Making Master Thesis: How to Write it?[*]
PART II: More Practical Issues on Writing Thesis

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Abstract

This document is a short, imprecise, but nevertheless (hopefully) helpful "living document". It might be more useful that Part I, which was mostly a philosophical guidance. This document is more about what should be in the thesis. However, it is not comprehensive and exhaustive list of the requirements and style. Sorry, you still need to figure out something yourself, and discuss more with "that thing called a supervisor".

1 Introduction

So, if you are reading this document, you are definitely about to write your M.Sc. thesis. We guess (that is the authors of this useless article) that you are about to write your M.Sc. thesis at the department of wireless networks. Hence, Although some of the advice is general, some of the specifics are aimed *only* for our own M.Sc. students. This is not a general guidebook for everybody.

1.1 Thesis in EE and CS

In the case you did not know, the thesis work is a traditional part of your curriculum. We refer thesis here as M.Sc. (Masters) thesis, although in German curriculum it is also known as a diploma-thesis. These terms are interchangeable, so it does not really matter. The formal definition for thesis could be stated as *"a treatise advancing a new point of view resulting from research."*[1]

Engineering thesis (we take a broad view here on what is engineering), like many thesis works in science, have a clear orientation. When you write your thesis, you should be able to tell the reader *what is the purpose of the thesis*. In practical terms, this means that typically there are well defined research questions (or a question) that you try to answer in your thesis. However, note that there are different levels of "research

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[*]This version is a draft (v0.68b).

[1]As unnecessary footnotes are nice and look scholarly we give also a partial quotation form Oxford English Dictionary [3]: thesis: *in Logic, Rhetoric, etc.* **1**. A proposition laid down or stated, esp. as a theme to be discussed and proved, or to be maintained against attack (in Logic sometimes as distinct from HYPOTHESIS 2, in Rhetoric from ANTITHESIS 2); a statement, assertion, tenet. **2**. A dissertation to maintain and prove a thesis (in sense 1); esp. one written or delivered by a candidate for a University degree.

questions". In science the good research questions tend to be *fundamental*[2], and this is the case for Ph.D. (doctoral) thesis works in its best. However, in the engineering and especially in the case of M.Sc. thesis, your question might be quite often more *practical*. Hence, your question might be expressed also in a more operational form like; *"How do I implement protocol X for gadget Z more efficiently than it is done perviously?"* In the any case, there should be a *justification* why this thesis is written and what is its contribution to the world.

The good test for the research question is, in a retrospective mode, to search it from different places in the thesis. If one is reading the abstract or the introduction, can one find out the question. How about reading conclusions? In minimum, the reader should understand what this thesis is all about; an operational questions being *"What is inside the thesis"* and *"What was done?"* .

Another important issue apart of the research problem is, of course, to provide *solution* to it. One should note that solution might mean implementation or analytical solution *per se*, but sometimes it is actually building a full experimental testbed. So the meaning of the solution varies, and is highly dependent on your problem and *goals*. It might be actually better sometimes to emphasis the point that M.Sc. thesis should at minimum state a clear goal for the work, and then accomplish this.

However, stating the goal (question) and then giving a solution is **not** an acceptable M.Sc. thesis. This would be merely (at best) a some sort of laboratory report. It is important that you put your work into the rigorous and wider context. Hence, you job is to also review your field, you need to show that you understand the basics of your selected domain of study. Moreover, you have to show in convincing way that you know the previous work done in the problem area. This is also required so that you can explain to a reader why your solution is better than the existing one (or maybe there was no existing solution). Note that there is requirement of *convincing way*, so you should show some evidence that you have tested and compared your solution – this is done by any appropriate means like mathematical analysis, simulations, or experimentation. The evidence that you know about prior work is shown by *bibliographical* references you cite (more about this will come later).

It short, what you should keep in mind is probably something like the following [1].

