Problem structuring (and: structuring the problem solving process)
Problem decomposition, “divide and conquer” method

1 Decomposition into solved and unsolved partial problems
1.1 Reference models and analogic transfer
1.2 Partially analogous reference models
1.3 Two sources of model construction
1.4 First, solution for standard cases and, then, for exceptional cases

2 Parallel decomposition: into simultaneous partial problems
2.1 Horizontal decomposition: same level of abstraction
2.2 Vertical decomposition: different levels of abstraction

3 Sequential decomposition: into a sequence of partial problems (steps)
3.1 Software (development) process

4 Inductive “decomposition”: into many individual cases
4.1 Cyclic inductive-deductive refinement

5 Problem structuring in a master’s thesis
5.1 Network modeling
5.2 Method matrix

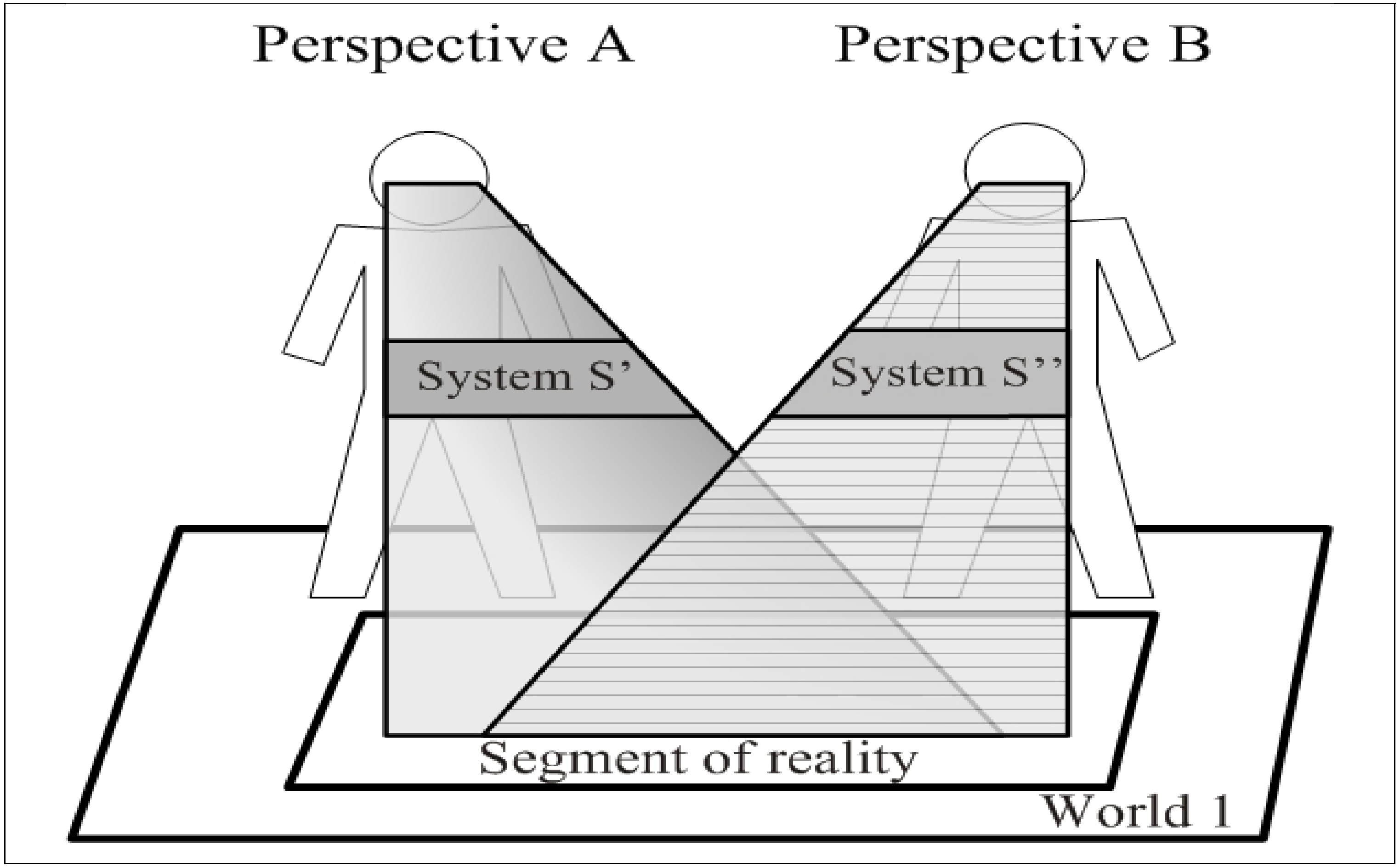
A problem is a question of definition

Mathematician / physicist / chemist etc.
gets a fence
and the task:
“catch a lion (or a flock of sheep) in an enclosure made of the fence”
What happens?

(different versions on the web)

A problem is a question of definition

multi-perspectivity of IS experts and organization / domain experts (ethnography)



Systems are relative to perspectives (adapted from Steinmüller 1993, 168)

1 Decomposition into solved and unsolved partial problems (parallel and sequential)

First, a mathematician / physicist
gets an empty bucket and a tap
and the task: “fill the bucket with water”

Then, the mathematician / physicist
gets a bucket full of water and a tap
and the same task: “fill the bucket with water”

What happens?

