14. Basic Solution Design and Invention

Lecturer: Dr. Sebastian Götz

Prof. Dr. Uwe Aßmann
Softwaretechnologie
Fakultät Informatik
Technische Universität Dresden
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http://st.inf.tu-dresden.de/teaching/acse

DRESDEN concept
Exzellenz aus Wissenschaft und Kultur

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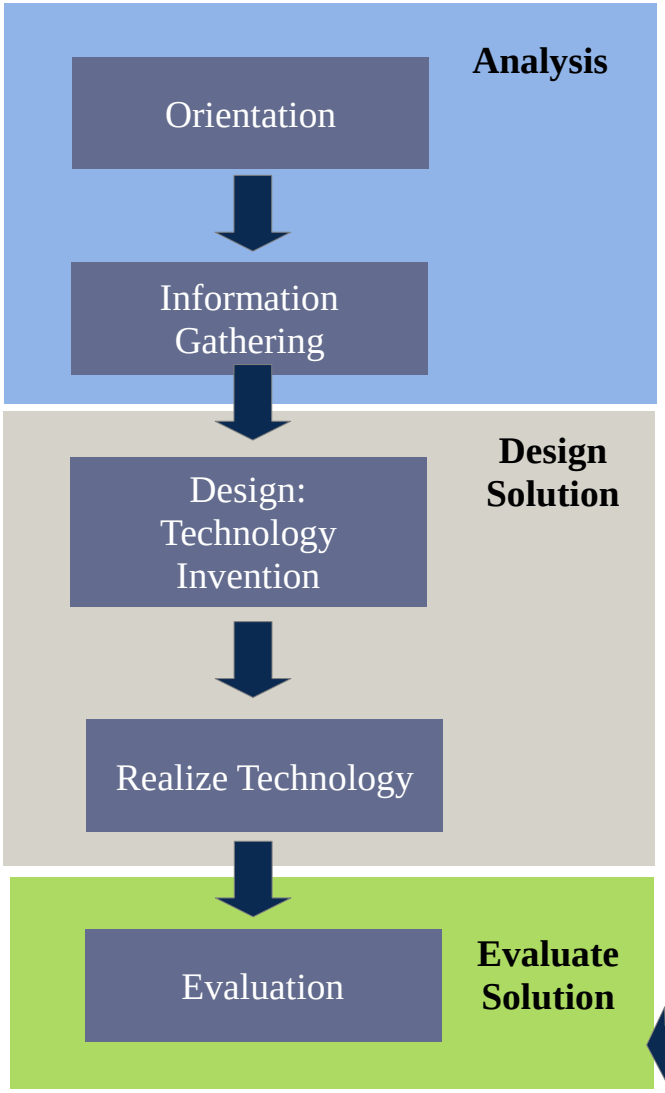
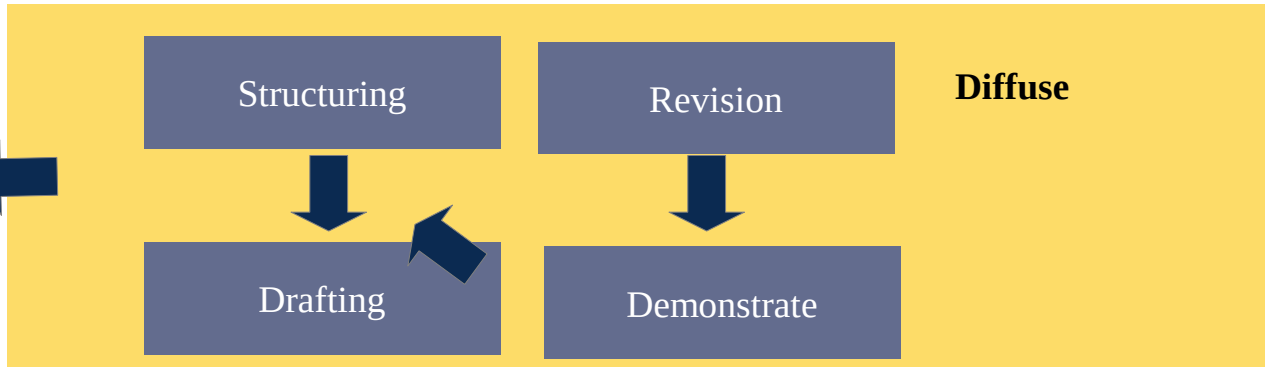
The AD-R-ED Research Process for Technical Science Thesis



- For technical science, in particular software engineering, a ***realization phase*** is required so that evaluation can take place
- In the technical sciences, a thesis must be *technical*, i.e., achieve and demonstrate a technical result.
- Success factors have to be analyzed to know whether a result is really needed

- Requirements of the solution
- Solution design, invention
- Design alternatives, assessment and selection
- Architecture development

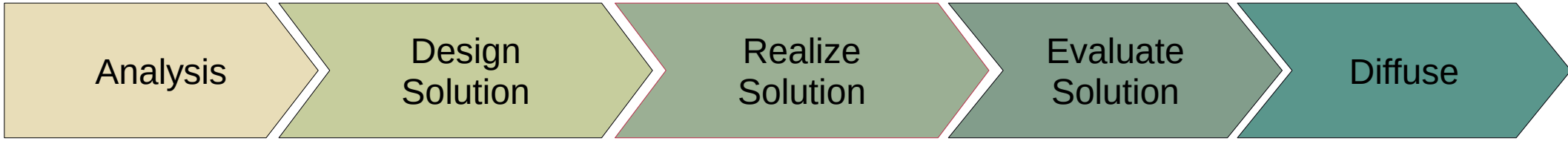
- Realize the architecture (implement components)
- Tune the system
- Stabilize the system for better quality (non-functional requirements)



Eternal Problems While Inventing

After problem analysis and literature analysis, solutions must be invented, designed, and selected.

Use systematic methods to
speed up finding a solution

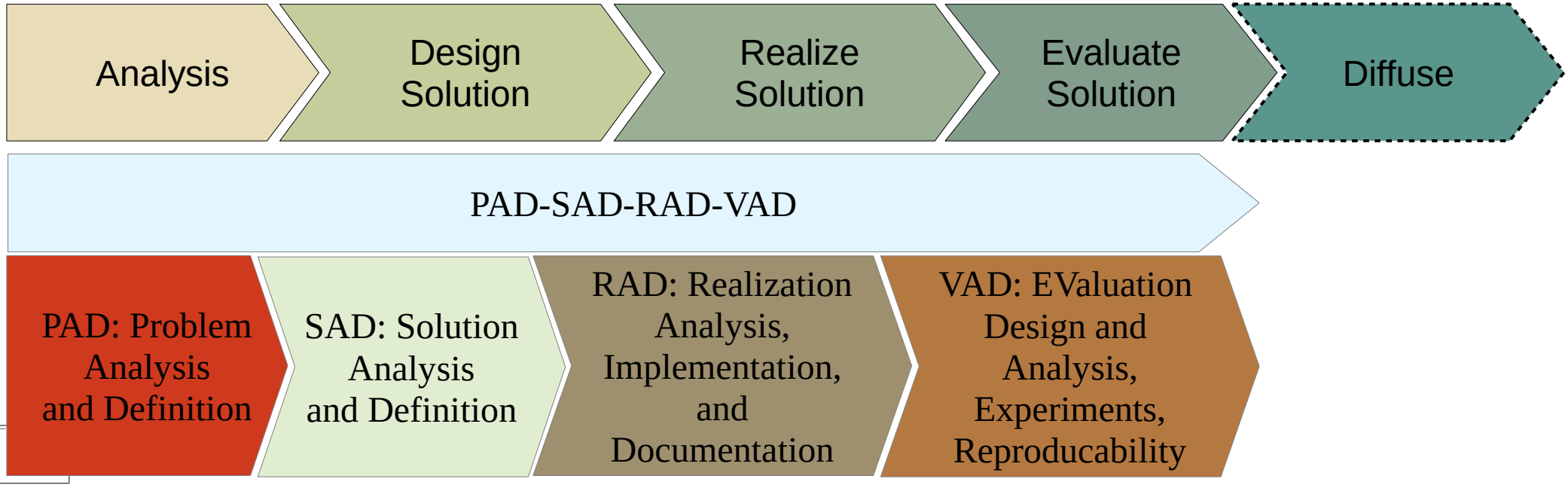


14.1 Complete Problem Solving Processes (PAD-SAD-RAD)

- A **problem solving process PSP** is a structured process to solve problems
  - Problem analysis and definition (PAD)
  - Solution analysis and design (SAD)
  - Realization analysis, Implementation, and Documentation (RAD)

