TU Clausthal

Institute for Software and Systems Engineering

How to Write a Thesis, or a Research Paper

A Short Introduction

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License and Disclaimer

- Updated versions of these slides will be available in our Github repository.

- Special thanks to Prof. Dr. Alex Norta, who taught the course *“How to Conduct Research? Thinking, research methods, structuring publications”* at Tallinn University of Technology, which inspired and formed the foundation of this presentation.

INTRODUCTION

Introduction

Overview

- **How to write a thesis, or a research paper?**
  - What are the required theoretical concepts to write a good thesis/paper?
  - What is the general document structure?
  - What are the specific steps of writing your thesis/paper?

Introduction

The Creative Process

1) This is awesome
2) This is tricky
3) This is shit
4) I am shit
5) This might be OK
6) This is awesome

Introduction
“Why?”

- **Why should someone read your thesis/paper?**
  - Introduce and motivate your topic/problem statement
  - Describe the State of the Art (SoA)
  - Detect a knowledge gap
  - Close the knowledge gap by providing an answer to the problem statement

Introduction

Detecting a Gap

@Mattes:
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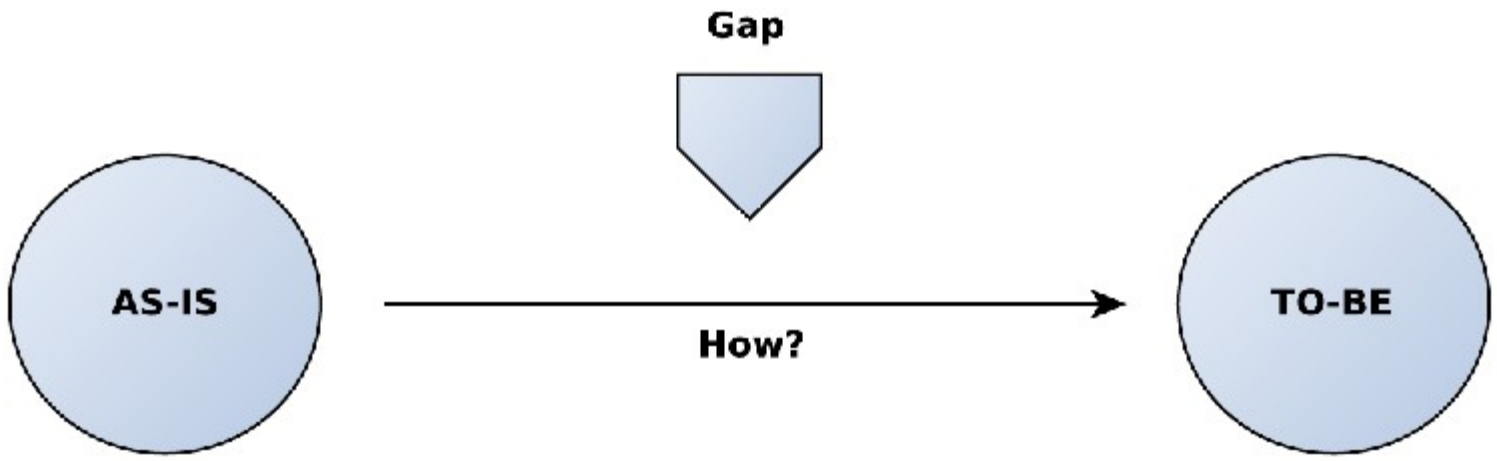

Introduction

Closing the Gap

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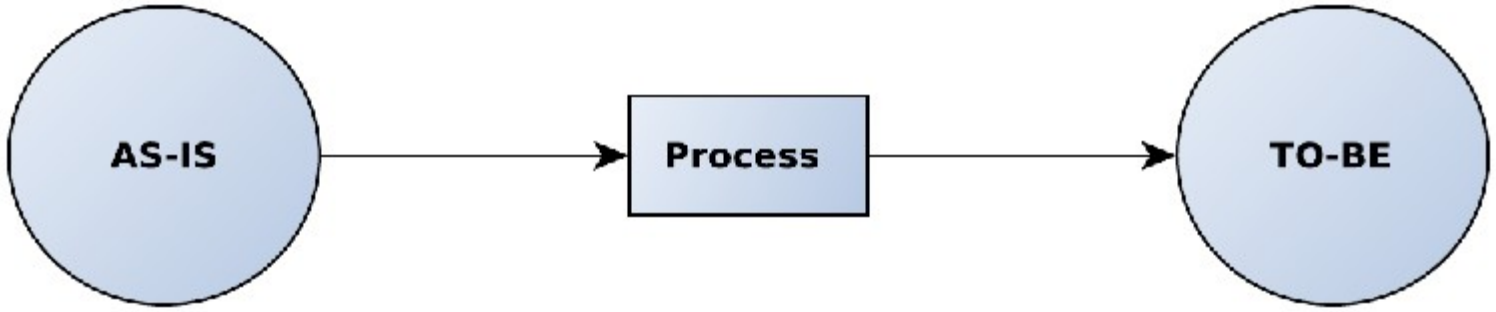

Introduction
Closing the Gap

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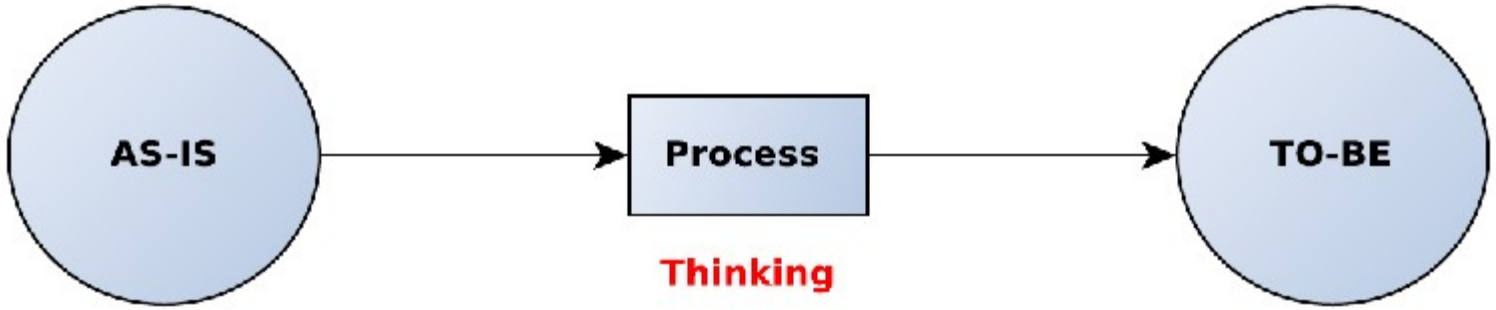

Introduction

Trivium

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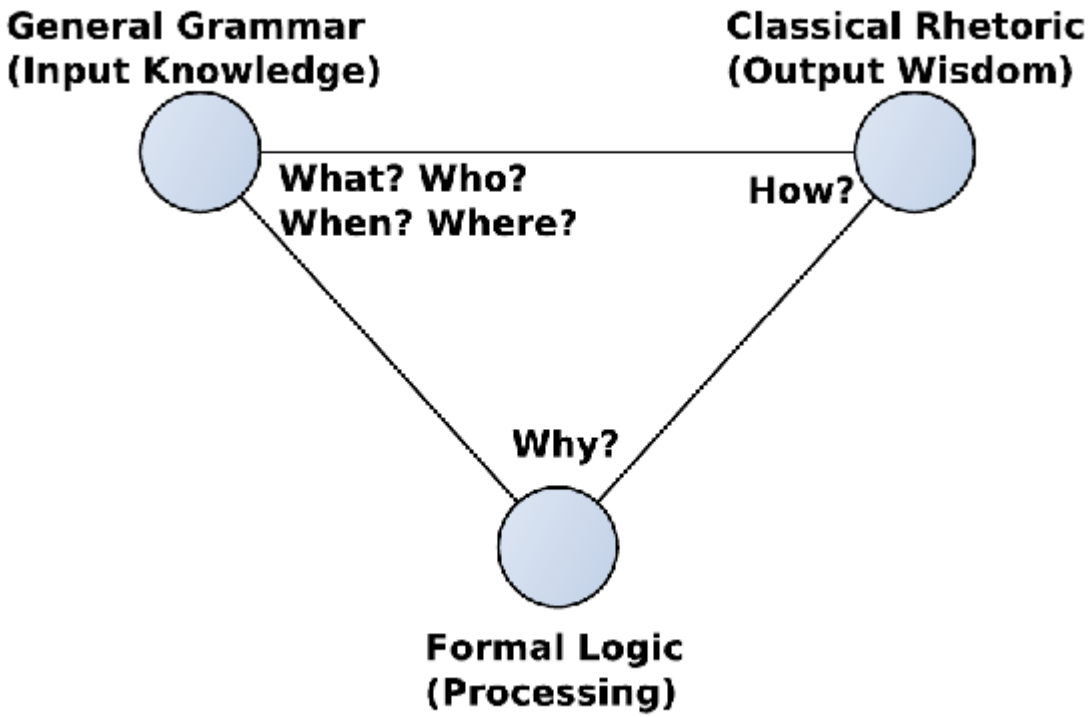