Reduction to an already solved problem

1.1 Reference models and analogic transfer

Here for data models; applies for process models as well

creditor	debtor	umbrella terms generic model
supplier groups ↓ suppliers ↓ outgoing orders ↓ order lines ↑ raw materials ↑ material groups	customer groups ↓ customers ↓ incoming orders ↓ order lines ↑ products ↑ product groups	business partner gr. ↓ business partners ↓ orders/contracts ↓ order lines ↑ items ↑ item groups

→ **one-to-many relationship**

Cf. class models: generalization and specialization of models

1.2 Partially analogous reference models

Complete model analogies are rare.
Split a problem into a solved and an unsolved partial problem.

Example 1: Number of order lines
orders with only one order line vs. orders with more order lines

customers **library users**	→	**orders** **-**	→	**order lines** **borrow transactions**	←	**products** **books**

Example 2: Individual identifiability of items
individually identifiable items (library books, cars) vs.
not individually identifiable items

borrow transactions **order lines**	←	**books (copies)** **-**	←	**books (titles)** **products**

1.3 Two sources of model construction

Starting from reality: empiristic method/approach

observation and interviews of employees by a model designer

(contrary to natural sciences: only observation)

abstraction, inductive type construction

often used for individual parts of an organization

Starting from models, concepts, ideas: rationalistic method

reference models

activation in a model designer's brain

analogic transfer

often used for standard parts of an organization, e.g. accounting

Final step: integration of individual and reference models

1.3 Two sources of model construction

<table>
<tr><td>external world
↓
World 1
objects of cognition</td><td colspan="3">phenomenon, individual experience
↓
World 2
knowledge of an individual subject of cognition</td><td>model, theory
↓
World 3
common knowledge</td></tr>
<tr><td></td><td>perception, cognitive processes (empiristic)
↓
reconstruction of World 1
→</td><td>memory</td><td>learning
rationalistic
↓
activations of World 3
←</td><td></td></tr>
<tr><td>←</td><td colspan="3">↓
creation, induction
↓
design, influence ← new ideas, knowledge → publi-cation</td><td>→</td></tr>
</table>

1.4 First, solution for standard cases and, then, for exceptional cases

Lab problem:
Process description: acceptance of an order at the phone
text, optionally with a diagram

1. describe your assumptions regarding the company
2. higher abstraction level: standard process (reference model)
3. lower abstraction level: details of the standard process
4. lower abstraction level: exceptions (observation)

Take care of exact correlations between 2, 3 and 4
Presentation as table with three columns for 2, 3 and 4