> *An acceptable Masters thesis should attempt to include both or either one of the following criteria: (a) it has a research problem, and original research results are achieved. Those are explained clearly and concisely; (b) the work has a substantially novel implementation or empirical study part whose results are interest for the engineering community in the specific field. The goals are archived and results are explained carefully and clearly.*

There is, however, also pedagogical issues that are related to thesis (after all we are the university, not just a research laboratory). Hence, the strong idea behind the M.Sc. thesis work is that you are able to show independence at the *reasonable level* (see also Part I of this document). The traditional view is that by writing M.Sc. thesis;

> *A student shows enough maturity and skills by being able to write a thesis independently. This also means that the student is able to indepen-*

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[2]Here we go again, the reference [3] is defining *fundamental*: n. **1**. a. A leading or primary principle, rule, law, or article, which serves as the groundwork of a system; an essential part. Chiefly in pl.; the sing. is obs. or arch. adj. **1** Of or pertaining to the foundation or ground-work, going to the root of the matter.

dently **acquire** *and* **process** *information, and is able to apply this information to the selected problem.*

This means that in the ideal case, the student is **not** "spoon fed", i.e. you can not expect to get everything and all background material from your supervisor. You are supposed to show skills on finding knowledge. However, this does not mean that you are left alone (that would be unfair anyway). Your supervisors give you initial starting point. If you do not know how to find more information ask (and information finding does not mean making just a "google" search). Part of the work is also being a "critical user" of the information. This is difficult part of the research, and if you need help of source critic, you should ask from your supervisor(s). Note that there is a degree of freedom here. The requirement of independence does not mean that you should work alone. On the other hand you should not expect to get everything "on plate". In principle, being able to work independently is good and correlates *in part* with excellence. However, taking a topic and coming back six months after with the document is probably not the best show of independence show, it could be even plain stupid. Asking around and picking other people brains is a good tactic – that is also what the established scientists do (within reason – and one issue is to learn to do this within reason). The degree of independence depends also on your topic, sometimes your topic might be a very difficult, new research topic, then you naturally need more help from supervisors. So remember that there are different levels. This is taken in account during the final evaluation. So in principle you should not worry too much.

1.2 Contents

There are different structures for thesis documents. Hence, it is impossible to give a single template that would work in every case. This is something you have to discuss and agree with your supervisor(s). However, there are some almost inevitable parts in the thesis.

Abstract You are *required* to provide abstract of your thesis. This goes into beginning as a separate part. The abstract must be **short**. This is a fuzzy definition, but it is definitely no more than one page, and in reality should be only few hundred words.

Introduction Virtually every thesis has an introduction. This should summarize background and paint the "big picture" of the field. It should also justify why you are writing your thesis, most probably it already includes your research question in the form of "research statement".

Conclusions This is a must. The work is not done before you give a summary on what you have been doing, and then give conclusions. What were the main results? What did we learn and/or gained from this work?

Future work Make yourself look good. Show that you understand the limitations of your work, and know what do next. This is a place, where a lot of nice and "fancy" statements are seen, like *"since we did not have enough time, supervisor was anyway sleeping, and a dog was eating part of my laboratory results we were not able to solve Riemann's Wireless Hypothesis, so it is left for the future work"*.

Bibliography This is where your references to articles, books and so forth goes. It is an **very important** part of your thesis (see some comments later).

Statement There is a standard statement you need to add (and sign for the library copy). You are basically declaring that you did work yourself and you are referring all the appropriate sources.

The rest is variable, but naturally you need to explain all the necessary background information, your methodology and tools, and finally show your results.

2 Important Issues to Remember and Consider

This section is drawing your attention to some important issues in almost FAQ (Frequently Asked Question) style. These are important issues, not only because we say so. So take them in account, accordingly, and you make yourself look good.

2.1 Length

It is often asked what is the perfect length of the thesis. There is no correct answer to this question. If you solve some huge mathematical problem with elegance and you need just few pages to solve it, and subsequently become world famous, that's all right. One the other hand, 500 pages saying nothing will not make you an engineer. However, if we look statistics, one could say that typical variation is between 60-90 pages, and if you are well below 50, or in excess of 110 pages, you should definitely discuss with your supervisors.

2.2 Language, Grammar and All That

There are two allowed submission languages; German and English. English is typically preferred in many projects, since many of our collaborators (especially in the industry) prefer it. You might need to ask permission to submit in English (this depends on your study regulations).

Although you will not be, primarily, evaluated by linguistic skills, a good representation helps you to look excellent. Remember also that the head of the department might read *literally* couple of dozen thesis works per year, so why make him tired with your thesis. That said if you write, e.g. in English, no one is expecting you to produce native text and 100% correct expressions. One of the reasons for several "polishing rounds" is to get the grammar and style to level that is reasonable and acceptable. That said there are, however, several small issues you can do to make things better.

First, use *spell checker*! The spell checkers are available for all major platforms, word processors and operating systems. So there is no excuse not to use them. However, note that sometimes spell checkers are plain dumb with engineering terminology, and might even suggest you *wrong* replacements.