Introduction

Trivium – Research Paper

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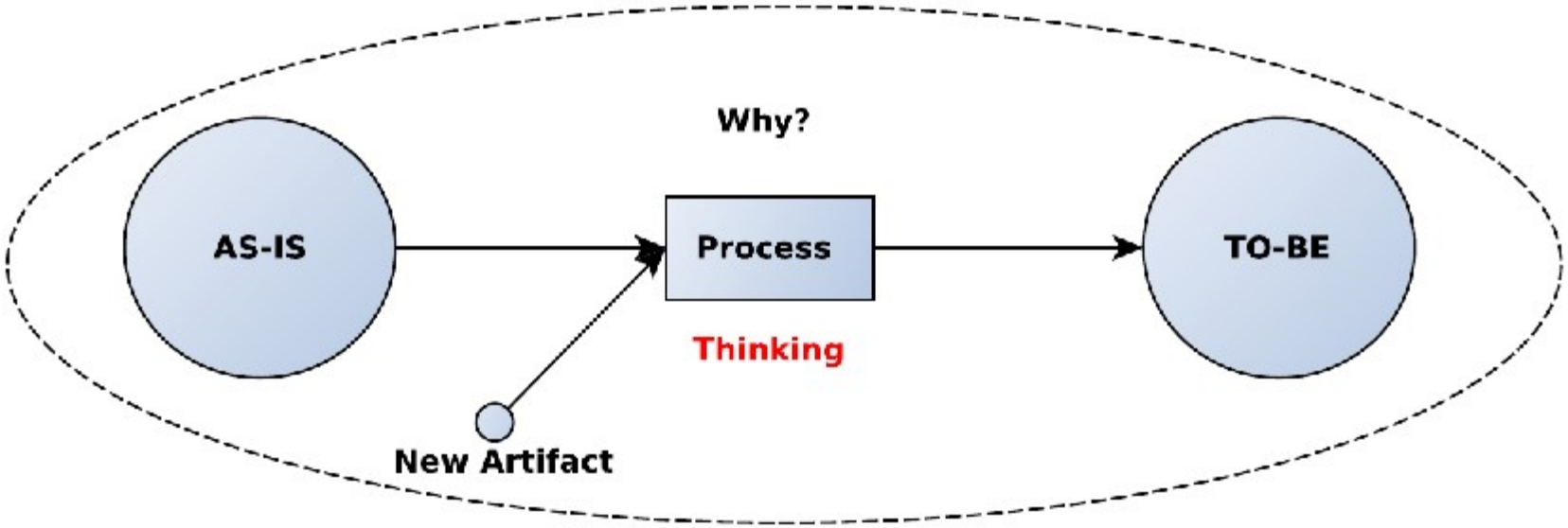

Introduction

Research Questions (RQ) – Paper

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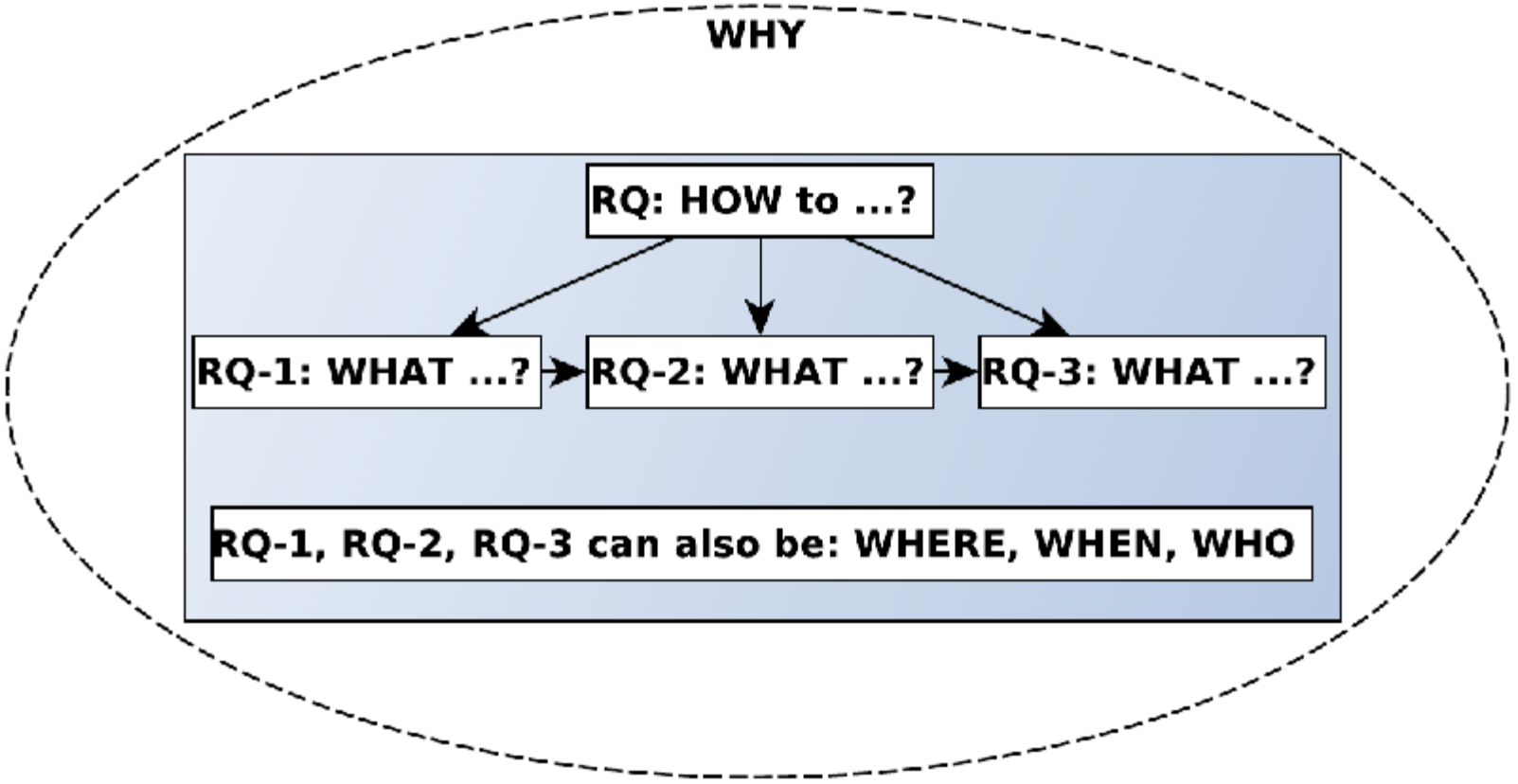

Introduction

Research Questions (RQ) – Thesis

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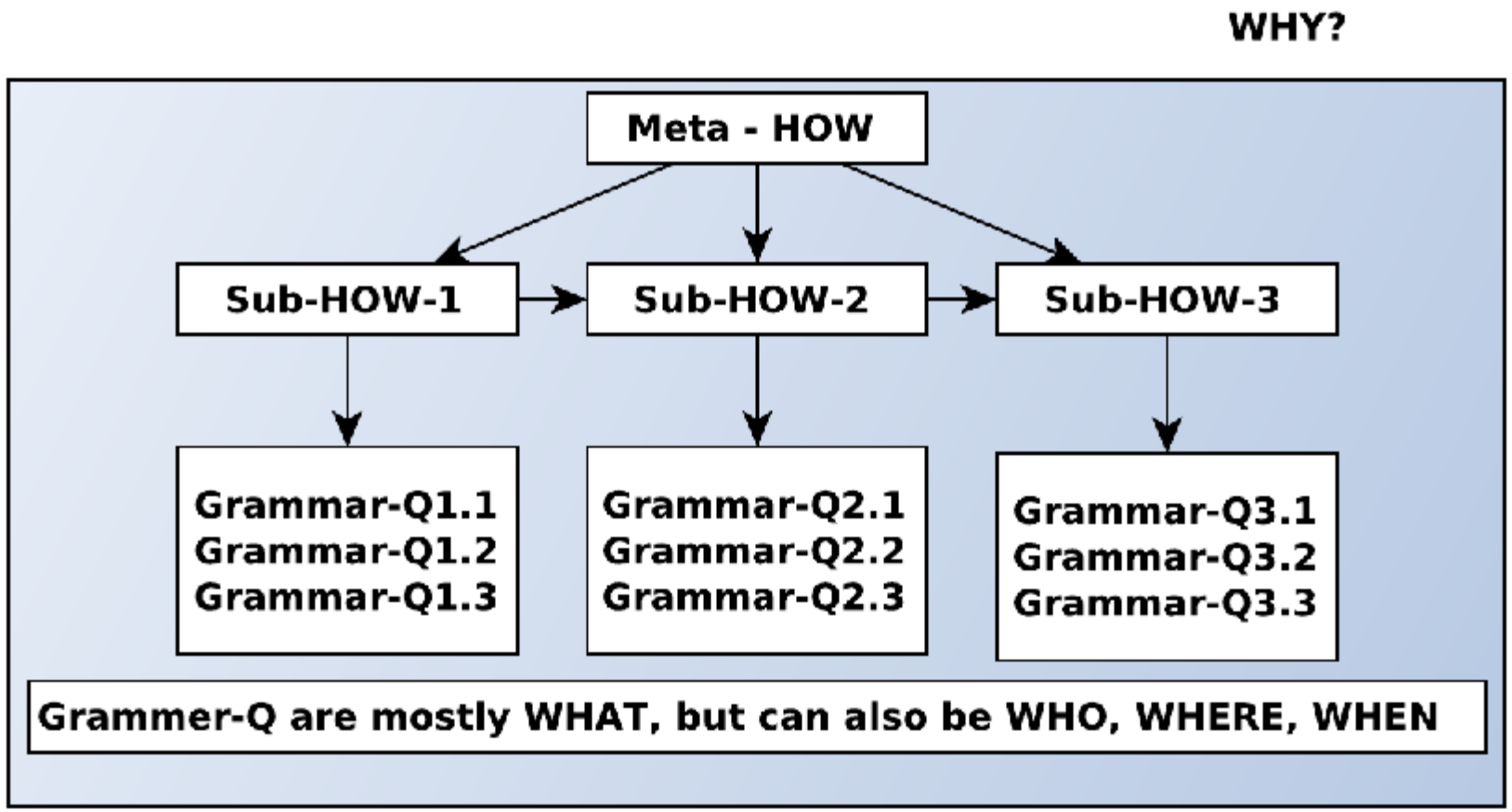

RESEARCH METHODS

Research Methods

Overview

Rigor in research methods is integral to producing valid, reliable, and credible findings – not only in computer science.

Research Methods

Overview

Rigor in research methods is integral to producing valid, reliable, and credible findings – not only in computer science.

- Rigorous research methods allow for accurate data collection, analysis, and interpretation, ensuring the reliability of results in computer science projects.
- Ensures validity of results, allowing for meaningful conclusions and actionable insights in developing technologies and algorithms.
- Studies and experiments can be replicated, corroborating findings and bolstering the reliability and utility of research outcomes.