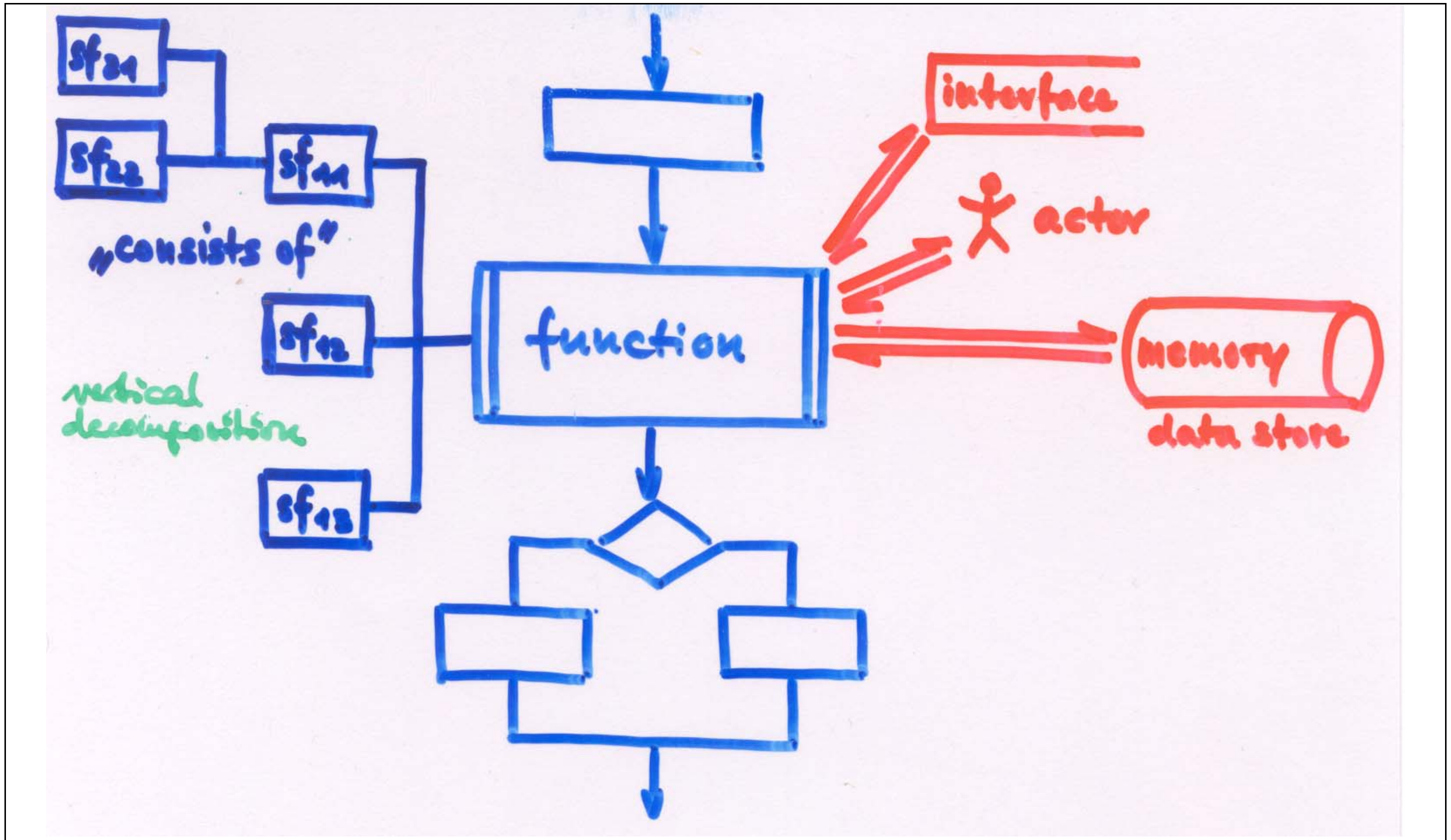
2 Parallel decomposition

Lab problem:
Normalization and integration (with overlaps) of partial data models (assume that the invoice data is stored in a separate accounting IT system)

Orders (sales department):	**Sales representatives (marketing dept.):**	**Item statistics (controlling dept.):**
CustomerID	SalesRepID	ItemID
CustomerName	SalesRepProvision	StatisticYear
CustomerAddress	CustomerID	StatisticMonth
OrderNo	CustomerName	Turnover
OrderDate		
ItemID		
ItemDescription		
PricePerUnit		
Quantity		

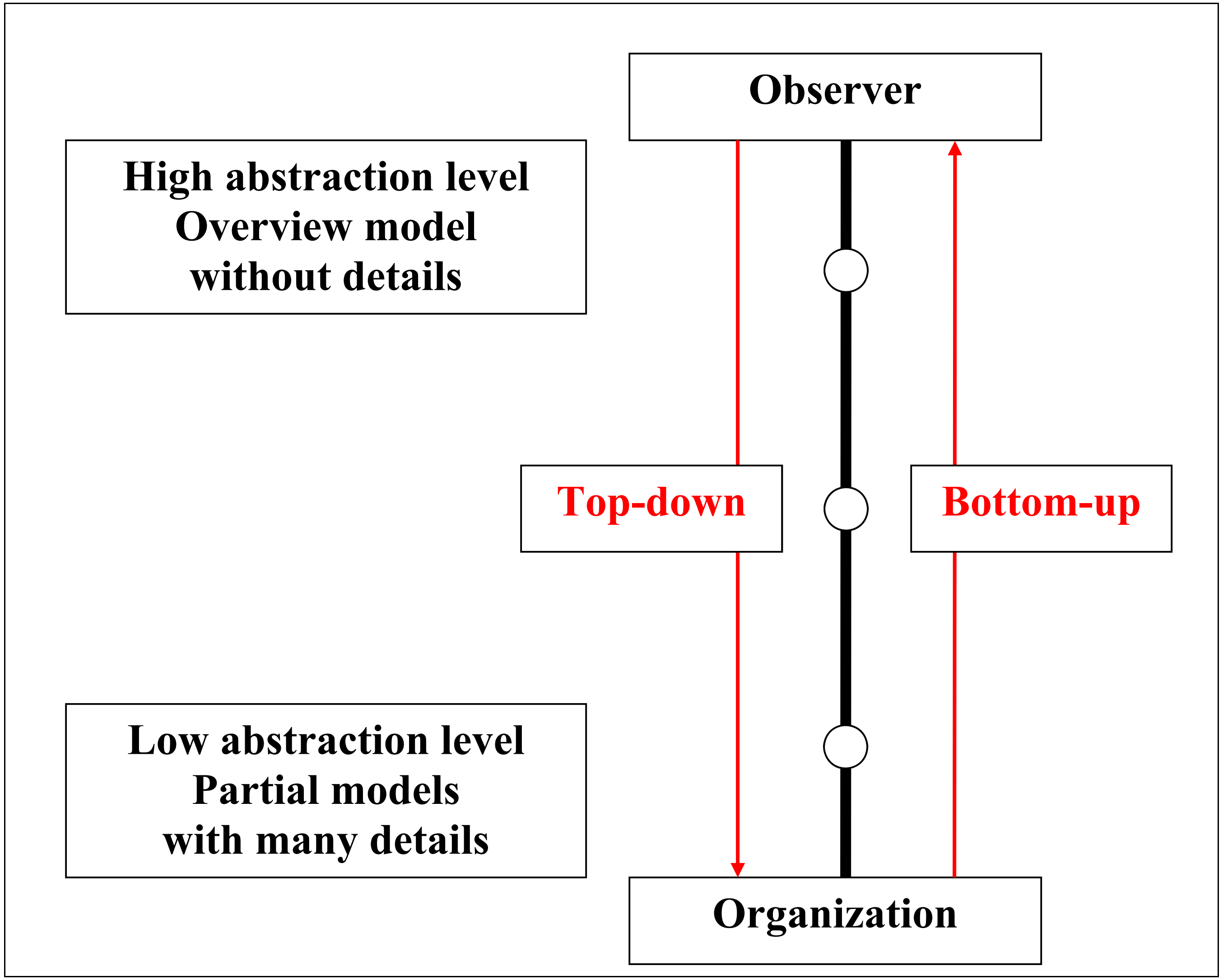
2.1 Horizontal decomposition: same level of abstraction