Second, re-read your text after putting it off for sometime. You will be surprised, how many issues you will find out after leaving text alone for awhile.

Third, think logically. The text should progress logically and in good order. If you are zig-zagging from topic to the another, it is no good for thesis – a document like this

one can survive (barely) from zigging[3], but in the case of thesis, well it suffices to say that you will get comments from your supervisor.

You have to strike a balance between using your time on grammatical polishing and catching up all the fancy errors, and doing "the real job". It is probably best to err on the side of "real job" than grammar (*"highly polished and nice looking rubbish, is still rubbish"*). Nevertheless some polishing is reasonable and necessary. If you are writing in English, you should see the polishing part as an *investment*. Virtually all the major research and standardization is written in English, and almost all the major companies use English as their corporate language (so why not invest now to look good for your employer).

It is out of the scope of this document to go in detail to style issues (better to ask, if you are confused), but nevertheless few pointers could be given (caveat emptor).

- Spelling; It was already mentioned that you should use spell checker whenever you are writing something as large as a thesis. As of the **dictionaries**, the *authorative*[4] source in English (as UK English) is *Oxford English Dictionary* a.k.a. OED [3]. If you like American English there are, e.g., Webster's available [4]. Do not forget also excellent Leo-dictionary for translations between English and German (available online http:\\dict.leo.org).

- Style and other nifty[5] advice can be found from many places. If you continue to write more regularly (Ph.D. thesis perhaps?) you could look veritable[6] Strunk's [6] *The Elements of Style*, see also Ritter [7]. There are lots of general lists that are summarizing general errors done in English style (see e.g. [5]).

- Writing Scientific English (German) is, however, different on writing good prose. You should read advanced text books, and most notably research articles to learn the difference. Your supervisors can also help you, and once more we do not expect you to know everything in the beginning, or even in the end of your thesis period. The particular differences are the use of "passive voice", and using "we" instead of "I" etc. A good example is the case of passive voice. Note that, generally speaking, in English it should be *avoided* unlike in German. The passive voice in English is often interpreted like an old-stylish and pompous writing tone. However, the passive voice is quite regularly used in scientific English. Confused? Well, only a practice and experience helps to find a right balance.

2.3   Background and State-of-the-Art

As mentioned you are expected to show that you know the background material ("state of the art") in your domain of research. Sometimes this part of the work tends to get

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[3]Believe of not this is found from the dictionary; *The first syllable of zigzag, used in the same way as ZAG. Hence 'zigging' vbl. n. and ppl. a.*

[4]According to [3], authorative is obs. rare (see the writer is so senile that he is using obsolete and rare words; Of the nature of authority, authoritative. More modern variation of the work is *authoritative* which again according to [?] **1.** Of authority, of the nature of authority, exercising or assuming power; imperative, dictatorial, commanding. **2. Possessing due or acknowledged authority; entitled to obedience or acceptance.**

[5]Oh no, here we go again. The author likes too much ODE [3], but maybe there is a reason for that. The definition for word *nifty*; a. **1.** Chiefly U.S. Smart, stylish; attractive; of good quality. **2.** Clever or ingenious; handy, nimble, dexterous. The history of the word is not so short as you could guess from its "slag" sounding form, it can be traced back down to B. Harte (Poems 93) in 1868, and Overlan Monthly Magazine in 1889.

[6]Haa, caught you. There is no dictionary definition here

too large, so you have to stop at some point and start to work with your own ideas. You have to also select a reasonable level of background material introduction to your thesis. Your ability to choose right topics and references out of the background noise, is one part of this exercise called thesis writing. The key part of the review is also to select right *references*.

Remember that you should not be just "parroting" other references. Make it clear in your mind what is the fact, and which part is an opinion or hypothesis. You should be able to read critically.

2.4 References and Bibliography

One part of the scientific process is to find out relevant references and then *cite* those. It is clear that it is not so easy to know exactly the issue of *relevance* in the beginning of the career. However, you should (maybe with help) select between good and bad. Using references does not mean that you randomly google something out, and then put that in your bibliography. You should read, analyze, judge and select.