Research Methods

Quantitative & Qualitative Research Methods

- Quantitative research methods
  - Usually associated with natural sciences
  - Methods associated with measurements, e.g., numeric scales
  - Used to test hypotheses or create a set of observations for inductive reasoning
  - Accuracy and repeatability of vital importance

- Qualitative research methods
  - Usually associated with social sciences
  - Methods involving case studies, surveys, etc.
  - Concerned with increasing understanding of an area, rather than an explanation
  - Repeatability might be challenging

Research Methods

Information Systems Research Methods

- **Common Information System (IS) Research Methods**
  - Design Science Research (DSR)
  - Action Research (AR)
  - Action Design Research (ADR)

Research Methods

Design Science Research (DSR)

DSR is a research methodology in computer science, combining practical problem-solving, theory building and testing, and iterative development to create robust and effective solutions.

- The key output in DSR is an artifact, which can be a model, a method, a construct, or software. The artifact is created to solve a particular problem.
- The DSR process involves the iterative design and testing of artifacts, where each iteration offers an opportunity for refinement and learning.
- By observing how artifacts work in practice, DSR can contribute to the development of new theories and the testing of existing ones.
- Rigorous evaluation plays a critical role in DSR, validating the effectiveness of the artifact in meeting its intended goals.
- DSR aims to make tangible contributions to the field, addressing complex issues and providing clear, actionable solutions.

Research Methods

Action Research (AR)

Action Research combines real-world problem-solving with scientific inquiry. By involving researchers and participants in a collaborative, cyclic process, it aims to bring practical improvements and expand knowledge within the specific context.

- AR involves the active participation of researchers and participants working together to solve a specific problem.
- The dual objectives of AR are to improve a particular practice (e.g., a process, a method) and to gain deeper understanding of it.
- It ollows a cyclic process of planning, action, observation, and reflection, resulting in a revised plan for the next cycle.
- It attempts to link theory and the real world, creating actionable knowledge that is applicable to real-world issues.

Research Methods

Action Design Research (ADR)

ADR merges the best of both worlds from design science research and action research. Via its iterative and participative process, ADR provides solutions to practical problems while contributing to the theoretical body of knowledge.

- ADR combines DSR and AR by integrating the problem-solving focus of DSR with the interactive, participatory aspects of AR.
- ADR operates in iterative cycles involving problem identification, solution design, implementation, and reflection, aimed at refining both practice and theory.
- ADR's stages include: problem formulation (Building), intervention in the application environment (Intervention), and evaluation of the intervention (Evaluation).
- ADR seeks to generate new theories emergent from the application of the design artifact in a real-world setting.

STRUCTURE

Structure

RQs – Paper vs. Thesis

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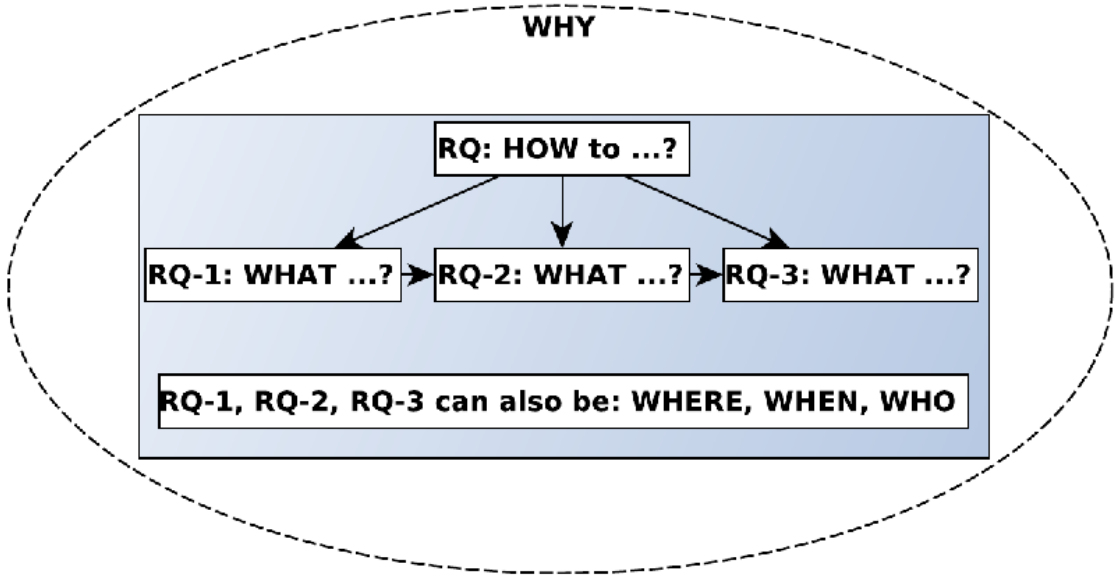
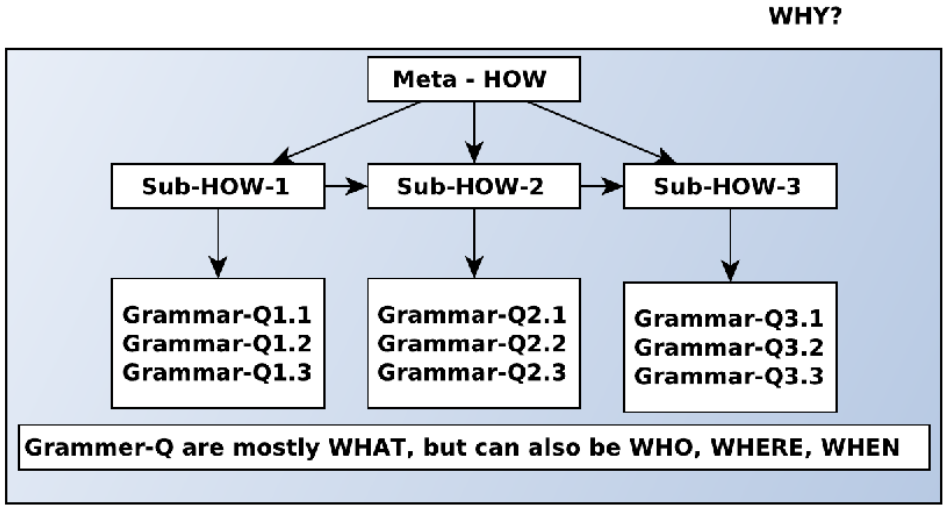
RECREATE (TU Clausthal Colors)