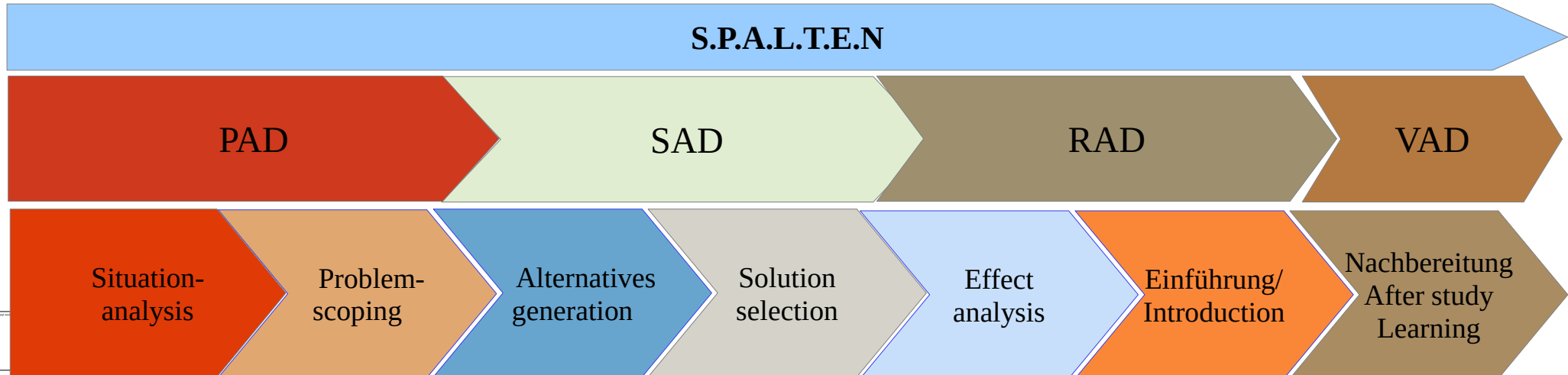
Complete Solution Processes Refine the First 4 Phases of ADRED

- For your research (Master's thesis, paper, etc.), you need a complete solution process
- Most often, problem-solving processes are driven by a problem analysis
- In general, there refine the 4 first steps ADRE of ADRED:
  - PAD: Problem analysis and definition
  - SAD: Solution analysis and design
  - RAD: Realization Analysis, Implementation, and Documentation
  - VAD: EValuation Design and Analysis
- PARGESI, SPALTEN, and DesignThinking are fantastic solution processes for your Master's thesis and PhD thesis



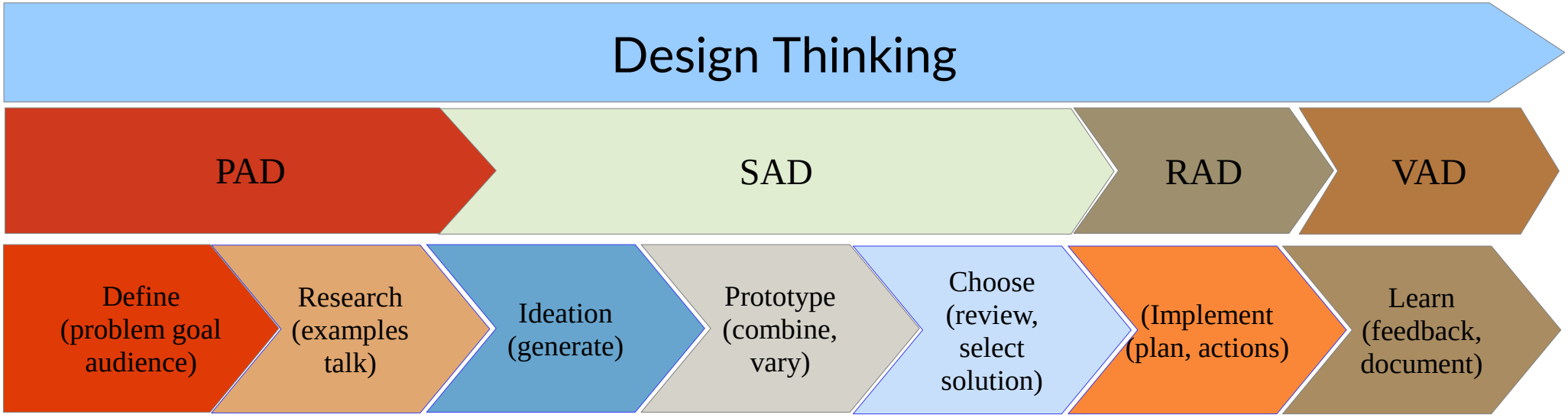
S.P.A.L.T.E.N. is a Solution Process with Assessment of Multiple Solutions

- SPALTEN is a problem solving process. Steps: [Albers]
  - PAD: Problem analysis and definition:
    - Situation analysis (Ist-Analyse, literature analysis)
    - Problem analysis (demarcation, scoping, identification)
  - SAD: Solution analysis and design with idea generation, evaluation and selection:
    - Alternative generation (ideation, solution identification and generation)
    - Evaluation (Assessment)
    - Selection (Prioritization)
  - RAD: Realization Analysis, Implementation, and Documentation
    - Effect, risk and consequence analysis
    - Introduction (measures and processes)
    - After study and learning, documentation



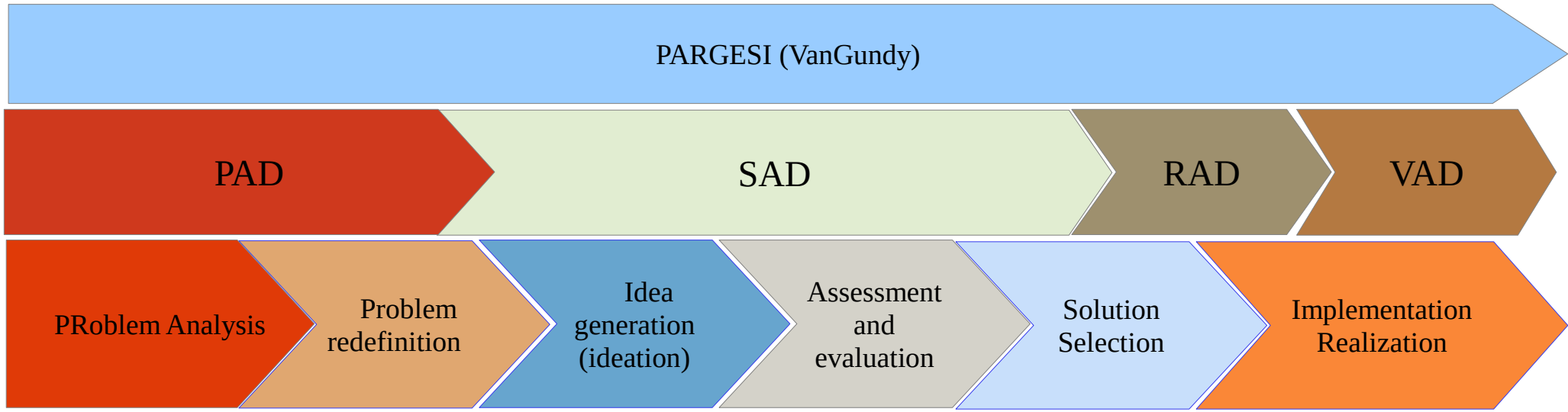
“Design Thinking” is a Solution Process with Prototyping and Assessment of Multiple Solutions

- Similar to SPALTEN, but using prototyping to test and select ideas
- Used by D-School in Stanford and HPI in Potsdam



Problem Solving with VanGundy Problem Solving Method PARGESI

- [VanGundy-ProblemSolving] contains a structured, very general process to solve structure problems: PARGESI
  - Problem analysis and Redefinition: It is an experience that the first problem definition is not stable, but must be reiterated.
  - Generating Ideas
  - Assessment and Evaluation of Ideas
  - Selection of ideas
  - Implementation and Realization



Write a Project Plan (GANTT) for the Solution Process of Your Next Project

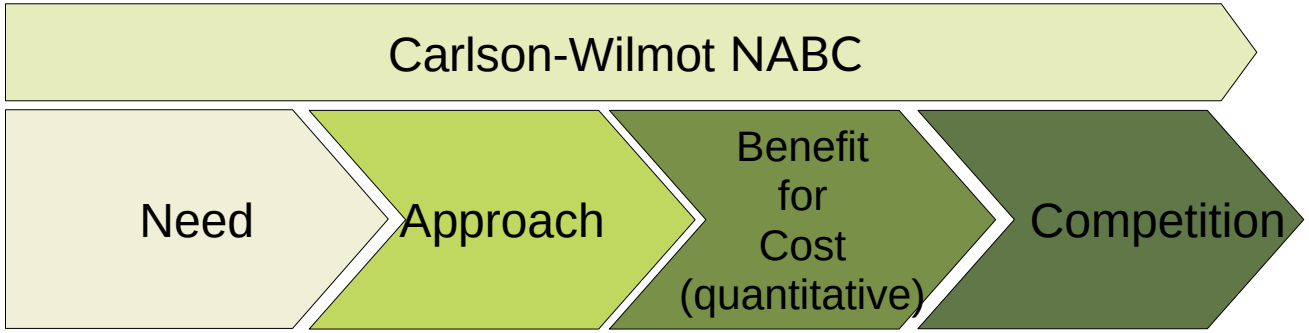
- PARGESI, SPALTEN, DesignThinking are fantastic solution processes for your Master's thesis
  - Write a project GANTT chart
  - Estimate weeks for every phase
  - What would you prefer for your Master's thesis?
- For a PhD thesis, they have to be iterated several times

14.2 NABC Value Proposition of Carlson/Wilmot

nABC Analysis [Carlson-Wilmot]

What does the customer really need?
What is of value for her?
What is a *pain* for the customer?