	Static models	Dynamic models
Data models	**Data (structure) models**: data structure diagrams; entity-relationship models (ERM); UML class diagrams	**Information flow models**: information / data flow charts / diagrams; Structured Analysis (SA); UML use case diagrams
Function models	**Function structure models**: compositional function trees; Jackson trees	**Behavior / process models**: algorithms (functions); Nassi-Shneiderman diagrams; (control) flow charts; business process models; UML activity diagrams; (UML sequence diagrams)

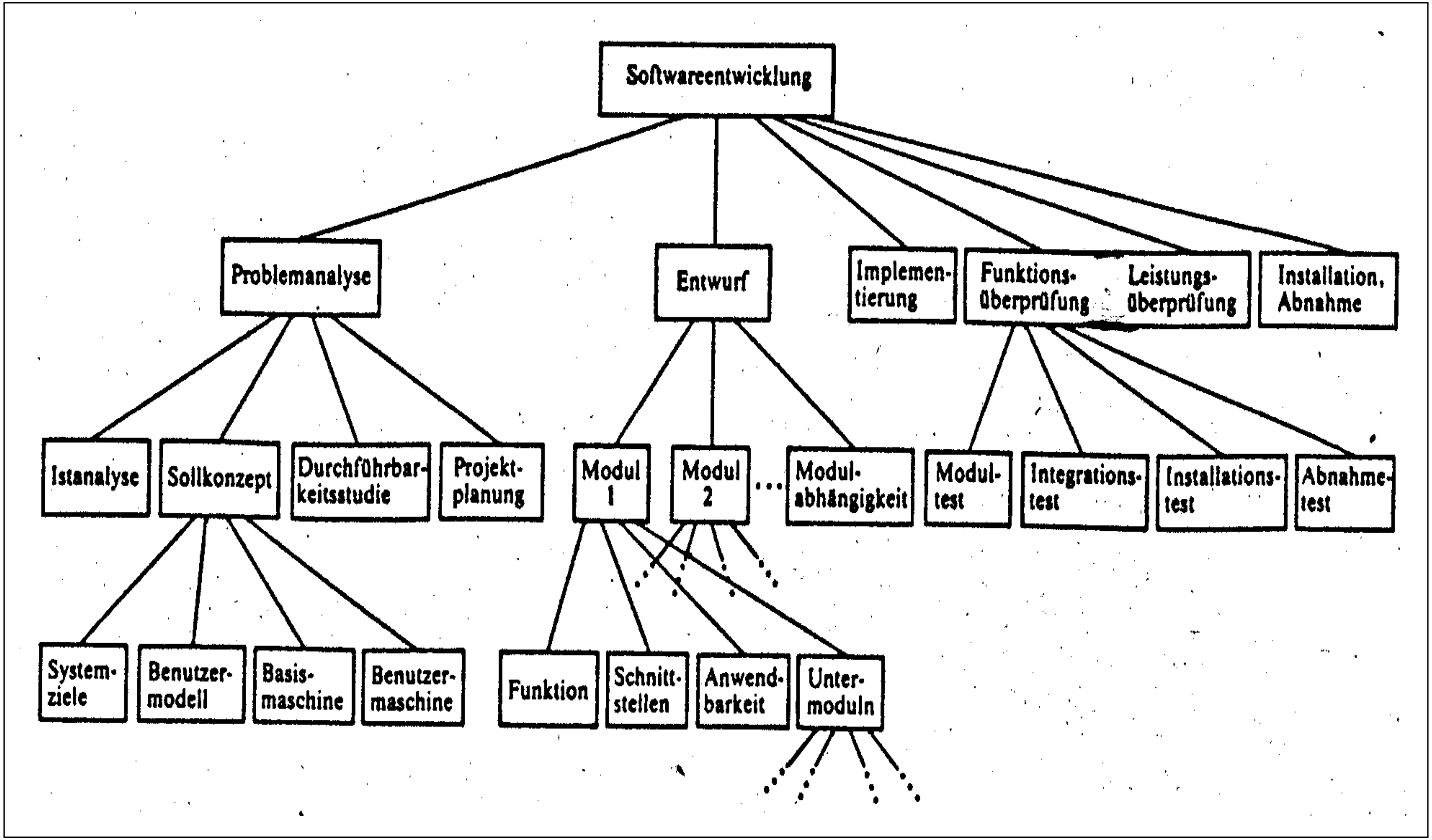


Static function model: function structure model irrespective of tests, iterations, sequences	Dynamic function model: control flow model	Dynamic data model: information flow model	Static data model: data structure model