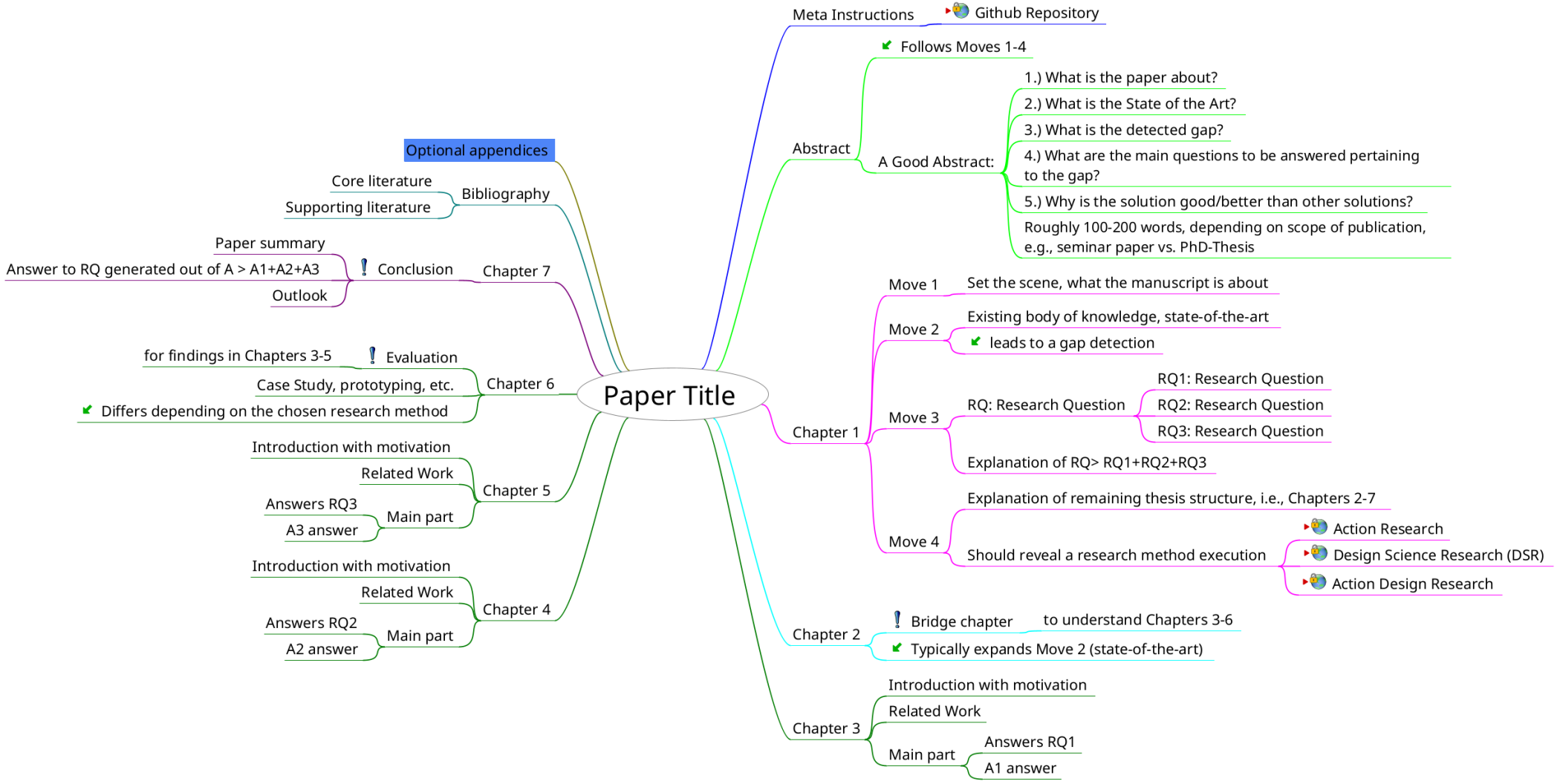




STRUCTURE – RESEARCH PAPER

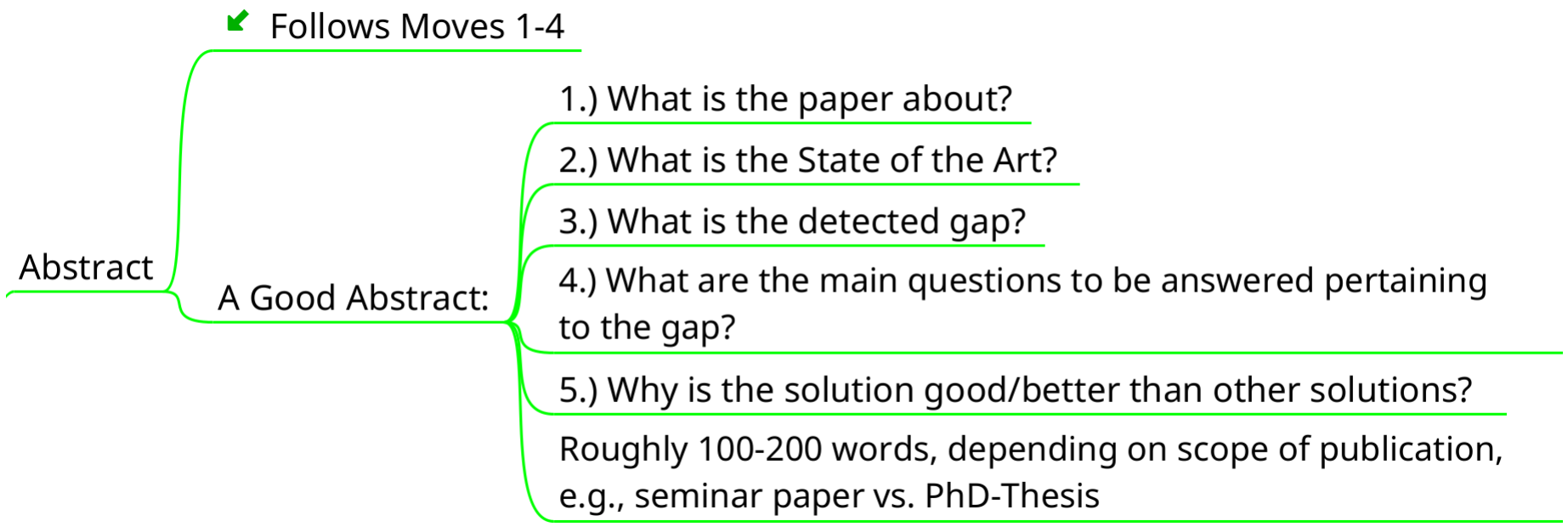
Structure – Paper

Mind Map – Overview



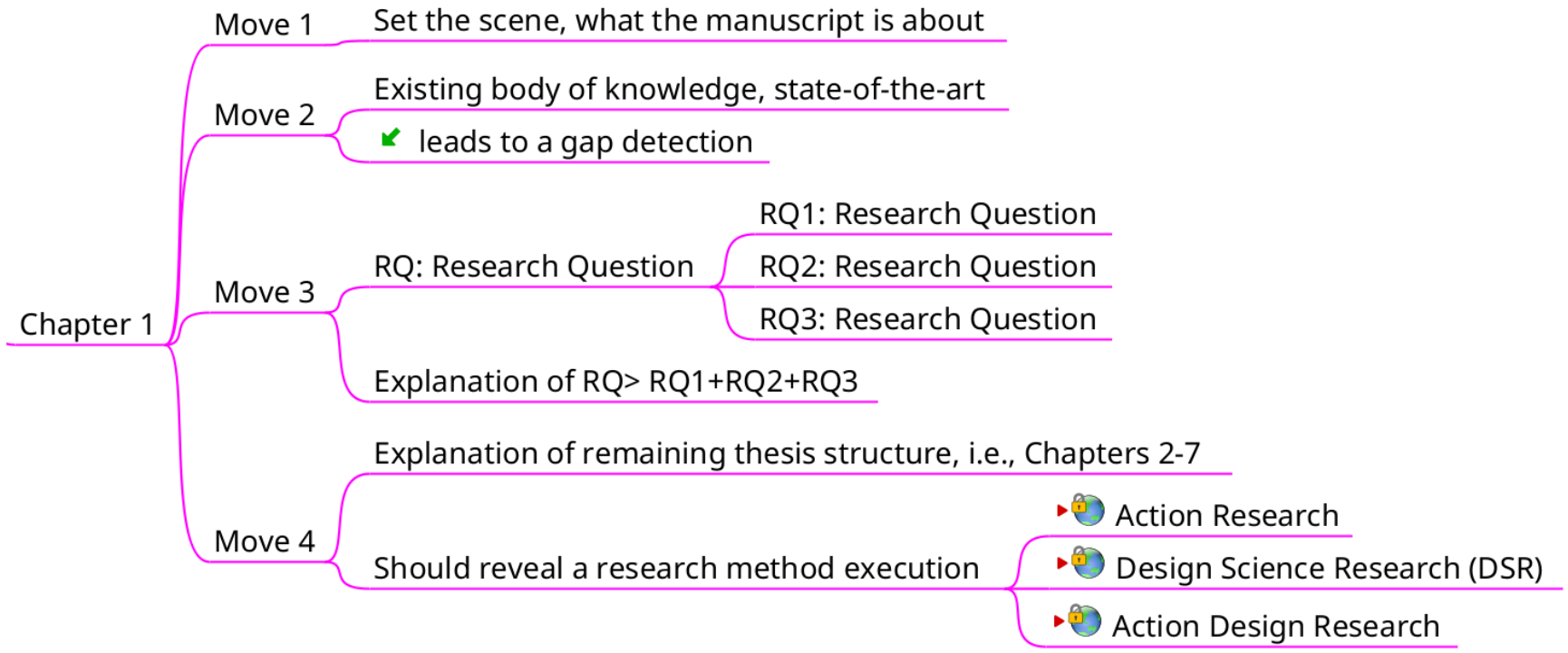
Structure – Paper

Mind Map – Abstract



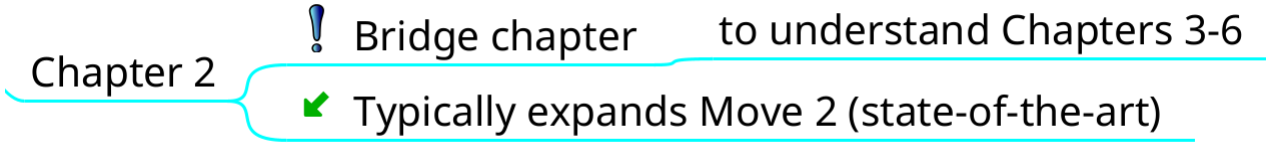
Structure – Paper

Mind Map – Section 1 (Introduction)



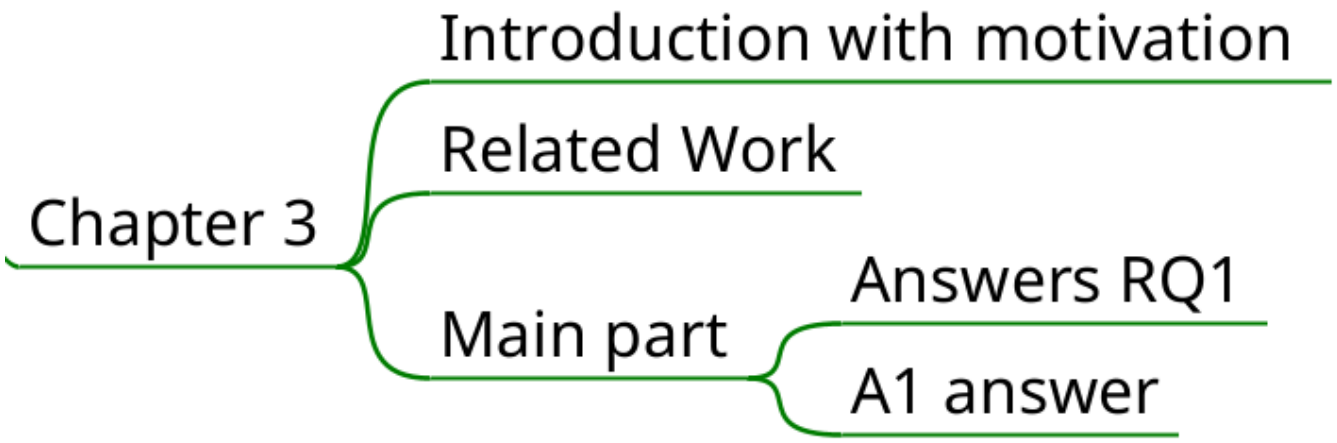
Structure – Paper

Mind Map – Section 2 (Bridge Section)



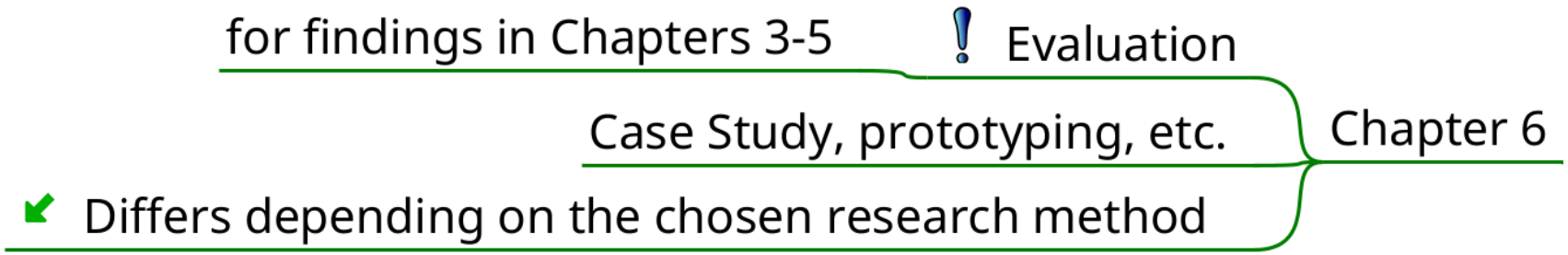
Structure – Paper

Mind Map – Section 3/4/5 (Answers to RQs)