How does your company solve the needs of the customer?
How does it create value for her?



How efficient is the solution?
How large is the benefit?
How large are the costs?
If possible, measured quantitatively

Who is in the market already?
What are your competitors

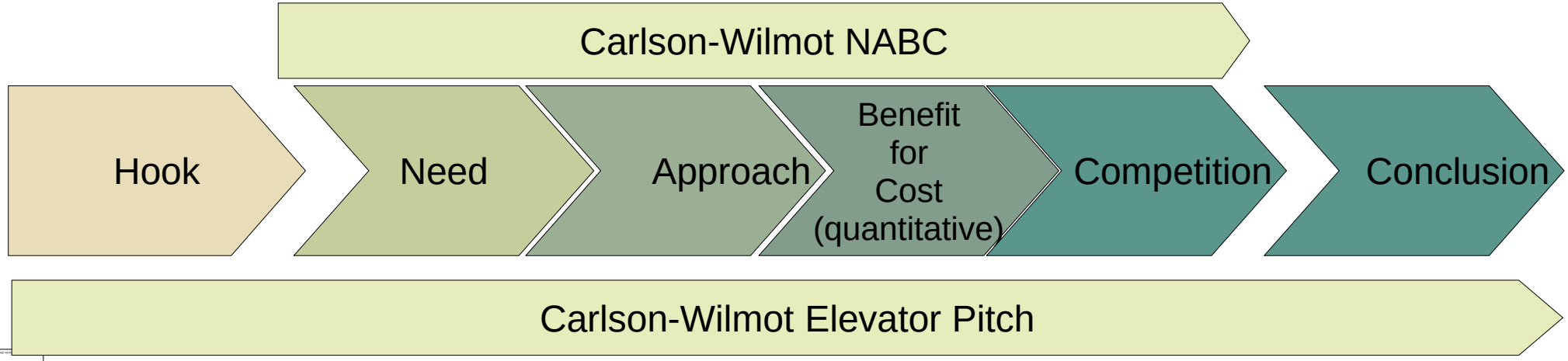
NABC Value Proposition

- After doing a ZOPP, you also should do an NABC Value Proposition [Carlson/Wilmot] and an elevator pitch
- The Value proposition is more directed to customers of your PhD thesis than to other scientists
- It explains ordinary people what your research is about, which need it solves

14.2.1 Elevator Pitches

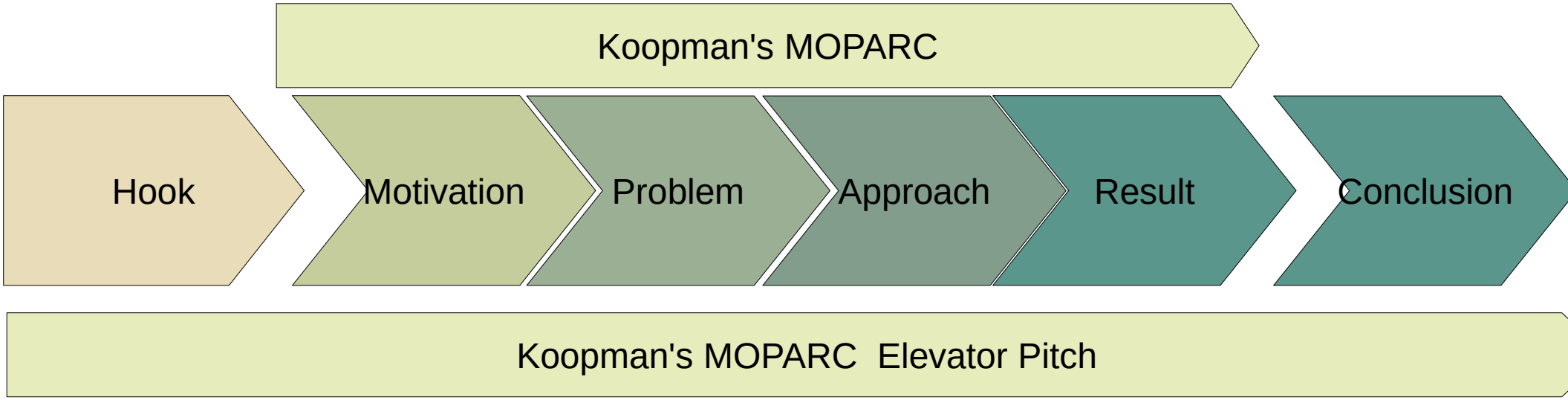
NABC Elevator Pitches

- An ***elevator pitch*** is a 2-minute speech about the NABC of your project
- You should be able to tell it
  - an important investor in an elevator (2 min)
  - your professor
  - your grandmother
- It combines a problem solving scheme with a hook, a gripping introductory remark.
- Very good: use NABC with a hook and quantitative benefit-for-cost.
- my solution is 30% better than the competitors'



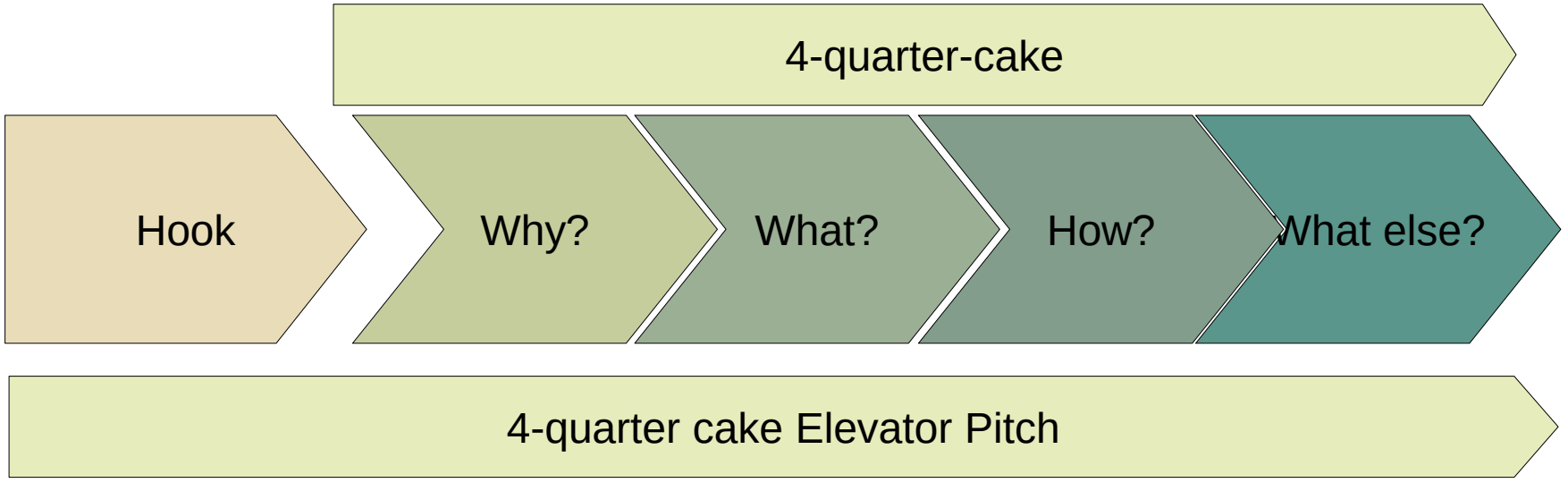
Elevator Pitches

- Philip Koopman has a scheme for abstract writing which is also good for Elevator Pitches