An important issue is that you have to cite your references. This is absolutely **"a must"**. The good scientific conduct requires that you will give *appropriate reference* to other works (but it does not mean that you have to reference inappropriate works or your boss' papers on gardening). This is also required in order for other interested readers to find out good starting point for their research (or learning). So referencing is not just a rule, it is also polite to do. Another important issue in the referencing is that you should do that if you are using, even in the somewhat modified form, other people results. It is a misconduct not to reference, so be careful. The typical expressions to explain a large context taken from other sources is to say, e.g., "according to Santa Claus et al. [3]", "...in the next section we are following mostly a reference [7] on...". If you are copying *verbatim* from some other sources you should use quotation marks (""), and explicitly refer to source. Again you are supposed to take care of this, and it is against the rule not to cite the source. Obviously, you might need help on deciding on how to do this, so *ask from your supervisor guidance even if you have a slightest hesitation.*

Now, another issue is the bibliography itself, i.e. the list of references in the end of your thesis. There are different tools to manage and make them (many people are using BibTeX, but obviously you can use whatever you want, up to just writing them into the end of word document). The tools do not matter, but **style matters**.

You **must** prepare your bibliography carefully, and even stylistically it must be at the level of *research papers*. Hence, you are not allowed to "cook-up" something that looks like the bibliography. As a major rule, you should follow the bibliographical style used in **IEEE** and/or **ACM** journals (or books). Easy way to understand it is just to look at journals, both organizations also explain the requirements in many web-pages. Discuss (if necessary) with your supervisors. Note that typically we use a referencing style with brackets and numbers, just like in this document. Note that one can still refer also to the authors in the text, e.g., "Gerla et al. [31] showed that ...".

In principle, we do not prefer the referencing with shorthand names (like "[White93]"), which is known as Harvard style (something like Gerla (1993) could be discussed, if you fancy that sort of style). The most important issue is to be **consistent**, you should not change style in the middle of the thesis.

The bibliographical references must be accurate and full. Do not be sloppy, if IEEE style requires you to give full name, journal, volume number and the first page, do it. Being sloppy do not help anyway, since in the end we will insist on exactness. The

only **variation of the rule** is that typically we do not insist that you need to refer both the first and last page of the article (like pp. 292-301); we are quite happy with the first page (pp. 292)[7].

2.5 Analyzing Results and all that

One of the issues related to analyzing results is drawing the figures. You should follow few simple rules;

- Pictures and Figures should be of good quality. If you are drawing block diagrams use some professional level software (xfig, illustrator, power point (ugh), vision), and if you are making plots again use something that produces professional output (Origin, gnuPlot, pgplot). Lots of software is available at the department, so there is no reason for making poor looking stuff.

- Pictures and Figures have *copyrights* and just like for the text you must give references. In general we advice against for making "copy-and-paste", since quality is bad and you will have some issues. If it is the last resort, be careful on giving a full reference. If you are redrawing almost completely something, give credit,e.g., "picture adopted from []" or something appropriate.

- Figure captions need to be full sentences. This means that they must make sense, they start with the capital letter and end with the period. You can use more than one sentence, there is nothing against it. Same goes with *Tables*.

- Do not overcrowd your plots, there is a limit for how many lines one can follow. Literally dozens of lines in one small figure does not make any sense. Use figure panels if that makes sense.

- Use colours with "taste". Do not use them for "flashy" effects, and do not use them if you can get same thing done without. However, do not avoid colour plots if they really make sense (e.g. some density distribution plots really require colours).

- Label your axis (both of them), put on major/minor markers.

The actual analysis depends on your topic (obviously). But as this is a thesis work, we are expecting that scientifically valid and appropriate methods are used. Analysis is often both quantitative and qualitative.

2.6 Few Issues to Check

Be certain that you bring out your *own work* in the right context. Even more important is that you clearly explain what is your own work, there is nothing wrong on being proud of your work. Your should not over stress it, but the thesis document should make it clear what was your own personal contribution. Especially in the conclusions you can clearly describe what was the major result of the thesis work.

Check once more references, figures, and tables before handing in the final version.

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[7]Why so? You can buy a cup of coffee to the author and hear some old people's stories about this.

2.7 Template and Tools

We are flexible on the tools, although a number of senior members in the department like LaTeX/TeX (its free and makes nice output), we do also accept, e.g. Word. The tools do not matter so much, it is the output. (That said, we do love LaTeX output).

There is no strictly fixed template, but you should roughly follow the style that is existing. The rough templates are available. However, if a small artist is living inside you and you want to design your own super-template, feel free to suggest it. The final decision to accept stays with the head of the institute. But he is known to be reasonable (this might be true or not).

The only issue that we insist *strongly* are A4 (no other size, please) and the front page must follow the general template. You can get template from the `common disk` in the departmental server, or just ask from the assistants. Fonts, there is nothing wrong with good old Times Roman, but lately we have liked some more stylish fonts too (like Palantino), but not too stylish (if you try to offer a thesis typed with Old English or Old German typeset, well lets say it will not fly).