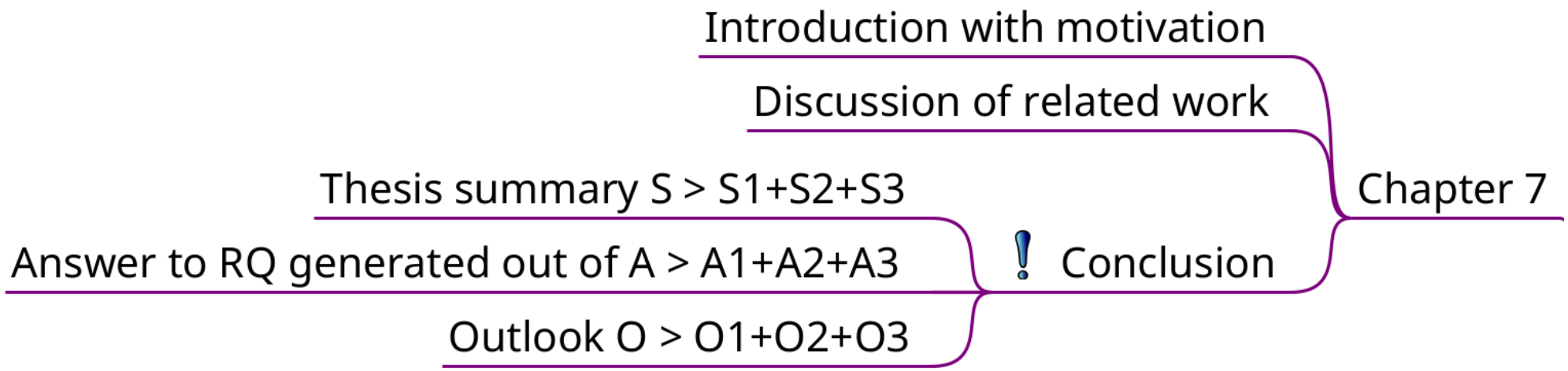
Structure – Paper

Mind Map – Section 6 (Evaluation)



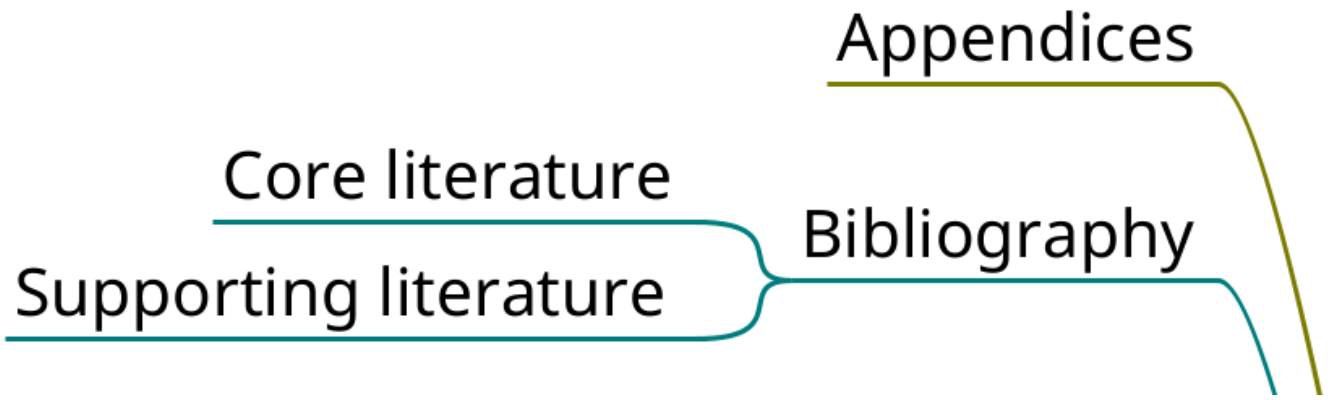
Structure – Paper

Mind Map – Section 7 (Conclusion)



