



# Bachelor Degree Project

Title of your degree project  
- *Optional subtitle*



*Author:* Your name here

*Supervisor:* Supervisor's name

*Semester:* VT/HT 20XY

*Subject:* Computer Science

## Abstract

The report shall begin with a summary, called abstract. The abstract is a teaser that should summarize the report. The abstract shall not be divided into multiple paragraphs

It shall contain:

- A short description your project's subject area.
- A description and motivation for the problems you investigate
- What methods you have done to address the problems
- A short summary of your results

From reading the abstract the reader should clearly understand what the report is all about. The purpose of the abstract is to make the reader interested in continue reading the report, if it covers something that the reader wants to know more about.

**Keywords:** select three to five keywords for your work here. *Examples: software architectures, adaptive systems, network intrusion detection, ...*

## **Preface**

You can have a preface in the report if you want, but it is not necessary. In this you can write more personal reflections on your degree project. In the preface you can also take the opportunity to thank the people who have been particularly helpful during the report writing, for example if you had any contact with a company that helped with the project, people that guided or helped you during the project, or your family and friends that supported you during the project. The preface shall not be longer than half a page.

## Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	Background . . . . .	1
1.2	Related work . . . . .	2
1.3	Problem formulation . . . . .	2
1.4	Motivation . . . . .	3
1.5	Results . . . . .	3
1.6	Scope/Limitation . . . . .	4
1.7	Target group . . . . .	4
1.8	Outline . . . . .	4
<b>2</b>	<b>Method</b>	<b>5</b>
2.1	Research Project . . . . .	5
2.2	Research methods . . . . .	6
2.3	Reliability and Validity . . . . .	7
2.4	Ethical considerations . . . . .	7
<b>3</b>	<b>Theoretical Background</b>	<b>8</b>
<b>4</b>	<b>Research project – Implementation</b>	<b>9</b>
<b>5</b>	<b>Results</b>	<b>10</b>
<b>6</b>	<b>Analysis</b>	<b>11</b>
<b>7</b>	<b>Discussion</b>	<b>12</b>
<b>8</b>	<b>Conclusions and Future Work</b>	<b>13</b>
	<b>References</b>	<b>14</b>
<b>A</b>	<b>Appendix 1</b>	<b>A</b>

# 1 Introduction

In this chapter you introduce your degree project. Start by providing some context: “*This is a 15/30 HEC Bachelor/Masters thesis in Computer science/Software Engineering*”. Think of introduction as a funnel, c.f. Figure 1.1, where you begin with a broad overview of what your project is all about. First a subject area and then the area of investigation.

Examples: If your project is *intrusion detection*, start with *security then intrusion detection*. If it is about *API:s* start with *software engineering and reusable artefacts then API:s*.

Similar to the abstract, the introduction shall make a reader interested in your report and continue to read. Don’t be too detailed here; there are plenty of opportunities to add details in later chapters. Not more than two to three paragraphs or 1/2 page.

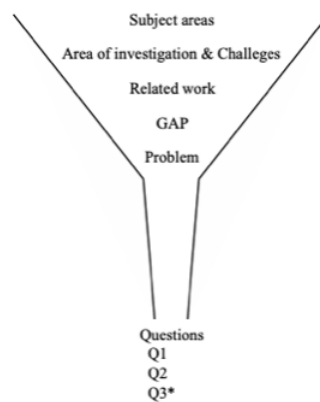


Figure 1.1: Introducing your problem step-by-step

In the subsections below you have four goals. Keep the funnel analogy, Figure 1.1, in mind all the time. Add details along the way, as you go.

1. *Background* – Provide a sufficient, but not too detailed, context to the *reader to understand what challenge you address in your thesis*.
2. *Related work* – Inform the reader about what has been done in the area *related to the challenge*.
3. *Problem formulation* – Present *the knowledge gap you intend to bridge!* What is not known?
4. *Motivation* – Argue why your work is relevant.

Now you should have introduced and motivated a problem you address in your thesis.

## 1.1 Background

After you have described your project, you shall continue with writing a background to the area your project is in. Here you elaborate on the area(s) of investigation. This should not be too detailed. Aim for a level-of-detail, which is sufficient to understand your challenge, related works, and problem definition. Remember that you provide all the details

for the areas of investigation in the Theoretical Background Chapter.

*Example: if you do a project that is about evaluating software architectures, you describe the software architecture concept, why it is important to design an architecture that suits a specific software system, methods for evaluating and comparing different architectures.*

End this part by introducing one or more challenges in the area of investigation.