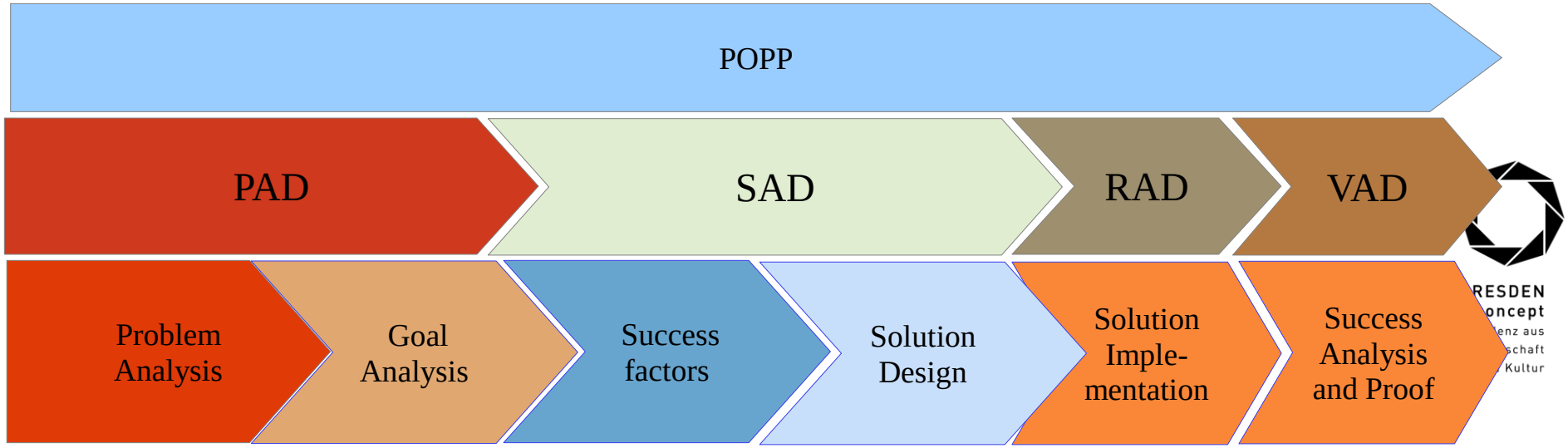
Other Elevator Pitches

- The 4-quarter cake of Vigenshow can also be used (uses honest serving men)



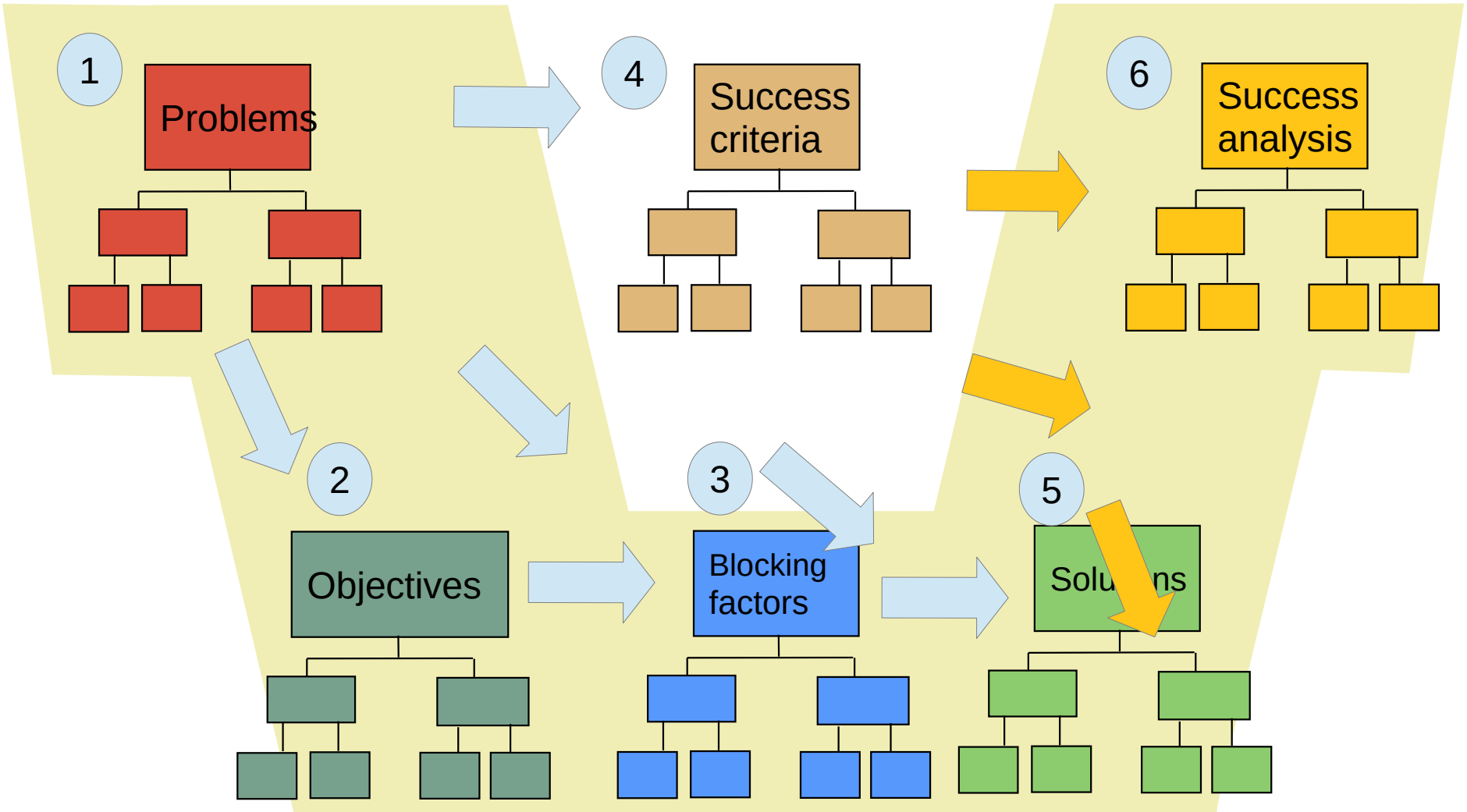
14.3 Variants of Hierarchical POPP

- POPP/ZOPP and its variants are simple Solution Design Processes
- Hierarchic, no alternative generation, covering of all problems provable



Hierarchical Problem and Goal Analysis with Blocking Factors (B-POPP)

- Sometimes, it is possible to determine ***blocking factors*** preventing that the objectives are reached.
- B-POPP is a ZOPP-like problem and efficiency analysis that checks blocking factors preventing that objectives are reached.



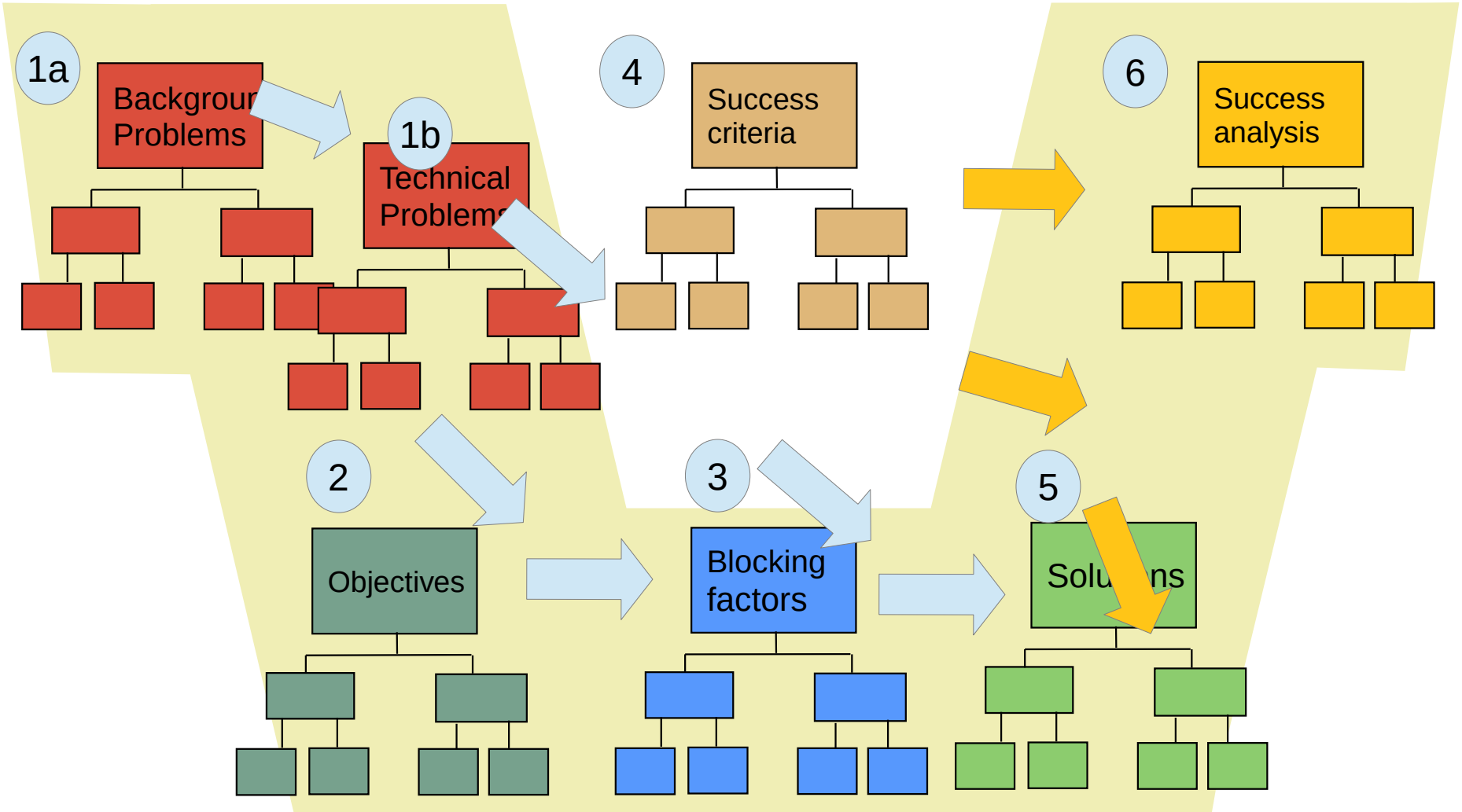
14.2.1 BATE-POPP for Papers

POPP For Your Research

- For all kinds of research: Bachelor, Master, PhD thesis, Research paper, Essay, Analysis study
- Do a variant of POPP and refine it over all the duration of the research
- Benefits:
  - If you do not solve a real problem, your research is not relevant
  - Goal analysis helps to think
  - Hierarchical goal analysis helps to focus on the more important issues
  - If your decomposition of the problem is good, you may say something about the solution's coverage of the problem:
    - Did I forget to solve a subproblem or are all problems solved? How complete is the solution?
- Benefits for your reports
  - Usually a good ZOPP or B-POPP gives you an introduction for free: just write a paragraph or a section on each of the steps
  - In particular, the research contributions (research results) become very clear.
  - An entire report can be structured like ZOPP or B-POPP