Structure – Paper

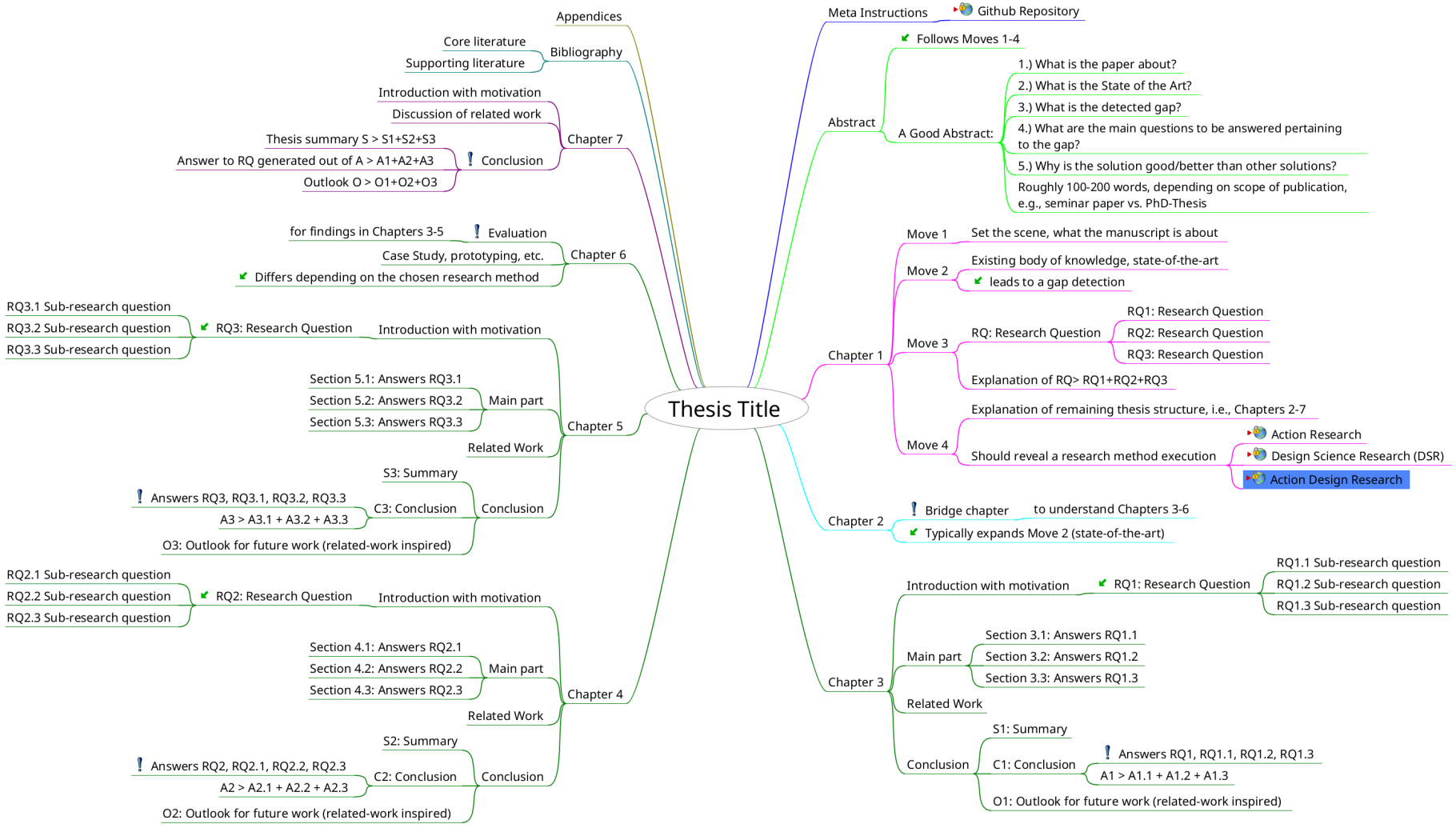
Mind Map – References



STRUCTURE – THESIS

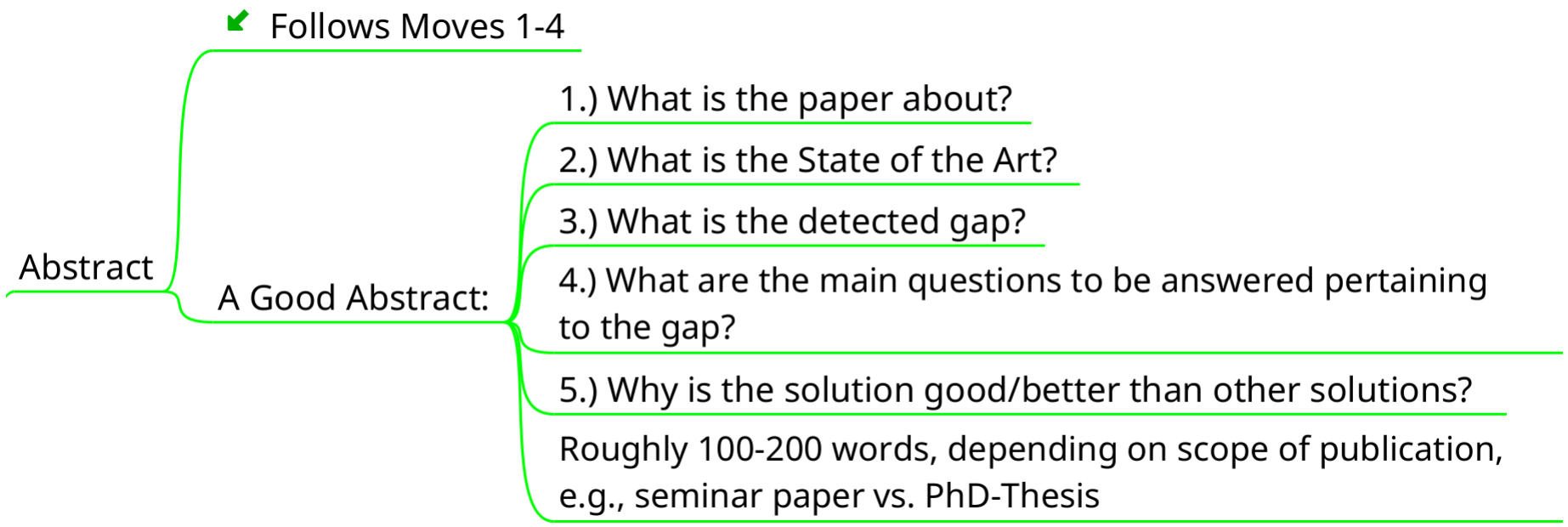
Structure – Thesis

Mind Map – Overview



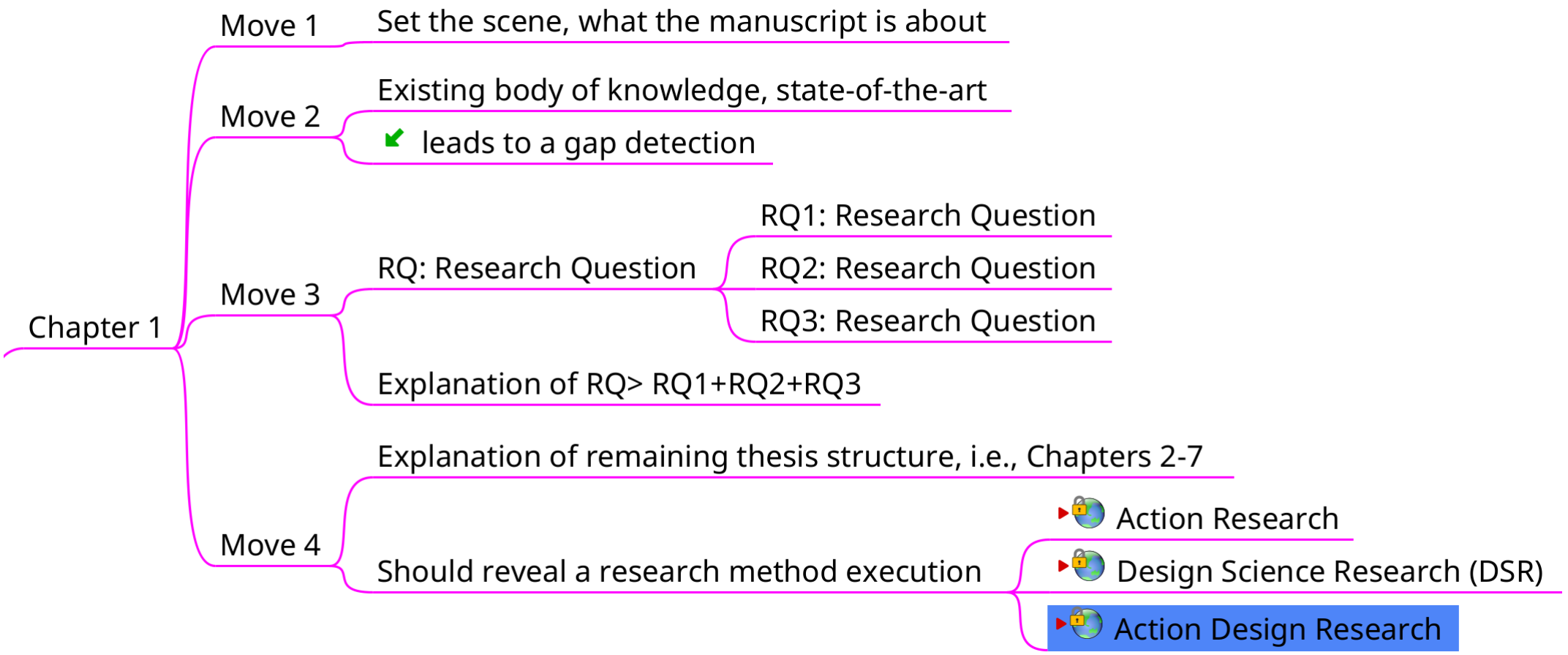
Structure – Thesis

Mind Map – Abstract



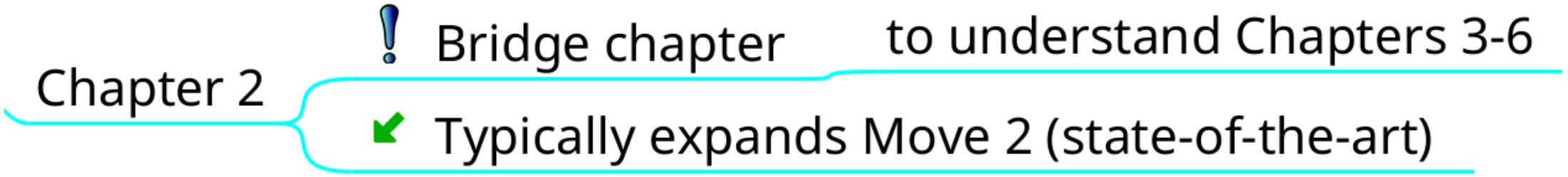
Structure – Thesis

Mind Map – Section 1 (Introduction)



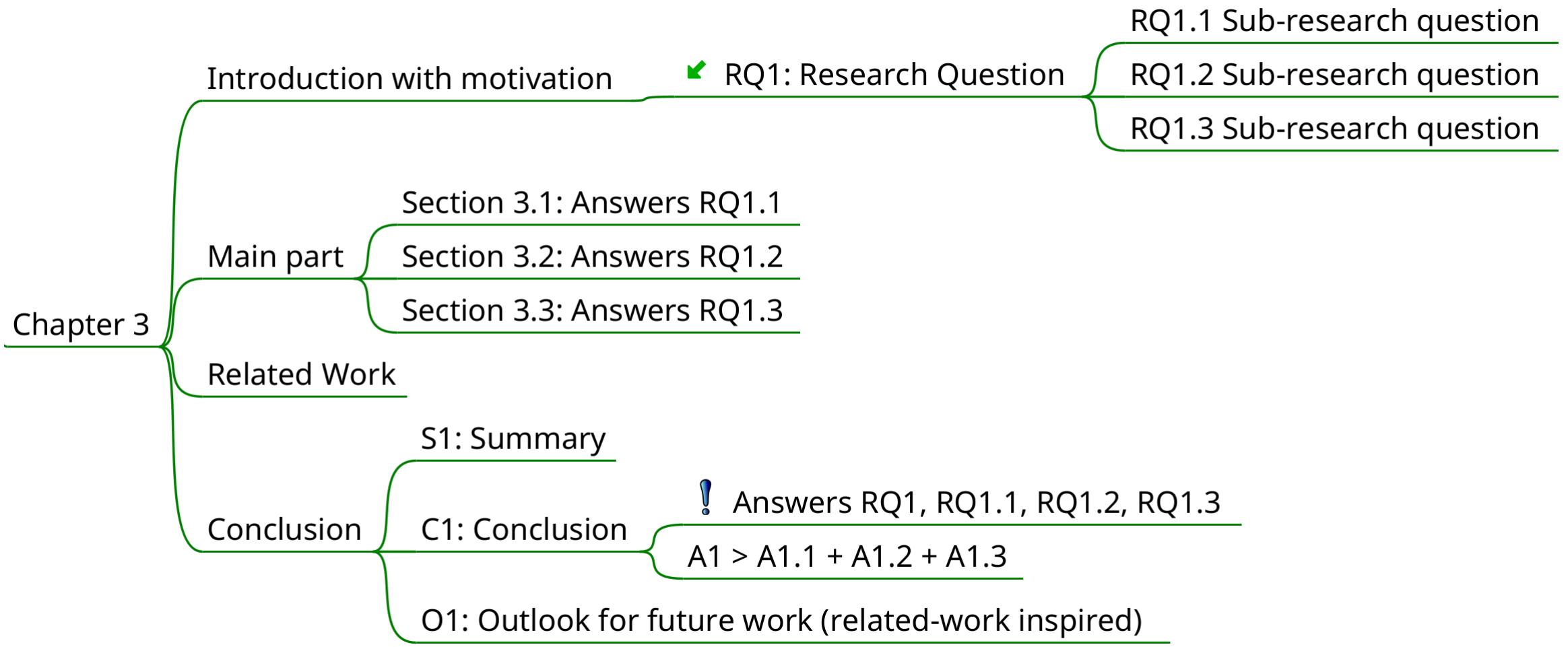
Structure – Thesis

Mind Map – Section 2 (Bridge Section)



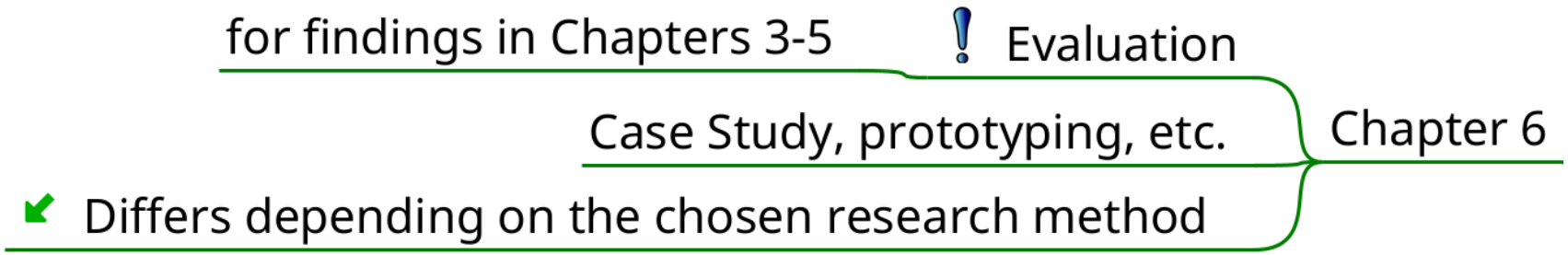
Structure – Thesis

Mind Map – Section 3/4/5 (Answers to RQs)