2.2 Vertical decomposition: different levels of abstraction



2.2 Vertical decomposition: software process as a tree model



2.3 Summary: horizontal and vertical decomposition

vertical
decomposition

↑
→ horizontal decomposition

3 Sequential decomposition

Geometric problem:
Transform an arbitrary quadrilateral into a square with equal area

Steps:
1. quadrilateral → triangle
2. triangle → isosceles triangle (equal legs)
3. isosceles triangle → rectangle
4. rectangle → square (triangle altitude theorem)

Network modeling for project management
Example: see 5.1

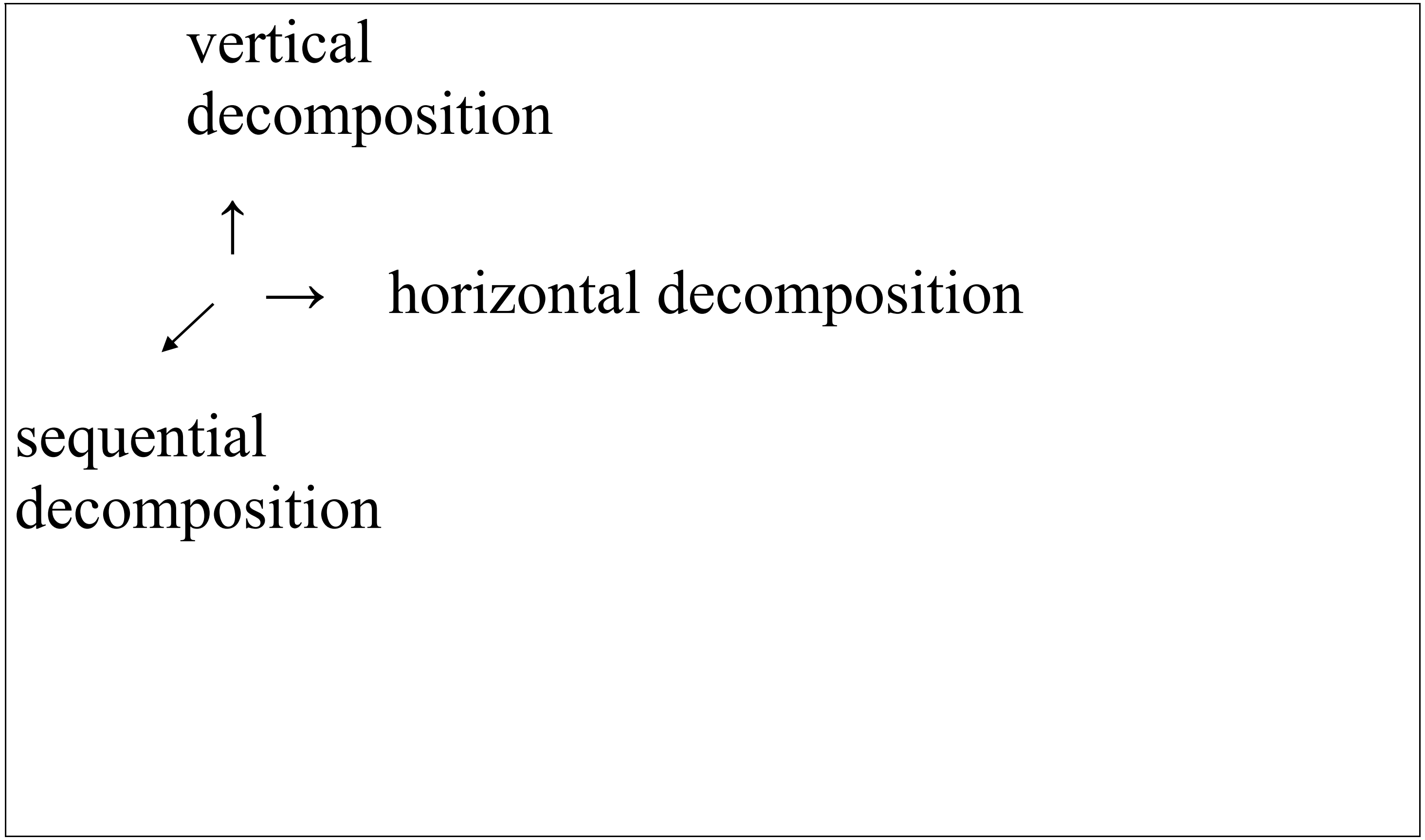
3.1 Sequential decomposition: software (development) process

Main phase	Subphase, model level	Methods (ex.)
Analytic phase: problem analysis	Elicitation of the current state of the org	Systems analysis, Reverse engineering
	Analysis of the current state of the organization	Requirements engineering, OOA
	Design of the planned state of the org. (sociotechnical IS)	Requirements engineering, BPM
	Design of the business concept of the IT system (technical IS)	Reference mod., test case description
Synthetic phase: IT system develop-ment	Design of the techn. concept of the IT system independ. of developm. tool	OO design, design patterns
	… depending on development tool	Unit tests
	Programming	Coding conv., agile programming
	Test	V model tests

3.1 Sequential decomposition: software (development) process

On its way through a software (development) process,
a model of a technical IS has to be transferred in several steps
via different models,
each of which in turn is split vertically and horizontally,
from an organization / enterprise model on the information level
to a technical model on the implementation level.
Every software process phase represents a certain perspective
(diaphasic multi-perspectivity)

3.2 Summary: horizontal, vertical and sequential decomposition



4 Inductive "decomposition": into many individual cases

Find a general formula for the sum of natural squares.