*Example: Evaluating information security and information privacy at the software architecture level is a challenge.*

Aim for 1/2 – 2/3 of page!

## **1.2 Related work**

Here you briefly describe what others have done in the field of study or how others have attempted to explain or solve the same or similar challenges that you are investigating. It is okay to refer to tech articles and online blogs and portals, but should always prioritize scientific, peer-reviewed articles. To find articles, use the search tools listed [here](#).

*Example: Provide a brief overview of relevant evaluation techniques, if something more specific has been done in the area “evaluation of information security and privacy”, etc.*

Target is 1/2 – 2/3 of page!

## **1.3 Problem formulation**

Relate to the Background and Related work. What is not known with respect to *the challenge*? This is a *knowledge gap*. Here you give a detailed description of the problem – the gap – you investigate. Rephrase your problem as a set of questions and present them in a list. Rephrasing them as questions will help you a lot when you analyze and discuss your results and when you conclude.

You can re-use the problem formulation from your project plan, but you must provide more reasoning and details about the gap. Shaw<sup>1</sup> describes several problem categories and typical questions to ask for each category. Use that as a source of inspiration.

*GAP Example:*

*There is a considerable body of work in software architecture evaluation. However, it seems that reasoning and evaluating software architectures for information security and information privacy concerns have gained no or little interest. This means that architects have to rely on less reliable techniques such as argumentation.*

In the example above you can see how we relate to the background and challenge, and to the related work to define *the gap*. So, the gap identifies that we lack knowledge about something. A knowledge gap that we may phrase as one or more questions.

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<sup>1</sup>Shaw, M. “What makes good research in Software Engineering”, International Journal on Software Tools for Technology Transfer. Vol. 4(1)

*Questions Example:*

1. *How may we evaluate information security and information privacy?*
2. *What would be a suitable methods or techniques for architecture level evaluation?*
3. *How precise and reliable would such methods or techniques be compared to other evaluation methods and techniques?*

At this point you should have described the area and challenge, described related work, pin-pointed the problems you plan to address, and more specific questions you have to answer along the way.

## **1.4 Motivation**

Here you motivate why your problem is interesting/important from

- a scientific perspective,
- important for society
- industrial perspective

You can re-use the motivation part from your project plan. You don't have to motivate your work from all three perspectives.

*Example: This thesis will advance the field of architectural evaluation [scientific]. The results will address two very important areas, information security and information privacy, that are essential components in a society's the digital transformation[society]. From an industrial perspective the results will assist software providers to develop systems that considers information security and information privacy early. Thus, build and provide systems that keep information secure and private[industry].*

There is always a risk that you make (too) bold claims here. Try to stay realistic and don't exaggerate.

## **1.5 Results**

Present results and the result types for your project. Describe each in a paragraph and refer to the question(s), or part(s) of question(s) it contributes to answer. Also discuss briefly how the results were validated. Use Shaw's article discussed above as a source of inspiration. The article discusses several results types that you may adopt for your work.

*Example:*

*We propose a new technique for evaluation of information security and information privacy at the architecture level. The technique prescribes a process and provide checklists to guide mainly architect's but also other stakeholders in the evaluation work.*

*We evaluate the technique by demonstration and interviews with practitioners. In the demonstration we show how the technique is use in three cases, by three different evaluator groups. Continuing, we argue that the technique satisfies the objectives. The interviews collect data on stakeholders' assessments of the technique. Here we focus on*

*precision and reliability; however, we also collect data on the technique's applicability and ease of use.*

Don't give away too much information about method here. It will be covered in the next chapter.

## **1.6 Scope/Limitation**

You cannot solve everything. Here you describe what you do, and what you don't do, in your project. Limitations can for example be that you only compare some frameworks of all frameworks available on the market, that you only suggest an architecture for a specific software product and not a general architecture, or that you only include university students in a study and not a broader population sample.

## **1.7 Target group**

Here you outline which target group for your work. If you, for example, do a project about software architectures, a target group can be professional developers and architects that work with similar software systems as the system you investigated.

## **1.8 Outline**

Here you outline the rest of the report. It shall contain which chapters that will follow, and what each of them is about.