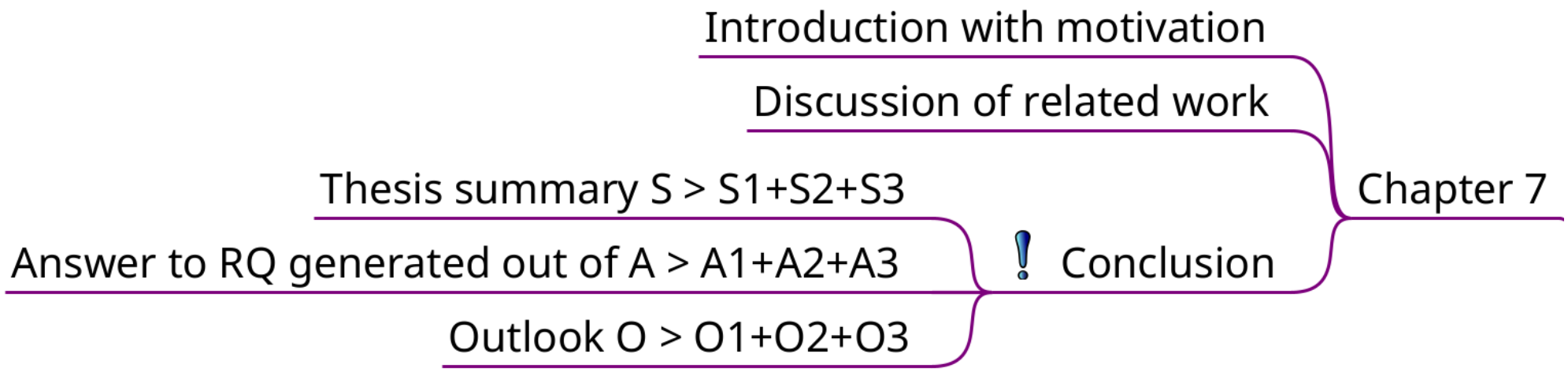
Structure – Thesis

Mind Map – Section 6 (Evaluation)



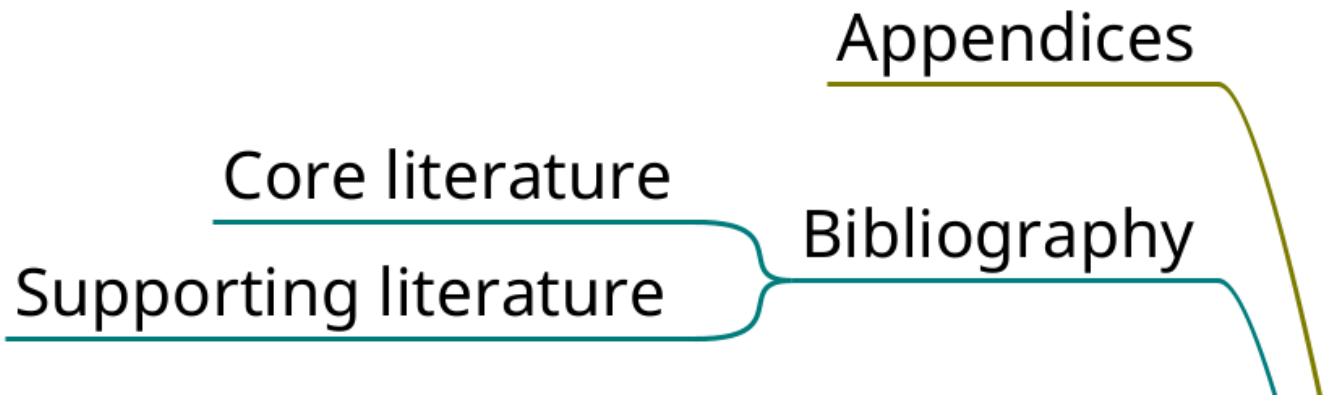
Structure – Thesis

Mind Map – Section 7 (Conclusion)



Structure – Thesis

Mind Map – Appendix



RUNNING CASE – SEMINAR PAPER

Running Case – Seminar Paper

Overview

- **How to write a seminar paper?**
  - RQ-1: What is a good way to review and process literature?
  - RQ-2: What is a good way to structure your paper?
  - RQ-3: What is a good way to write your paper?
  -

Running Case – Seminar Paper

Overview

- **How to write a seminar paper?**
  - RQ-1: What is a good way to review and process literature?
  - RQ-2: What is a good way to structure your paper?
  - RQ-3: What is a good way to write your paper?
  -

Might not be the best and most well defined RQs

Running Case – Seminar Paper

Literature Sources

- Google Scholar → Link
- Journals/Conferences/Magazines/etc., eg.,
  - IEEE → Link
  - ACM → Link
  - AISeL → Link
  - Etc.
- Libraries
- Researcher
- Etc.

Running Case – Seminar Paper

Systematic Literature Review

- Systematic Literature Review in Computer Science - A Practical Guide → Link

Running Case – Seminar Paper

“Good” Literature – Examples

- Peer-reviewed paper, journals, poster, etc.
- Scientific books
- (Bachelor-, Master-, PhD-Thesis)
- (Patents)

Running Case – Seminar Paper

“Difficult” Literature – Examples

- Whitepaper / Technical Reports
- Websites (Blogs, Newspaper, etc.)
- Unreviewed scientific materials (e.g., arXiv.org)
- Peer-reviewed ≠ good literature (e.g., bogus/predatory conferences)

Running Case – Seminar Paper

How to Read a Paper?

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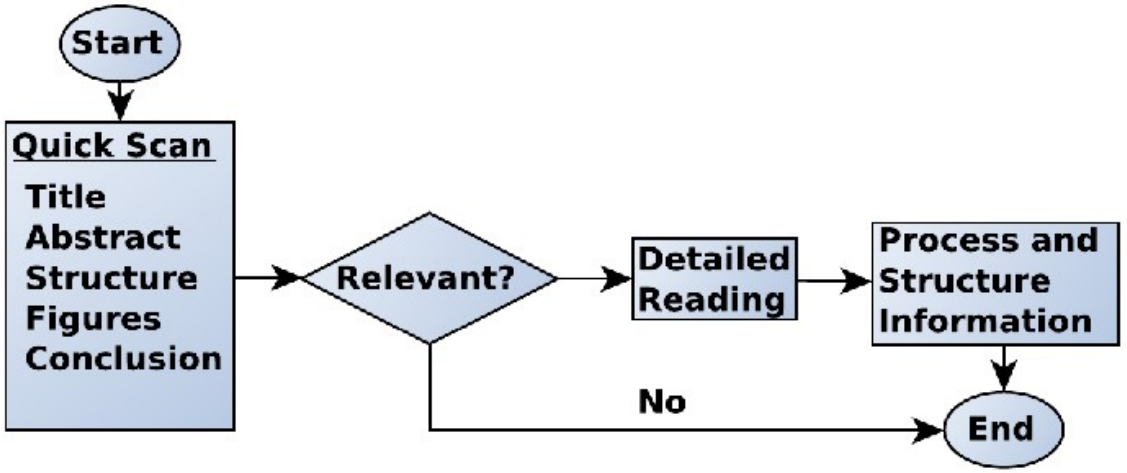

- Critical thinking!
- Check the references of papers that you read!

Running Case – Seminar Paper

Identify Your Gap and Define Your RQs

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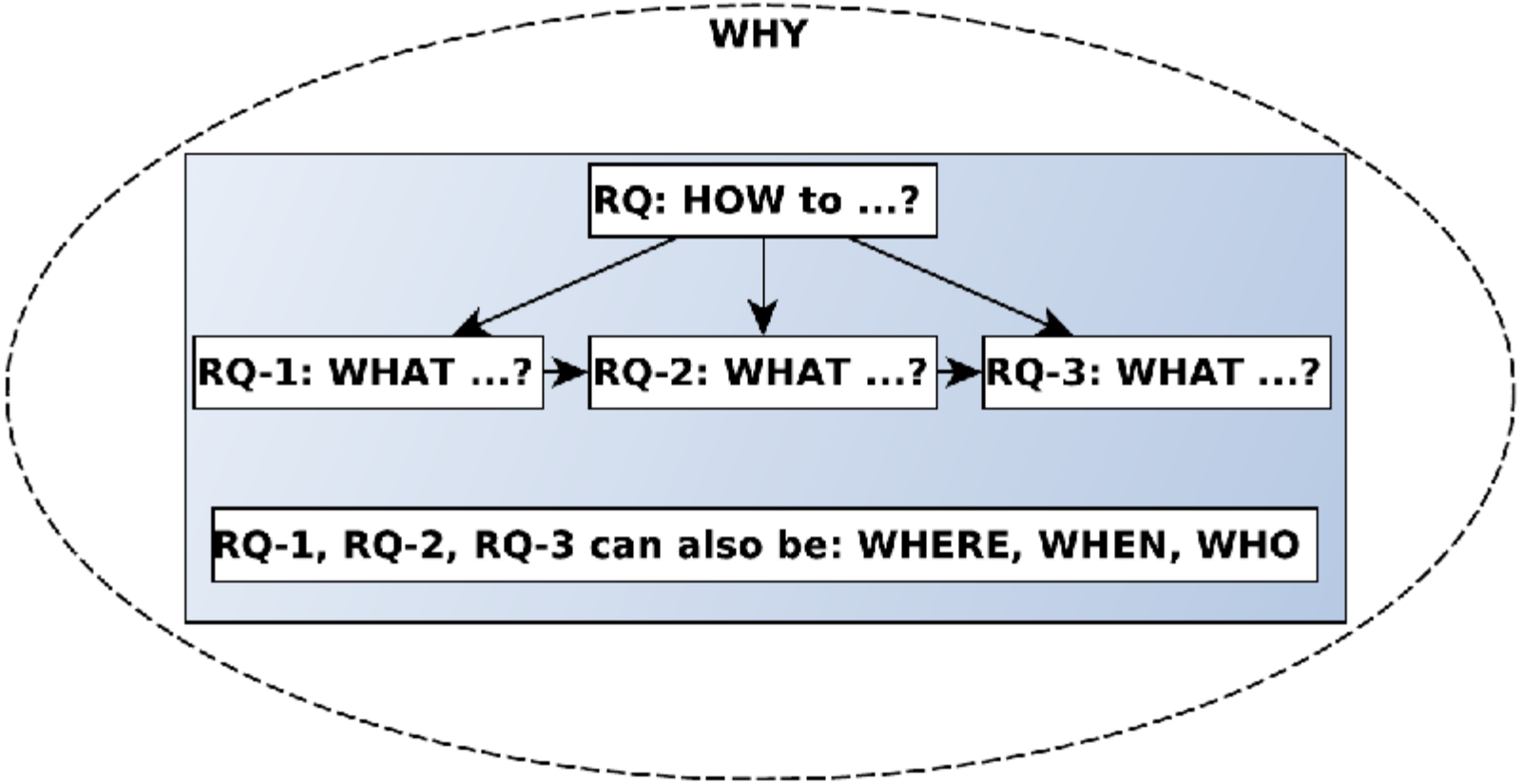

Running Case – Seminar Paper

Write Your Paper – LaTex vs. Word

- LibreOffice / Word:
  - Widespread
  - Nice for short paper (1-3 pages)
  - Awful for long papers and complex structures
  - Move one figure and you may accidentally summon Satan

Running Case – Seminar Paper

Write Your Paper – LaTex vs. Word

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  - Nice for short paper (1-3 pages)
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  - Move one figure and you may accidentally summon Satan

- LaTex:
  - Simple scripting language
  - Professional results, customizable and reusable
  - Visualize complex mathematical equations
  - Awesome reference management (Bibtex)
  - Required by most conferences, journals, etc.
  - Many templates available (Paper, Bachelor, Master, PhD, Book, etc.)

