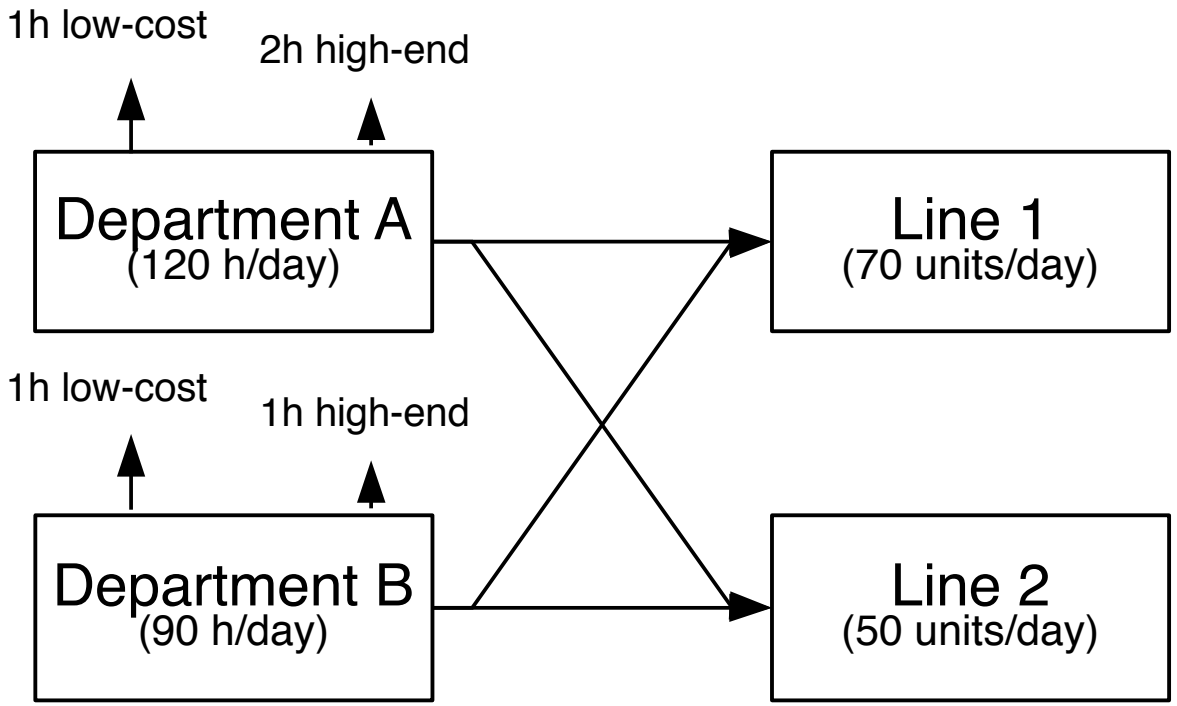
Department B: 50h for high-end cases (50 cases) ⇨ 20h for low-cost cases (20 cases)

Line 1: 20 low-cost radios per day

Line 2: 50 high-end radios per day

Daily profits: 20*20+50*30=1900 Euro. Is there any better solution ?