1. Find solutions for individual cases (there are no standard cases)
2. Generalize these solutions

$$1^2 = 1$$

$$1^2 + 2^2 = 5; \quad \text{is the sum equal to } \frac{n \cdot (n^2 + 1)}{2} \text{ ?}$$

$$1^2 + 2^2 + 3^2 = 14$$

$$1^2 + 2^2 + 3^2 + 4^2 = 30$$

As there are n summands, the biggest of which is n^2,
the solution has the order n^3 and a good starting point is:

$$\sum_{j=1}^{n} j^2 = an^3 + bn^2 + cn + d$$

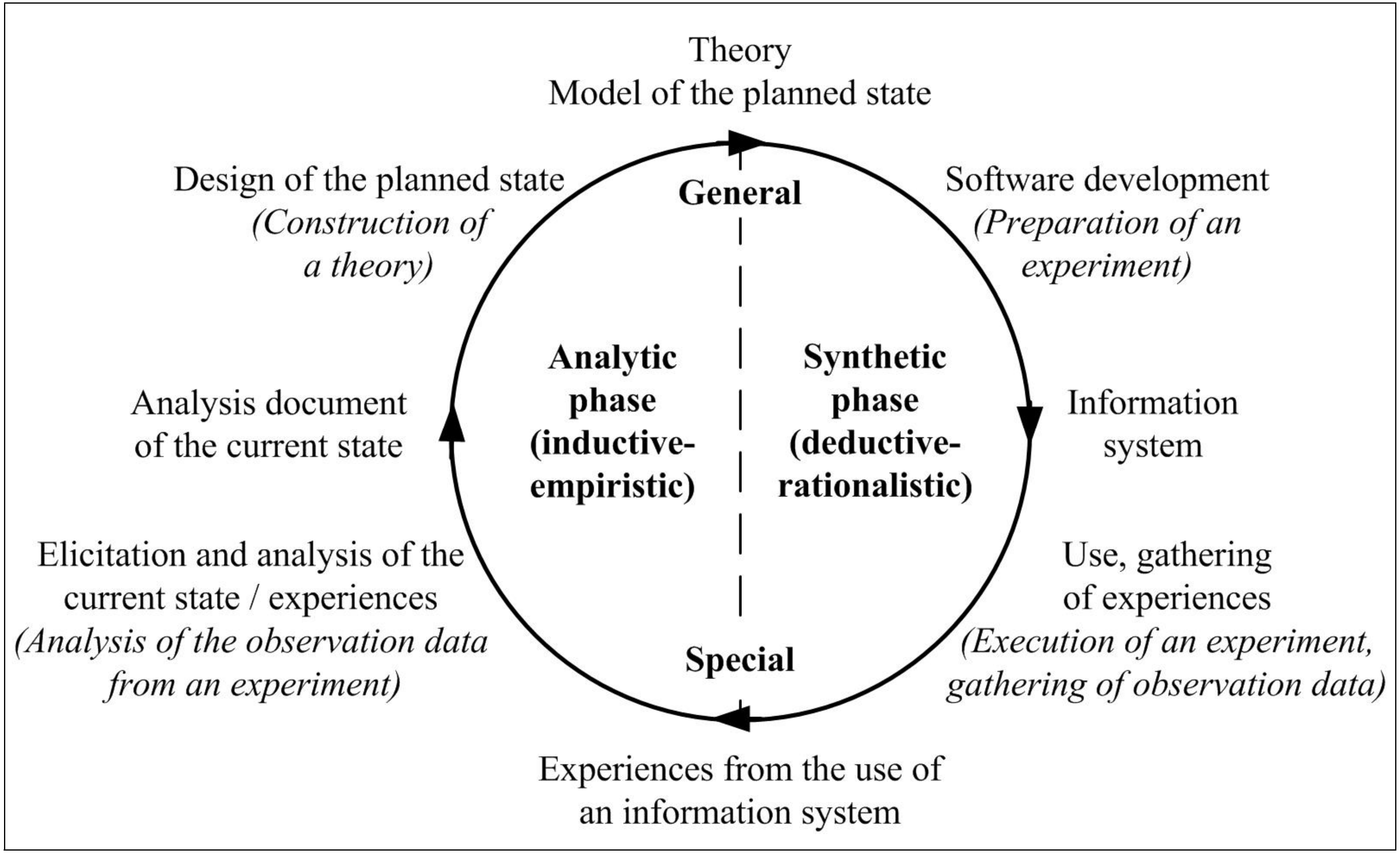
which leads to four cubic equations in four variables (difficult!).