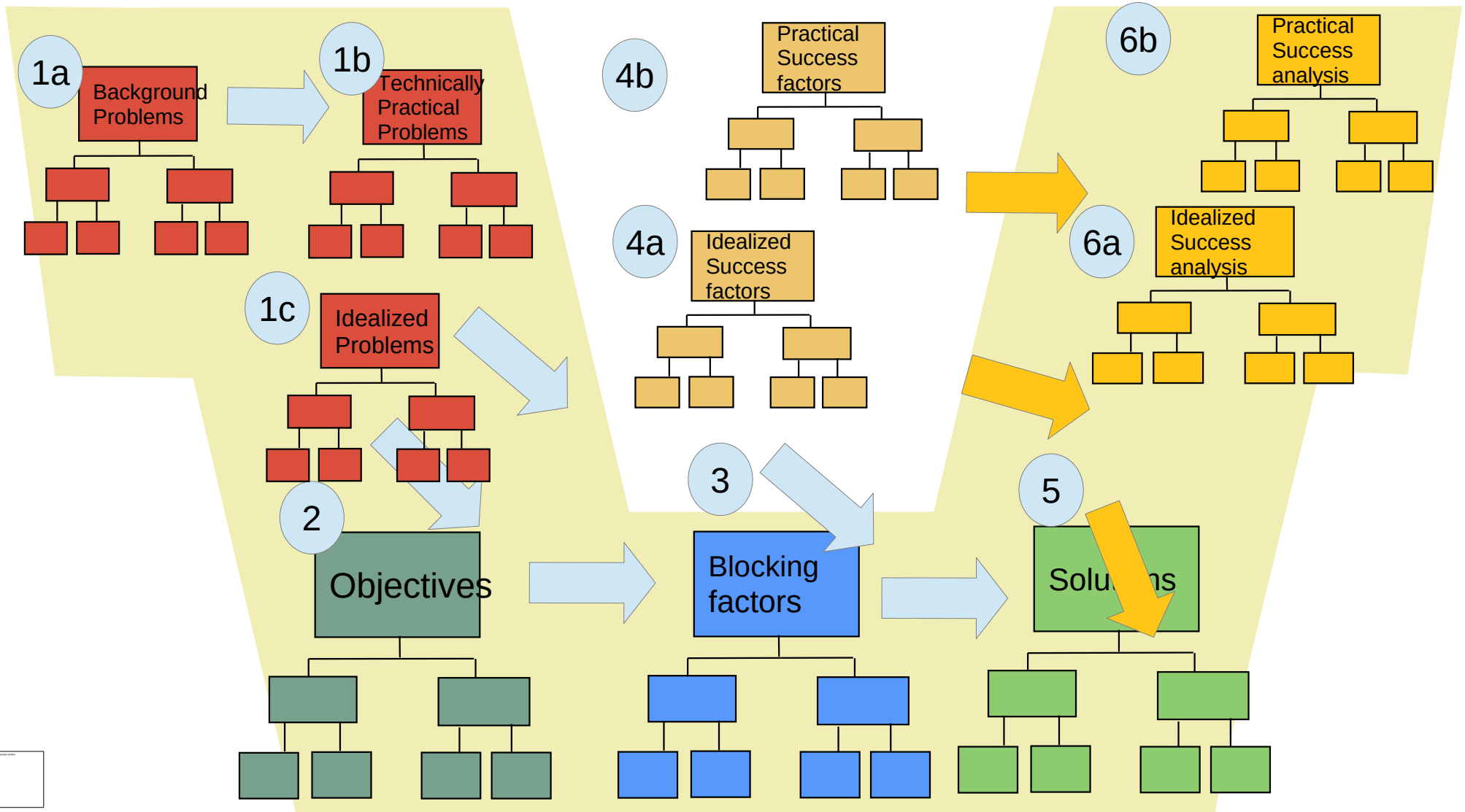
Improved BATE-POPP

- For technology research, it is useful to split problems into background and technical problems
- Background problems show economic, societal, ethical importance
- Good for research project proposals!



Improved BATEID-POPP for Theorem Papers

- For idealized research, it is useful to split problems into background and technically practical, and idealized (model) problems
- Split also success factors and success analysis: This is called funnelling

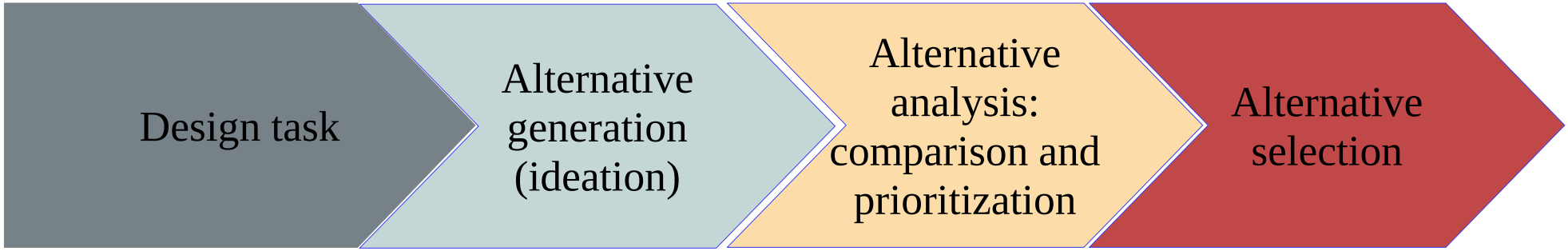


14.5 Solution Design (SAD) with SGAP: Generation of Ideas, Alternative Analysis, and Prioritization

- When there is not only one solution idea, but many, ideas have to be compared and prioritized
- [VanGundy-ProblemSolving]

Motivation: How to Develop Your Chapter on “Design” or “Architecture” in your Bachelor/Master Thesis

- So far, all solution processes have the disadvantage that they are happy if they find one solution
- In a design phase of a thesis, not only one design should be investigated, but several alternatives
  - They should be compared, assessed and documented in the report (alternative analysis)
- Technical science motivates the selection of a best technology according to assessment criteria
- Your work is not scientific if you just choose the first solution and do it



Generation of Prioritized Lists with SGAP

- SGAP (Solution Generation → Assessment → Prioritization) is a fine-grained SAD process separating assessment and prioritization
  - For assessments and prioritizations of ideas, problems, solutions, risks, etc.
  - For alternatives if difficult decisions have to be taken

Generation of Solution Ideas (Identification, Elicitation, Ideation) → **Assessment (Rating, Scoring, Grading)** → **Prioritization (Ordering, Selection)**

Thinking
Clustering
7-W questions
Structure Trees
Brainwriting
Brainstorming
Delphi-Studies
Checklists

Isolated Assessment and **Grading**

Metrics (on scales)
onedimensional
multidimensional

Comparative Assessment and Selection

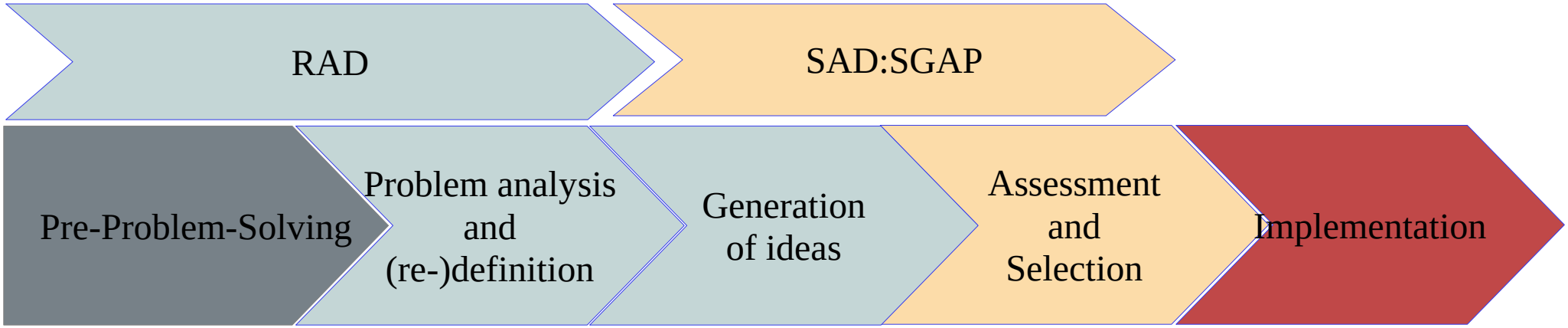
single-criteria analysis
multi-criteria analysis
and optimization

Scientific Aspect of SGAP for Design Chapters of Final Theses

- For a problem of technical science, usually, several designs exist (tool and software architectures, etc.)
- Though one design must be selected, the alternatives should be
  - G: generated (invented, developed, documented)
  - A: assessed (evaluated individually)
  - P: prioritized (evaluated individually), ordered and selected
- A good design chapter discusses several alternatives and why the chosen design is the best!