*Example:*

*This report is organized as follows. In Chapter 2 we discuss the methodological framework, research methods and ethical considerations. Chapter 3 provides a full account for the theoretical background and discusses the knowledge gap. used in the project. In Chapter 4 we discuss the objectives for an evaluation technique, which guide the design of a technique that we present in Chapter 5. Chapters 6 and 7 describes the validation of the technique. First, we demonstrate the technique on three cases in Chapter 6. In Chapter 7, we describe the case study design for the stakeholder interviews. Chapter 8 presents and discusses experiences and results from the demonstration and interviews. These are analyzed and discussed further in Chapter 9, where we also discuss threats to the validity of the work. In Chapter 10 we Conclude and discuss Future work.*



## 2 Method

In your degree project you have identified a knowledge gap, something that is not known. You defined a problem to investigate and some specific questions to answer.

*In the method Chapter you should*

- *demonstrate that you have a broad knowledge of research methodology,*
- *demonstrate that you are knowledgeable of the research methods you use,*
- *discuss, argue and motivate your research project's organization, and*
- *why you have organized selected specific research methods.*

*In addition, you should also demonstrate*

- *That you understand the concepts of reliability and validity, and*
- *Discuss threats to these and measures taken to reduce the effects of these threats.*

You need some problem-solving activity to answer that problem or more precisely find trustworthy answers to the questions. This is what we mean with a method. We have a problem, and we need some proven and structured way of approaching and solving that problem. There is no single way that works for all problems. Researchers have learned through history that particular methods are effective for problems that share some characteristics (in terms of purpose, context or problem). You can, therefore, look at how others have answered similar problems as your own problem, and use a similar method.

There is a wide range of methods you can use in your project. The most common ones used in degree projects are:

- Controlled Experiment
- Survey using questionnaires
- Interview
- Case Study
- Systematic Literature Review

### 2.1 Research Project

In a project, you often combine several methods. This is referred to as *multimethod research*. A specific variant of multimethod research is *design science*. Design science is particularly useful when you develop an artefact, for example a new technique or algorithm,

*Example:*

*You may use interviews to collect data to understand what architects expect from an evaluation technique. You may also interview security and privacy experts to complete the picture. Another useful source is existing literature. You perform some type of literature study to understand the theoretical background or framework for your project. You can*

*continue and perform case studies or controlled experiments in the evaluation.*

It is important that you successfully describe the overall project. What do you plan to do, and which methods will you apply? What are the intermediate results? Think of this as activities and objectives you do in your project. You perform an activity (research method) to provide a result (objective). An objective shall be understandable, not too small or too large, and possible to define when it is completed or not. You already defined objectives in your project plan. Reuse them but think of the method you plan to use and reformulate them as activities and objectives.

Describe your method at the project level as a roadmap. You should have a look at the design science model for inspiration. Here you should provide a description of design science first and motivate your choice. Don't forget to outline **your** project.

*Example:*

*Company X initiated this project. They have asked for a technique that can help them to evaluate their software architectures. We selected the design science approach and we will start by defining the problem and setting the objectives for a solution. We will design and implement a solution that we demonstrate on cases provided by the company. We will validate the technique together with stakeholders at the company.*

Continuing you are expected to describe each step in the DS methodology and in detail describe which research methods you use and motivate why.

## **2.2 Research methods**

This part should cover two aspect

- Each method you use should be described in detail. You must demonstrate that you have a complete understanding of the methods you use and some understanding of the methods you considered but didn't use.
- Describe each that you research method in some detail focusing on how you use it, where and for what. Motivate your decision and relate it to the problem type, stakeholders, thesis project setup, etc. It is important that you can use the same method for different activities in your research project. You need to describe, explain, and motivate each use.

*Example:*

*We plan to conduct interviews at the company to elicit problems and details from the company using interviews. We think that interviews is the best method because it we will have the opportunity to ask more specific questions if interesting problems occur. A survey is difficult to produce because we currently don't understand enough about the problem at hand.*

*We also plan to collect data for the solution objectives at the same time. We did consider creating a survey that we could distribute to a larger group to validate the problems and objectives after we analyzed the interviews. However, we decided to discard this idea due to time constraints.*

## 2.3 Reliability and Validity

Here you discuss the reliability and validity of your project. To answer your problem you use a method, collect (and possibly analyze) data, and draw conclusions from the data.

Reliability means if others will get the same result as you if they replicate your work. Reliability problems can, for example, occur if you use the wrong method for data collection.

It is important that you only draw conclusions that are valid, i.e. that is supported by the way you have done your work and the data you have collected.

You can read about reliability [here](#) and about validity [here](#). Discuss if you have any reliability issues or validity threats in your project here.