Solution:

$$\sum_{j=1}^{n} j^2 = \frac{n \cdot (n+1) \cdot (2n+1)}{6}$$

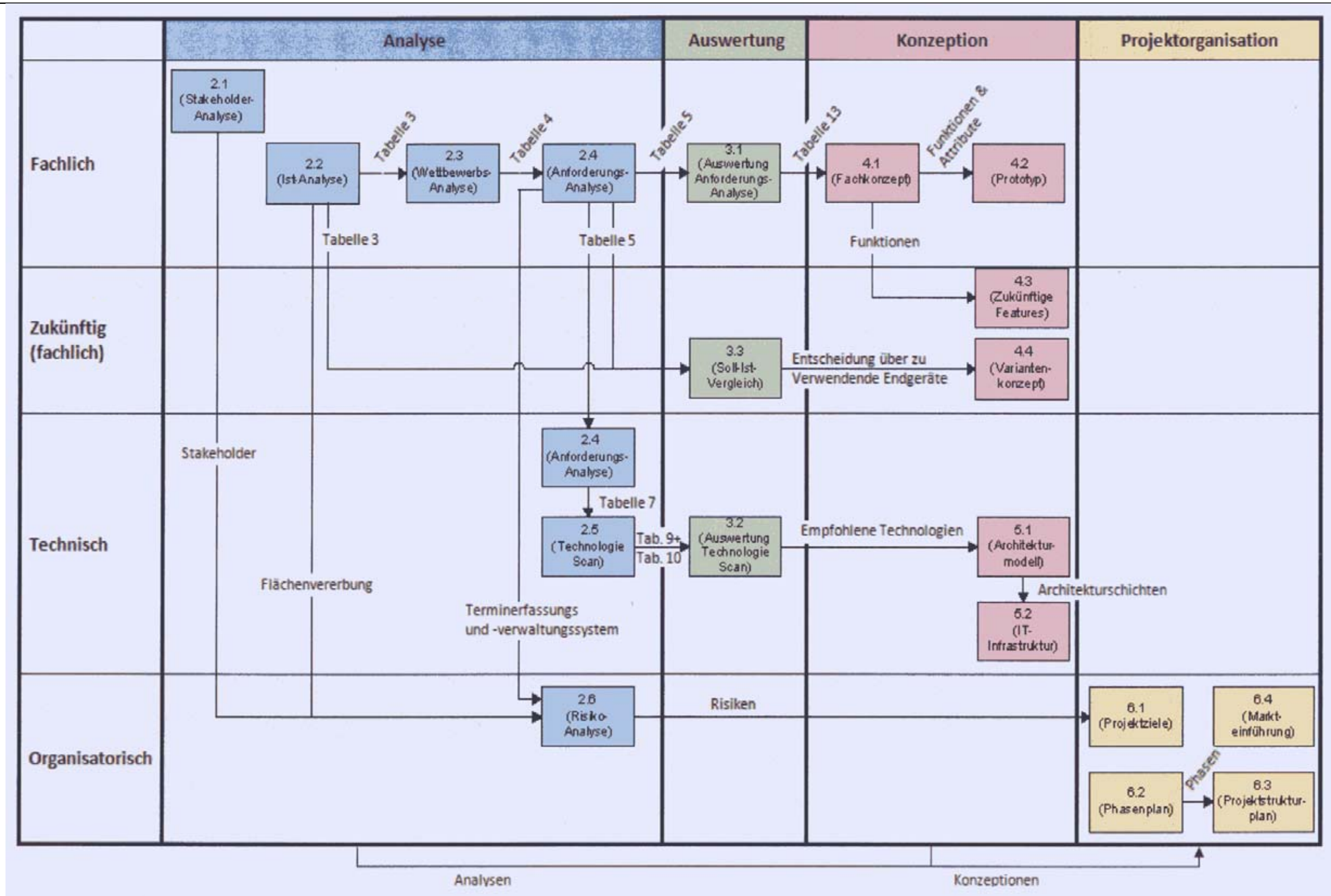
Proof with mathematical induction.

4.1 Cyclic inductive-deductive refinement



(Holl / Paetzold / Breun, IS anti-aging, 2008; according to Holl, 1999, 175)

5.1 Problem structuring in a master’s thesis: network modeling



5.2 Problem structuring in a master's thesis: method matrix

Description / motivation of the structure (from where? how? where?)