Embedding of SGAP in the VanGundy Problem-Solving Process

- [VanGundy, Kap.2] uses SGAP, but combines Assessment and Selection
  - This book has many techniques, both for individual and group processes



Variation and Extension Method for Ideation

- Variation Method about Variability Analysis [Hill, Zwicky]
  - In a basic solution, try to find variables (variation points) which might be changed. In specifications or designs, the variables are called variation points
  - Analyze their range: which values may they take?
  - Change the variables
  - Build variant solutions
- Extension Method, Extensibility analysis
  - In a basic solution, try to find variables which might be extended. In specifications or designs, the variables are called extension points
  - Analyze their range
  - Extend the variables
  - Build variant solutions

14.6 Assessment and Prioritization Methods

- Comparative Analysis: how do approaches of the literature compare?
- Advance Analysis: how far advanced is my approach?

Prioritization with Simple Numeric Grading (Ordinal Scales)

- Traffic lights: Valuate with red, green, yellow
- School grades: Assessment with 5 points
- “A-Level-grading”: Assessment with 15 points
  - multiply school grades by 3
- “Percent grading”: express the adequateness as a quotient of value and whole (20%, 81%, 2/3, ¼, etc.)
- “Identify the Champion” for taking an explicit standpoint and forcing of decisions (Oscar Nierstrasz)
  - A: I fill fight for it
  - B: I am in favor, but I will not fight for it
  - C: I am against, but I will not fight against it
  - D: I will fight against it

[Hill]

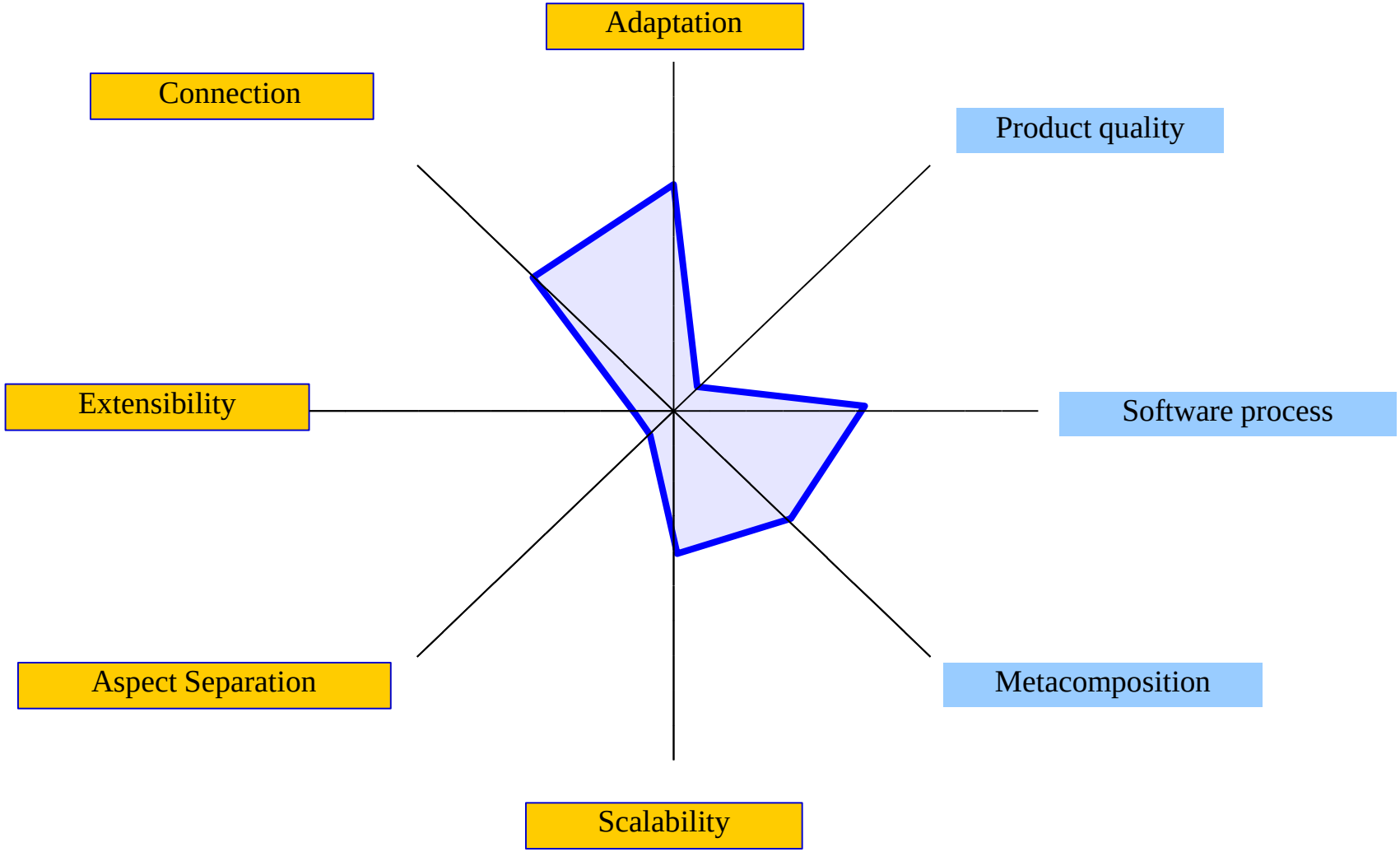
A Simple Form of Assessment and Binary Prioritization: de Bono's PMI (Plus-Minus-Interesting)

Plus	Minus	Interesting

- [DeBono] introduced a very simple 3-step for thinking about decisions
- Do this really sequentially, i.e., do not add Plusses if you are working on Minuses or Interesting
- The third category “interesting” helps to find out whether the arguments on Plus or Minus are really important
- PMI can be used for Discussion parts, Idea, topic, argument generation

Multi-Criteria Attribute Analysis with Kiviat-Graphs

- A Kiviat-Graph draws a vector from an n-dimensional space into the plane.
- It visualizes a multi-criteria analysis



Assesment can be on Olympic Questions or Efficiency Questions

- Approaches, ideas, and solutions can be evaluated with regard to
  - Olympic criteria (faster, higher, farer) or
  - Efficiency criteria (cost vs utility)

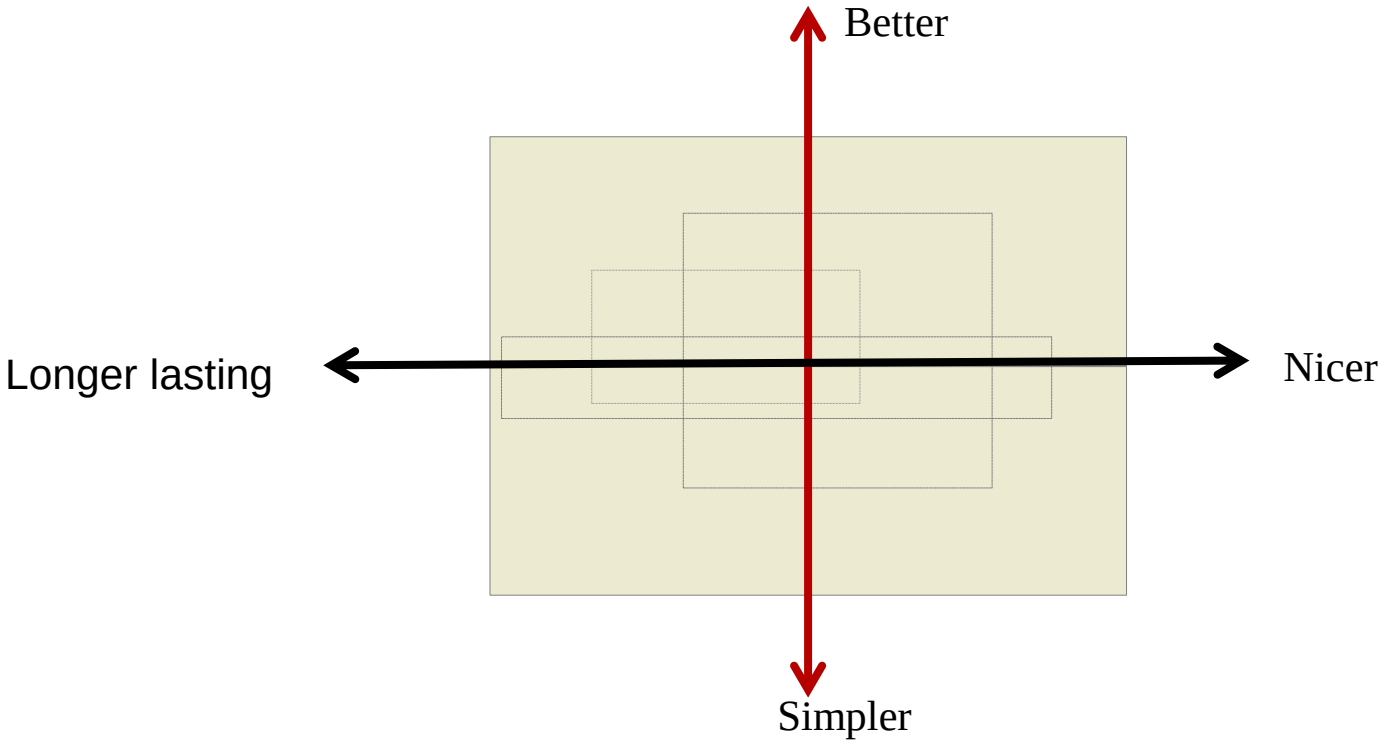
14.6.1 Examples for Multi-Criteria Analyses