Identify different threats and how likely it is that it will impact your result. Discuss measures you have taken to reduce the impact. For example, triangulation. In this section you demonstrate that you understand the limitations of research and how you can combine approaches to move beyond these limitations.

## 2.4 Ethical considerations

You are required to discuss any ethical considerations in your project's research design. If you don't think there are any considerations **state that and motivate why!**

If you do an experiment you will most likely not have any ethical considerations, but in a survey ethical considerations can for example be how you make sure that the privacy of the people participating in the study is not violated (by for example removing names from the gathered data).

It is important to think of (among others)

- Confidentiality – if you collect data from surveys/interviews. Describe and discuss measures for maintaining confidentiality. Where and how is data stored? Consider GDPR for participants.
- Sampling/Bias – Which data have you selected. Are there any risk for biases?
- Risk of harm – Maybe not applicable to CS but balance risk-of-harm – possible gain.
- Participation and Consent – Are the participants in your study aware of this? Have they said ok to participate.

### 3 Theoretical Background

*In this Chapter you should*

- *demonstrate that you have a broad knowledge of area of investigation,*
- *introduce, describe and explain the theories to the reader,*
- *identify and describe relevant challenges in the area of investigation and describe related work to these challenges.*
- *formulate a research gap and discuss, argue and motivate your it as a research problem*

This section is not about solving a problem, but it may answer one or two of your research questions. If you use a multimethod research approach, this Chapter may provide a partial answer, outlining the state-of-practice and state-of research, and by identifying a gap. In design science, this chapter can be one source of information to the problem and motivation, and maybe also to the objectives for a solution.

The basis for the theoretical background chapter is most often some lightweight literature survey. Think of it as a focused textbook that introduces and explains slices of theoretical areas. Cover theories that are required for both the problem and solution, and sometimes also for the evaluation. It should be textbook like with figures and examples. This is the chapter where your reference list grows fast!

Create a Chapter outline and then take a critical stance where you put yourself in the reader's position.

- Do you provide a sufficient but not too detailed level?
- Are all areas important and less important areas covered?
- Do you discuss why related work is insufficient with respect to your problem?

## 4 Research project – Implementation

*In this Chapter you should*

- *introduce, describe and explain all activities you have realized to collect data for your study.*
- *describe all your designs and implementations.*

The structure of this Chapter depends on your research project. If it is a design science project where you develop a technique you may also develop an application to demonstrate it. It can be a mobile app, a stand-alone application, a website, a game, etc. In that case, you may choose to describe the design and the technique in one Chapter, the implementation concerns in another, and the demonstration in a third.

If you are comparing two techniques in a controlled experiment you will describe the design (and implementation) in this chapter. The same is true if you are conducting a case study or perform a systematic literature study.

The goal is to describe in great detail How you collect data, data that will be the basis for answering the remaining research questions. This or these Chapters.

*Example:*

*For the thesis on Architecture Evaluation techniques for Information Security and Privacy, we devote one chapter to the new technique we propose. In the chapter we introduce the technique, the process, activities and artefacts. Further, we have one chapter reporting on the demonstration. Introducing and explaining the cases and providing step-by-step walkthrough of the technique for each case. We also planned a case study for evaluation so we describe the case study design in a separate chapter.*

## 5 Results

In this chapter you show and describe your results. If you have a multimethod study, then you may have multiple result section. Sometimes even multiple results chapters.

You shall only **show the raw results without any analysis**, and you shall not put any conclusions or opinions in the description of the results. Try to be as objective as possible. An example of results from an experiment comparing five sorting algorithms is shown in Table 5.1 below.

Run	Bubble	Quick	Selection	Insertion	Merge
1	17384	24	3258	3	30
2	17559	21	3386	3	27
3	17795	19	3344	4	28
4	17484	20	3417	3	28
5	17642	19	3358	3	30
Average	17572.8	20.6	3352.6	3.2	28.6

Table 5.1: Execution times for the five sorting algorithms on 100 000 random numbers between 0 and 10 000.

What you show heavily depends on the type of method you use and what type of data you collect. Numerical data can for example be shown in both tables and graphs. A complementary graph for the sorting algorithms example is shown in Figure 5.2. For a questionnaire you can show the frequency (how many participants that selected the same answer) of each possible answer to a question.