Example: product mix

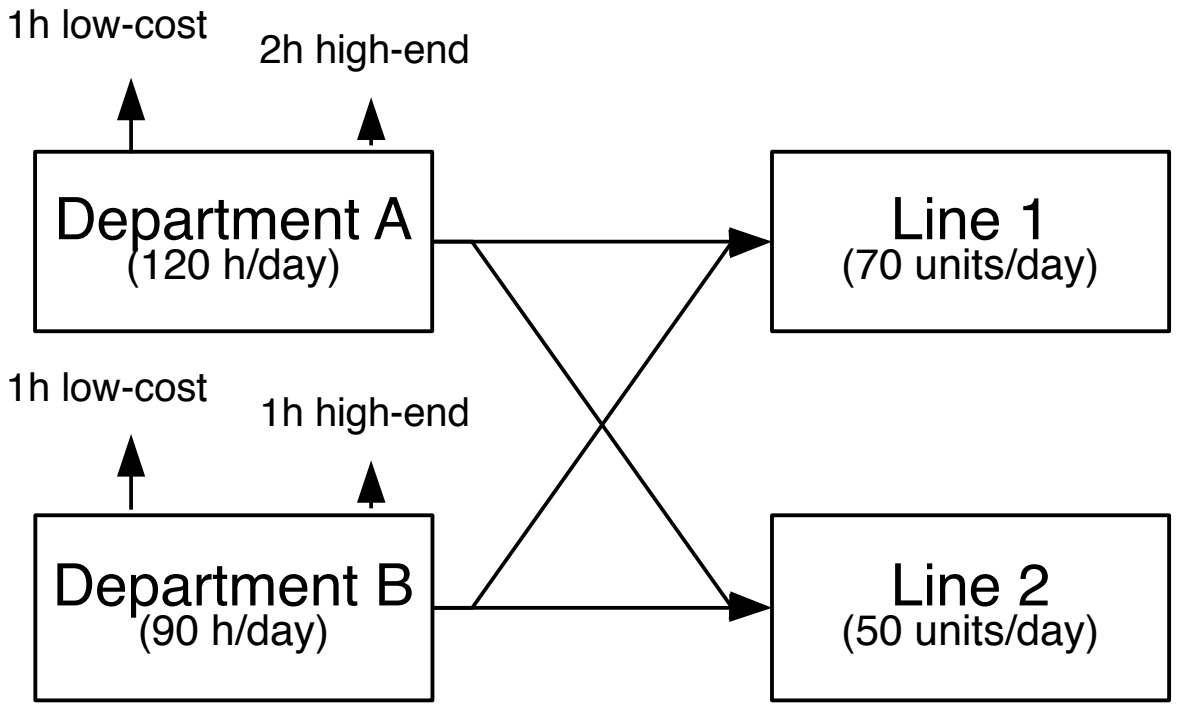


Smart manager: 60 low-cost models and 30 high-end models

Department A: 60h for high-end antennas (30 antennas) ⇨ 60h for low-cost antennas (60 antennas)
Department B: 30h for high-end cases (30 cases) ⇨ 60h for low-cost cases (60 cases)
Line 1: 60 low-cost radios per day
Line 2: 30 high-end radios per day

Daily profits: 60*20+30*30=2100 Euro

Example: product mix

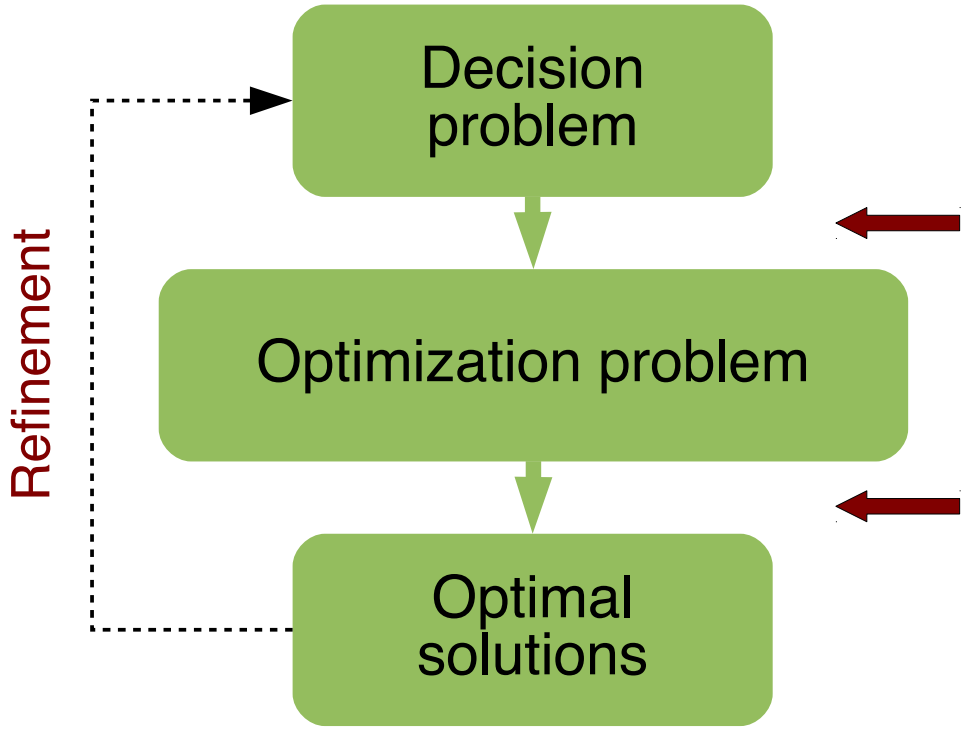


Decisions tacken by the smart manager are optimal (profits cannot increase)
How the manager came up with this plan ? How can we certify it is optimal ?

Answers to both questions in the next lectures !

Automation of decision processes

Decisions based on quantitative models: workflow



Derive a mathematical model (optimization problem)

Algorithms for solving optimization problems