Quantitative and Qualitative Comparisons for Olympic and Efficiency Success Criteria

- An **olympic research problem** is about increasing benefit or reducing cost
- An **efficiency research problem** is about doing both

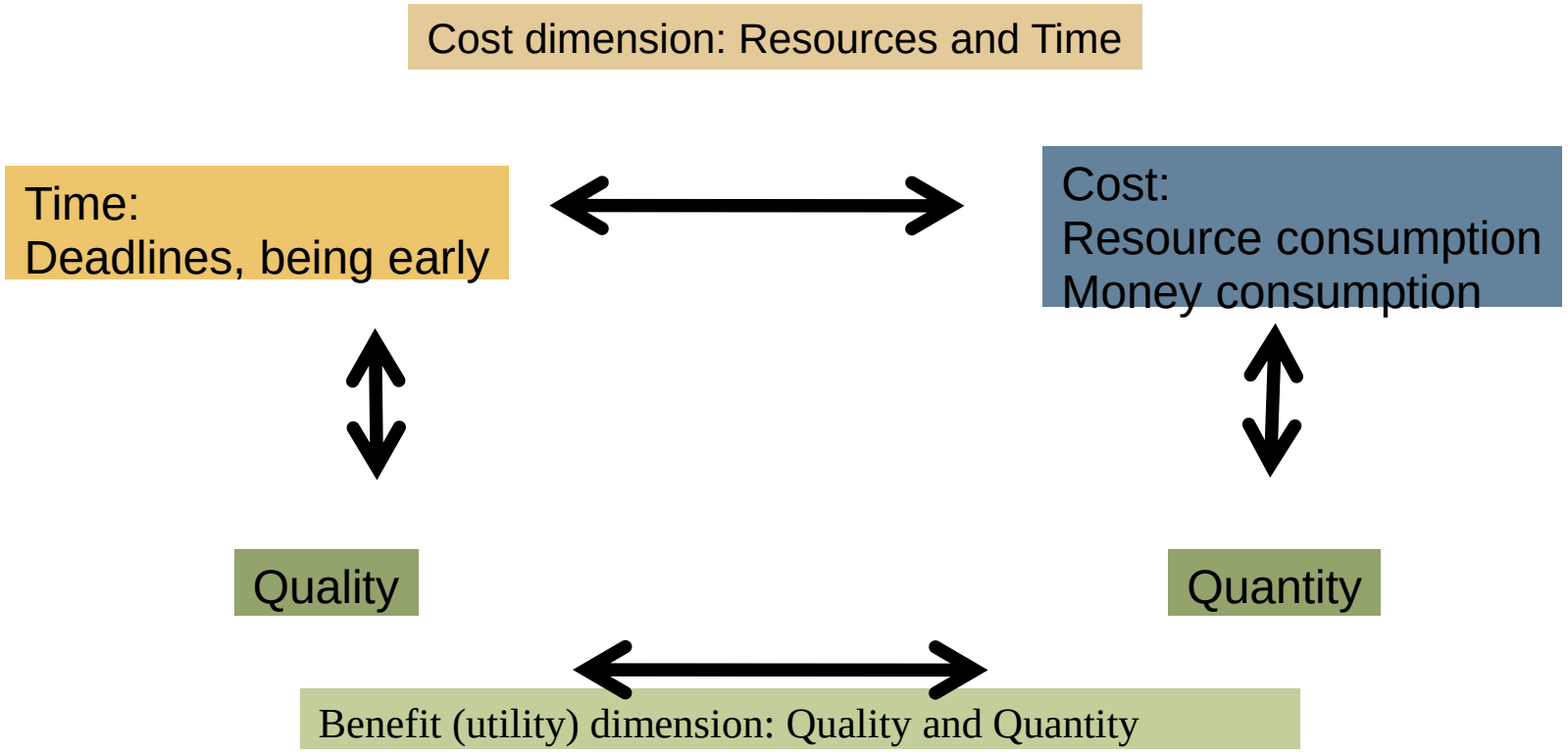
Olympic Assessment with BeNeSiLo – Which Progress are we interested in?

- **BeNiSiLo** is a 4-D attribute analysis utility (olympic), measuring progress qualitatively or quantitatively (Better, Nicer, Simpler, LongerLasting)
  - Larger rectangles denote greater utility
- Enter your own technology and competitors into BeNeSiLo for qualitative or quantitative olympic analysis
- Qualitative comparison: without scales
- Quantitative comparison: with scales (e.g., ordinal)



“Magic Rectangle” Efficiency Analysis for Research and Projects (CoTiQQ Diagram)

- Many research problems in technical science deal with benefit (utility) or cost (resource consumption)
- These are efficiency problems: increase benefit while reducing cost
- These are related to efficiency goals



14.6.2 Comparative and Advance Analysis in Tabular Form - Comparisons for Approaches with Regard to Success Criteria

- Advance analysis compares a set of approaches in the literature with regard to some success attributes/criteria/factors.
  - These criteria may stem from a literature analysis or classification.
  - The comparison is usually multi-criteria.
  - Display with tables, kiviat, or portfolios.
  - Qualitative (boolean) or quantitative (scales)

Ex.: Boolean Advance Analysis

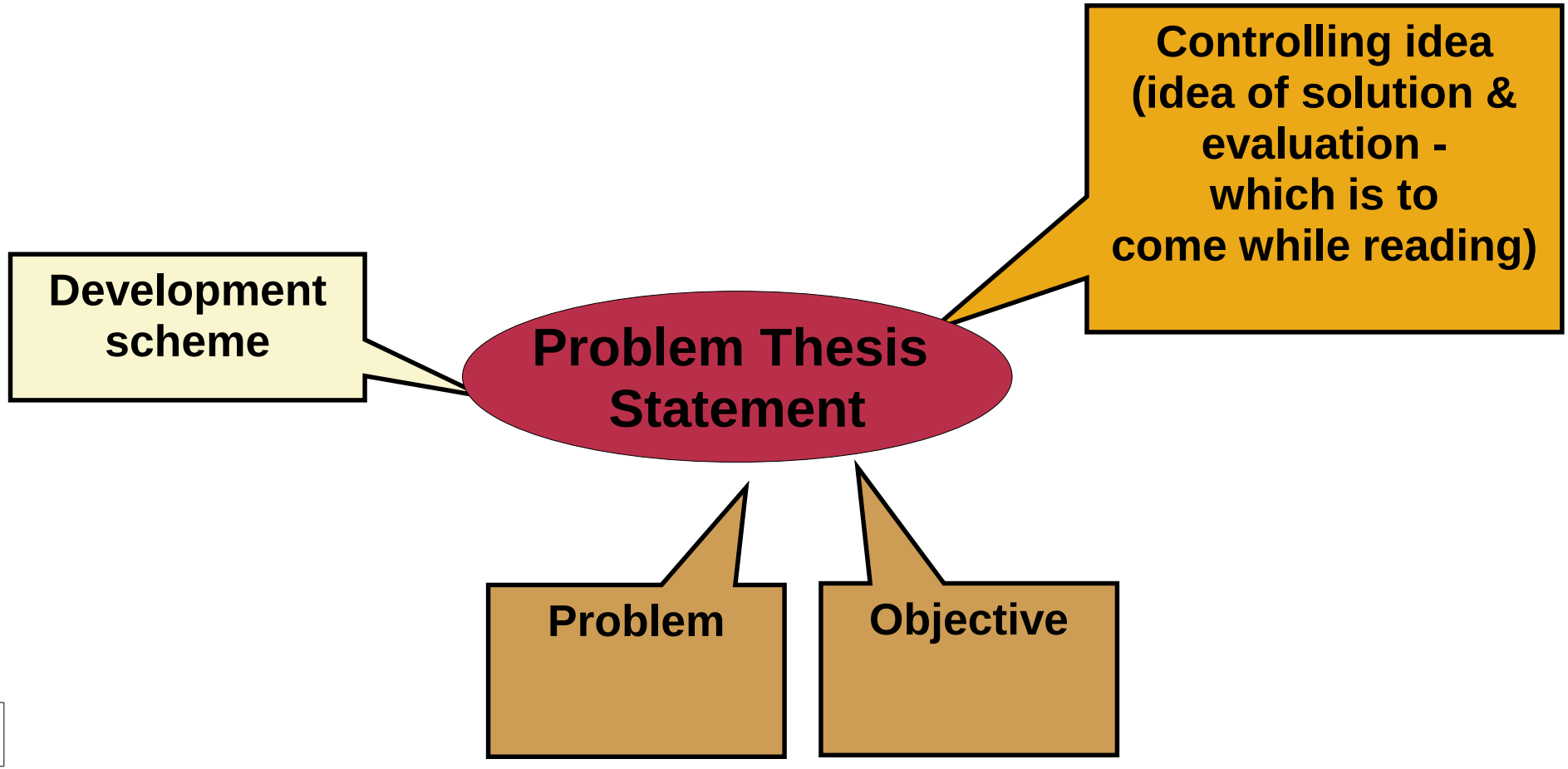
	Approach 1	Tool 2	Technology 3	My approach
Criterion 1	no	no	no	yes
Criterion 1.2	may be	yes	no	yes
Criterion 1.3	no	unclear	yes	yes
Criterion 2	yes	yes	no	yes
Criterion 3	yes	no	no	yes