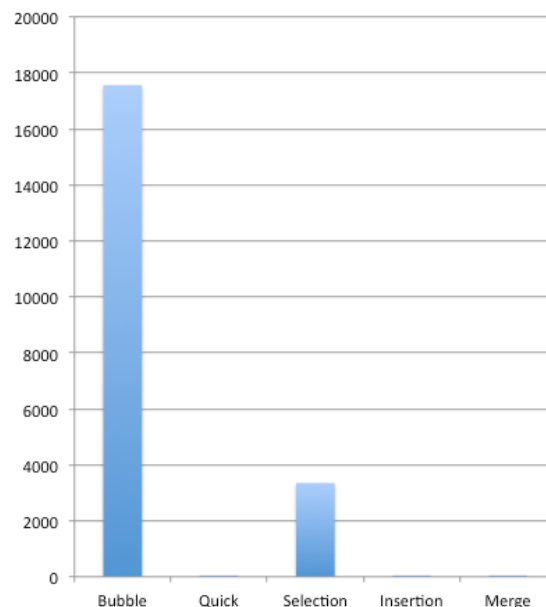


Figure 5.2: Execution times for the five sorting algorithms shown as a graph.

Note that Tables and Figures shall be labeled with chapter.number, for example Table 4.1 and Figure 1.6.

## 6 Analysis

In the analysis you turn your data in to evidence(strong) or arguments(weaker). You can choose different ways to organize this chapter. Say that you have conducted a controlled experiment. In that experiment you use hypothesis testing. In the analysis you perform statistical analysis on your data, apply various test, create box plots or descriptive statistics.

If you performed a systematic literature review you can also do statistical analyses, but the analysis may also use other methods to derive arguments.

What conclusions can you draw from the results? It is important that you don't draw any conclusions that cannot be backed up by your data. Consider using statistical tests to back up your claims if it is feasible with the data you have. You can read about statistical testing [here](#).

Use your problems and the questions to structure. Try to provide arguments or evidence in your data. Often it is not a definitive yes or no, shades of gray more frequent. Sometimes data can be interpreted in different ways. Ethics is important. You often find bias in this part. You look for evidence to support your opinion! **Stay away from that!** Remember that finding out that something doesn't work is also knowledge. Never exaggerate the importance and validity. Be honest in your presentation.

## **7 Discussion**

Here you discuss your findings and if your problem has been answered. Think of the project as a feedback loop. You define a problem, find a method of approaching it, conduct the study or experiment, and gather data. The data is then used to answer your problem, thus creating the loop.

You shall also discuss how your findings relate to what others have done in the field of study. Are your results similar to the findings in the related work you described in the Chapter 3? What is the impact of limitations? How generalizable are the findings?

This chapter is typically written in the present tense, while the previous chapters typically are written in past tense.



## **8 Conclusions and Future Work**

In this chapter you end your report with a conclusion of your findings.

What are the results of your thesis project? Try to relate the results to the questions and problem. Did you bridge the knowledge gap?

Are your results relevant for science, industry or society as discussed in your motivation in the Introduction Chapter? How general are your results (i.e. can they be applied to other areas/problems as well)? Also, take a critical stance and question if anything in your project could have been done differently to possibly get better results.

You cannot do everything within the limited scope of a degree project. Here you discuss what you would do if you had continued working on your project. Are there any open questions that you discovered during the project work that you didn't have time to investigate? Are there findings from the evaluation/validation that trigger further investigations?

Here you shall include a list of all references used in your report. The reference list shall use the IEEE format. You can read about IEEE referencing [here](#). In the reference list below you can find examples of how to list a webpage [1][2], a journal article [3], a book [4] and a conference proceeding (article) [5].

## References

- [1] Linnaeus University. (2015) Course Room for Degree Projects. [Online]. Available: <https://mymoodle.lnu.se/course/view.php?id=5297#section-4>
- [2] Monash University. (2015, Oct. 13) Citing and referencing: IEEE. [Online]. Available: <http://guides.lib.monash.edu/citing-referencing/ieee>
- [3] C. Lynch, “Big data: How do your data grow?” *Nature*, vol. 455, pp. 28–29, 2008.
- [4] S. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach*, 3rd ed. Prentice Hall, 2010.
- [5] D. Agrawal, S. Das, and A. E. Abbadi, “Big data and cloud computing: current state and future opportunities,” in *Proceedings of the 14th International Conference on Extending Database Technology*, 2011, pp. 530–533.

## **A Appendix 1**

In the appendix you can put details that does not fit into the main report. Examples are selected snippet of source code, long tables with raw data and questionnaires. It is ok to refer to source code repos that are permanent. We don't like 50 pages of source code print out in the Appendix!