3 Other Issues

The writing your first thesis feels sometimes like climbing a mountain. It is a huge task, and can be even painful. However, you are not alone in your task, and actually it feels good when you have done it. A good advice is that you should start to write as soon as possible, you will find out that writing takes time much more than you are expecting. You should reserve at least one (1) month for writing, but note that the speed varying highly between individuals.

Make notes (written one) all the time of your work. Joggle down your references, findings and thoughts. How about keeping up the laboratory notebook, if you are doing experiments? Keeping regular notes available for you, will make the actual final write-up much less painful affair.

4 It's ready!

So finally you have submitted the final version to your professor, and there was only minor comments to do. So what are the remaining hurdles, if any. Well, we are good on hurdles, so you still have something to do.

Thesis presentation (viva, thesis exam) is a public talk at the department, where you must present your main results. After the talk you should be prepared to answer questions from the faculty members, but also from the general audience. The talk should last about 35-45 minutes (discuss with your supervisor on length, format and expectations). It needs to cover in the concise form the whole of your thesis (research), i.e. background, own work, results and conclusions. The questions are (more or less) limited to the area of your thesis work.

As you know traditionally, if you pass (and you should plan to pass), we have celebrated after the thesis presentation with coffee and cake. Ask from the previous students or the secretary, how this goes if you do not know already.

After the successfully defended thesis presentation, the department will grade your thesis officially and inform the faculty on the result. The final paper work will take some time, so you should be prepared to wait before you will get your official diploma, but (hopefully) not too much.

4.1   Hard-Cover Thesis and CD-ROM

There is also tradition (read: requirement) that after the successful thesis presentation, you need to do last polishing of the thesis (if any). Then you have to make a final print-out. The tradition is that you should produce two (2) hard cover thesis documents to the department. Note that you thesis is *public document* (even more reason to reference all the big names accordingly). You should also make a cd-rom out of your raw data, computer codes, and text of the thesis document (TeX/LaTeX, Word, etc.). The cd-rom should also include slides of your final presentation.

On the issue of hard covers for thesis document, you should consult Ph.D. assistants on where people have typically done it. You can do, naturally, copies same time for your family or yourself, we require only two. Note that you should not in any event do the hard-cover version, before you have been explicitly said that it is all right. Another issue on bounded copy (a.k.a. blue-cover thesis) is that there is a consecutive numbering for M.Sc. thesis documents. The placement of the number and the author's name is fixed. This information you will get also from Ph.D. assistants. In order to stress, the job of engineering is sometimes to be exact, so be sure with hardcover binding that;

- The tone of blue is really the same as in the other covers.

- The placement of the sequence number and your name in the back of the book goes RIGHT. It needs to be at the same height as the other numbers. Your name needs to at the same height as the other names. The direction of the fonts, is **English bookending** not German/French one (if you place the book on the table, you will be able to read text without twisting your head). If you are uncertain, consult a previous thesis in the library, or you can even ask to borrow one and take it as an example for a bookbinding company.

- Make certain that you are printing out the final version, and that should be done to clean white paper. If you have colour pages, you can ask that the department prints out the colour pages by our laser printer (in fact, it is a colour phaser).

On the issue of cd-rom, ask help from the administrator. The easiest way is to copy everything into common disk, and then ask the administrator to burn a copy for the departmental archive.

Note that if you work has been done in under NDA or in the confidential project, the non-disclosure agreement (secrecy agreement) is in effect even after the thesis. However, everything that is put into the thesis document itself will become public. If you are in doubt, ask.

References

[1] MIT, *The Masters of Engineering Thesis Guide 2004-2005*, Department of EECS, MIT. Available on line "http://www.eecs.mit.edu/ug/thesis-guide.html" (visited 05/2005).

[2] Mähönen P., *Curious Thougts and Internal Memo on Why Thigs fall apart in Thesis Projects*, not published but might be available for people wanting to waste time.

[3] *Oxford English Dictionary*, Oxford University Press, 2004.

[4] Webster, *11th Collegiate Dictionary*, Merriam-Webster, 2004.

[5] see *Common Errors in English* in mboxhttp:\\www.wsu.edu/ brians/errors/ (visited 05/2005).

[6] Strunk W.I., White E.B. (Editor), *The Elements of Style*, Longman, 1999.

[7] Ritter R. M., *The Oxford Style Manual*, Oxford University Press, 2002.