- Boolean values in the multi-criteria analysis

14.8 Writing Problem, Objective, Solution-Idea Analysis Papers (POS papers)

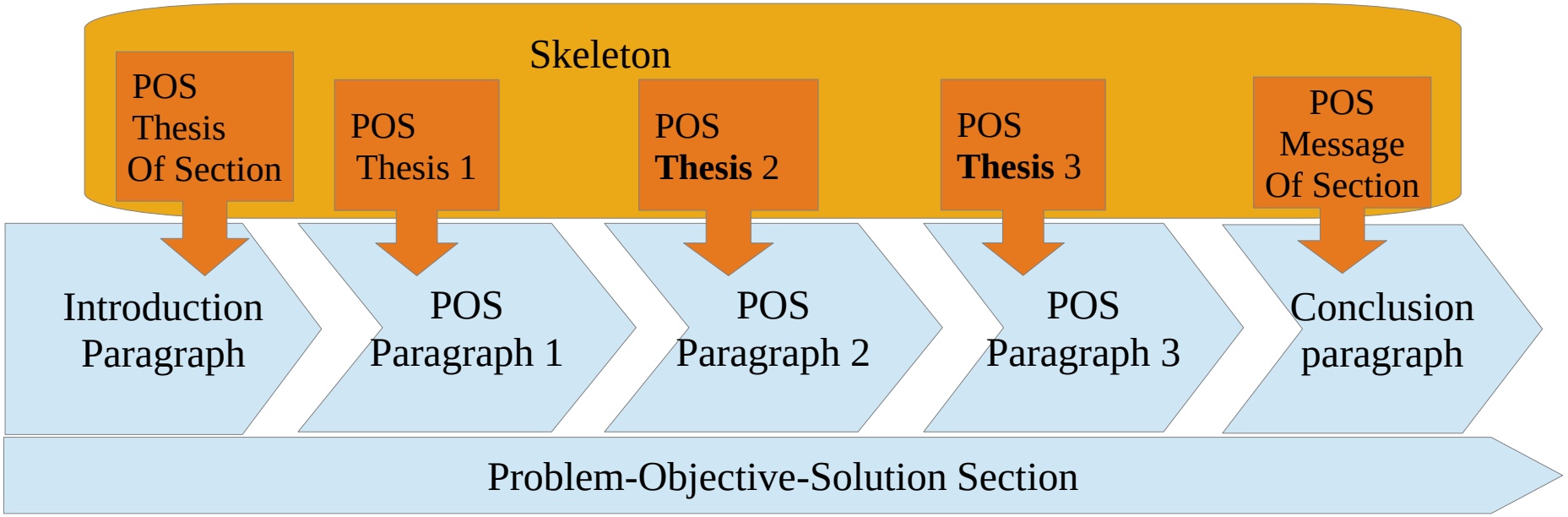
Problem, Objective & Solution (POS) Statements

- A Problem, Objective & Solution (POS) thesis statement is a thesis statement showing a problem, an objective and a solution
  - If evaluation is added, it is called POSE statement
- Thesis: Problem + Controlling idea (idea of solution+evaluation) + Development Scheme



Skeletons of Problem-Objective-Solution Sections

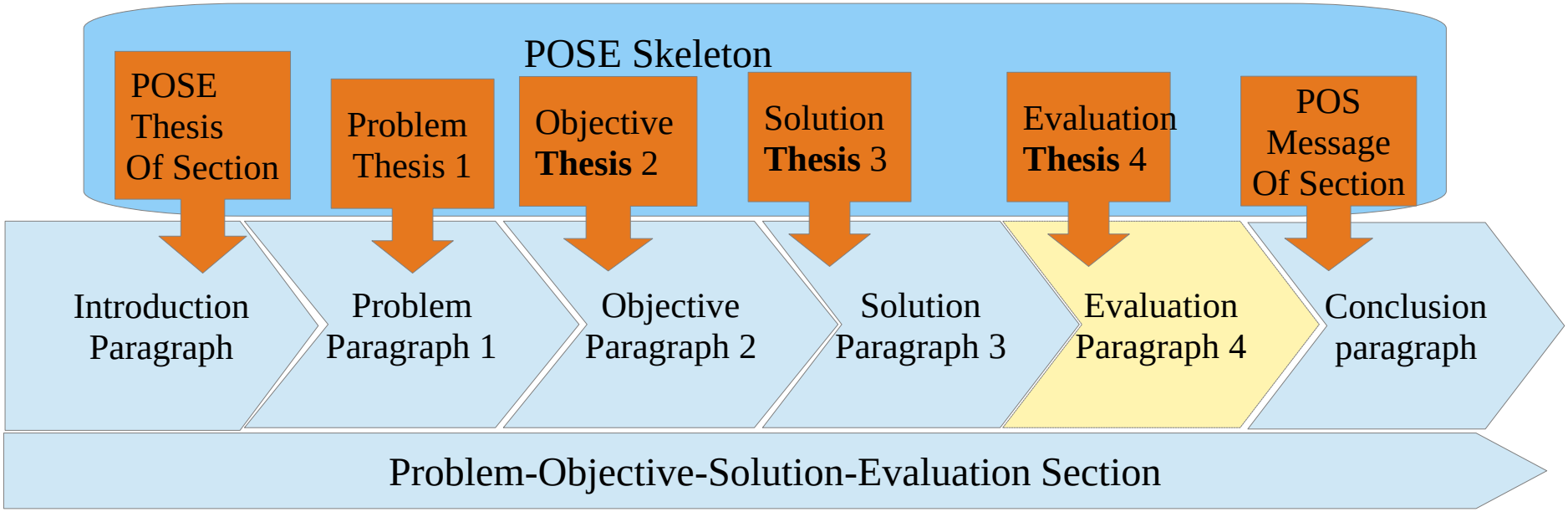
- The skeleton of a POS section is the sequence of all POS thesis statements of all paragraphs
- A problem section has unity if all problem theses of the paragraphs support its section problem thesis
- Problem sections may be positioned as section 2 or 3 of a paper



14.9 Writing Problem, Objective, Solution, Evaluation Papers (POSE papers)

POSE Introduction Sections

- A **POSE (problem-objective-solution-evaluation)** section gives an overview over a paper (introduction section)
- The POSE section has unity if all theses of the POSE paragraphs support the section thesis
- Sometimes, evaluation is not available – then it becomes a POS introduction



Why Do We Need Solution Design

- Every thesis needs a structured solution design method
- Many students loose time because they don't know any
- SPALTEN, DESIGN THINKING, ZOPP and other POPP methods are extremely valuable for YOUR thesis
  - to organize your thoughts
  - to write research exposés
  - to guide a reader through the work, or your defense talk
- Solution design processes organize your work systematically
  - make you much faster!
  - PAD-SAD-RAD is a 3-step schema for solution processes
- SGAP is important for finding alternative and evaluating solution ideas
- Olympic and efficiency comparisons are very important for
  - comparing your work to others
  - selecting the best ideas
  - showing other people why they are best
- Knowing and using different classes of questions opens a discussion, an ideation process, or closes it