Running Case – Seminar Paper

Write Your Paper – Tips

- Tell a story!
- BUT, don’t write about your personal journey from the problem to the solution. Instead, write about the final and “*correct*” approach that leads to the solution.
- Write for your audience? (Beginners vs. Experts)
- Are you writing a BA/MA/PhD-Thesis, a seminar paper or a research paper?
- Writing is only 25% of the work, the other 75% happen before you even start writing.

Running Case – Seminar Paper

Write Your Paper – Tips

- Avoid spelling mistakes.
- Many iterations and proof-read several times.
- Adhere to the template guidelines.
- Avoid long sentences.
- Clarify special notations.
- Figures are very helpful, but make sure to properly integrate them into you text (reference, comment, analyze).
- Use equations if necessary, but be careful (+ same as for figures).
- Balance between details and abstract ideas (page limits).
- Making a claim? Provide a source or proof it!

Running Case – Seminar Paper

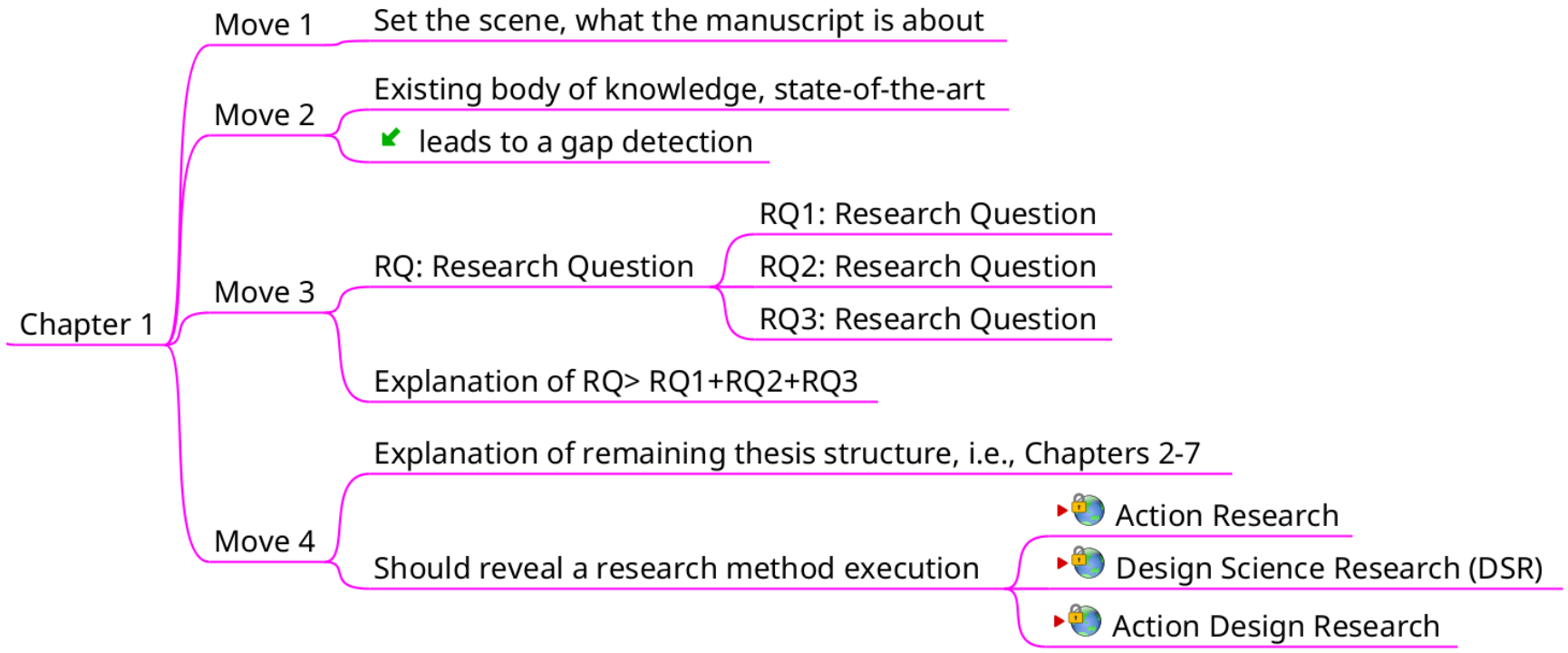
Write Your Paper – A Good Abstract

1) What is the paper about?
2) What is the State of the Art?
3) What is the detected gap?
4) What are the main questions to be answered pertaining to the gap?
5) Why is the solution good/better than other solutions?

- Roughly 100-200 words, depending on scope of publication, e.g., seminar paper vs. PhD-Thesis

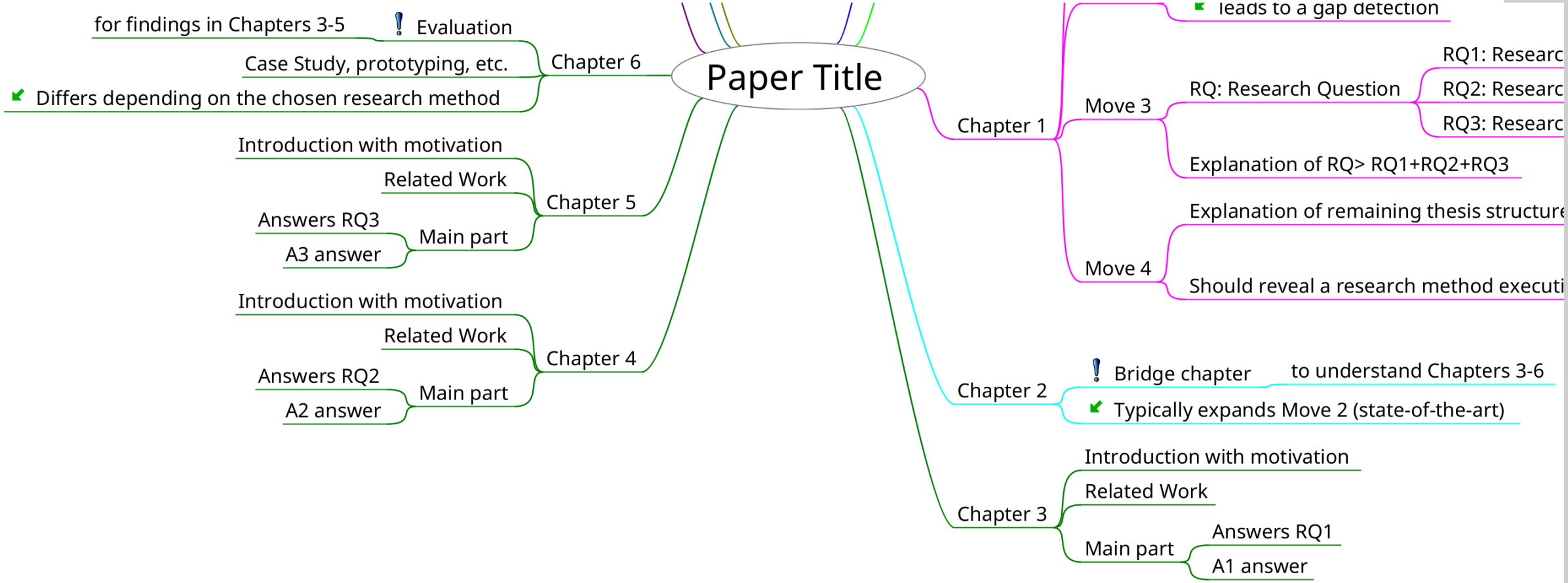
Running Case – Seminar Paper

Write Your Paper – Introduction



Running Case – Seminar Paper

Write Your Paper – Main Part



Running Case – Seminar Paper

Write Your Paper – A Good Conclusion

1) General summary
2) Answer to RQ-1
3) Answer to RQ-2
4) Answer to RQ-3
5) (Evaluation)
6) Future Work

Running Case – Seminar Paper

Write Your Paper – References

- Different sources (book, paper, phd/master thesis, website, journal, etc.)
- Direct vs. indirect citations
  - *“Penguins are black and white”* vs. *The authors [Ref.] argue that penguins are black and white.*
- Different citation styles (IEEE, APA, MLA, etc.)
- It is not your own idea or work? Provide reference to the original source!

Running Case – Seminar Paper

Write Your Paper – References (BibTex – Example)

- Example for the publication “Self-managed and blockchain-based vehicular ad-hoc networks ” - Link

```
@inproceedings{leiding2016self,
    title={Self-managed and blockchain-based vehicular ad-hoc networks},
    author={Leiding, Benjamin and Memarmoshrefi, Parisa and Hogrefe, Dieter},
    booktitle={Proceedings of the 2016 ACM international joint conference on
    pervasive and ubiquitous computing: adjunct},
    pages={137--140},
    year={2016}
}
```

ADDITIONAL RESOURCES

Additional Resources

Templates

- Mind Map Template (Freeplane) – Paper → Link
- Mind Map Template (Freeplane) – Thesis → Link
- Latex – Paper (Springer) → Link
- Latex – Paper (IEEE) → Link
- Latex – Thesis → Link

Additional Resources

LaTex Tutorials

- A simple guide to LaTeX – Step by Step → Link
- A Beginner’s Guide to LaTex → Link
- Using BibTex: A Short Guide → Link

Additional Resources

Systematic Literature Review

- Systematic Literature Review in Computer Science - A Practical Guide → Link

Additional Resources

Research Methods

- Design Science Research → Link
- Action Research → Link
- Action Design Research → Link

Questions?