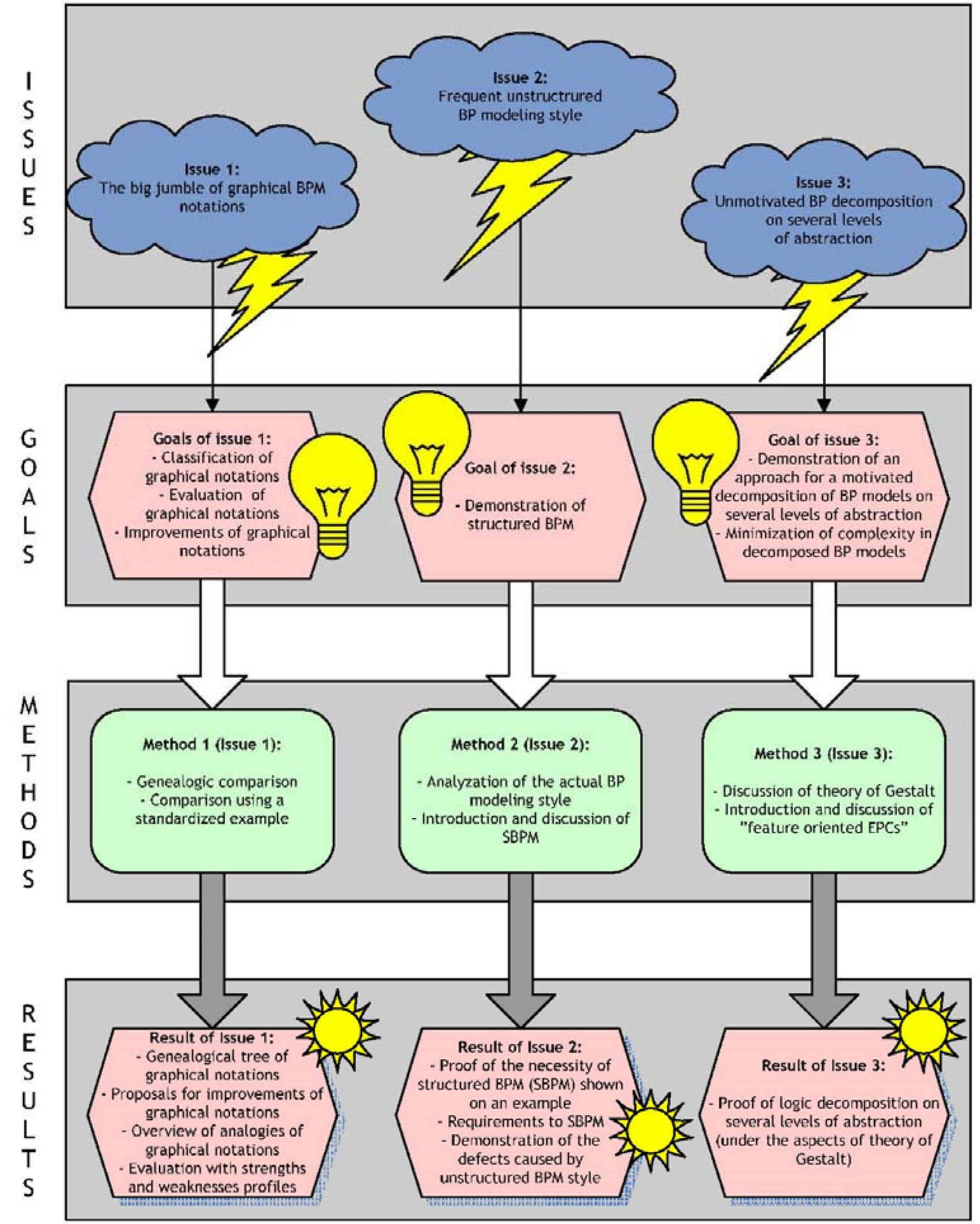
- Starting point of your thesis: what do we know? Where are the problems?
  Clear description of research questions / scientific issues

- Exact definition of the objectives (to answer the research questions),
  description of your task in detail;
  motivation: what is the purpose of your thesis? What are you aiming at?
  Objectives: reachable, pragmatic, not too optimistic / high / broad

- Motivation of the selection of the methods used and
  the way how the methods are applied
  (how shall the objectives be reached) and
  motivation of the use of particular methods.

5.2 Problem structuring in a master's thesis: method matrix

	Where from? Starting point scientific issues	Where? Definition of the objectives	How? Methods (and their use)	What? (Form of the) Results
Entire thesis				
Chapter 1				
Chapter 2				
Chapter 3				
etc.				


ISSUES
Issue 2:
Frequent unstructrured
BP modeling style
Issue 1:
The big jumble of graphical BPM
notations
Issue 3:
Unmotivated BP decomposition
on several levels
of abstraction
GOALS
Goals of issue 1:
- Classification of graphical notations
- Evaluation of graphical notations
- Improvements of graphical notations
Goal of issue 2:
- Demonstration of structured BPM
Goal of issue 3:
- Demonstration of an approach for a motivated decomposition of BP models on several levels of abstraction
- Minimization of complexity in decomposed BP models
METHODS
Method 1 (Issue 1):
- Genealogic comparison
- Comparison using a standardized example
Method 2 (Issue 2):
- Analyzation of the actual BP modeling style
- Introduction and discussion of SBPM
Method 3 (Issue 3):
- Discussion of theory of Gestalt
- Introduction and discussion of "feature oriented EPCs"
RESULTS
Result of Issue 1:
- Genealogical tree of graphical notations
- Proposals for improvements of graphical notations
- Overview of analogies of graphical notations
- Evaluation with strengths and weaknesses profiles
Result of Issue 2:
- Proof of the necessity of structured BPM (SBPM) shown on an example
- Requirements to SBPM
- Demonstration of the defects caused by unstructured BPM style
Result of Issue 3:
- Proof of logic decomposition on several levels of abstraction (under the aspects of theory of Gestalt)

6 Appendix

6.1 Function point method: weighted aspects (pros, cons)

6.2 Decision table

6.3 Examination of the context / environment of a problem
(Ex.: improve the purchase processes …)

Etc. etc.